Environmental Assessment Report

Cumberland Fossil Plant

Cumberland City, Tennessee

Tennessee Valley Authority

Title and Approval Page

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Prepared By:	Tennessee Valley Authority
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TVA Compliance Point of Contact	8/2/23 Date
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0	April 29, 2022	EAR Submittal to TDEC
1	January 26, 2023	Addresses August 9, 2022 TDEC Review Comments and Issued for TDEC
2	August 14, 2023	Addresses May 16, 2023 TDEC Review Comments and Issued for TDEC

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Executive Summary

On August 6, 2015, the Tennessee Department of Environment and Conservation (TDEC) issued Commissioner's Order No. OGC15-0177 (TDEC Order) to Tennessee Valley Authority (TVA) to establish a process for investigating, assessing, and remediating unacceptable risks from management of coal combustion residuals (CCR) at TVA coal-fired plants in the state of Tennessee. There are four CCR management units[1] at the Cumberland Fossil (CUF) Plant included in the TDEC Order: the Stilling Pond (including Retention Pond) and Bottom Ash Pond, which are surface impoundments, and Dry Ash Stack and Gypsum Storage Area, which are landfills. TVA constructed the CUF Plant between 1968 and 1973, and the four CCR management units are currently operational and comprise approximately 326 acres. The CUF Plant location is shown below.

In accordance with the TDEC Order, TVA and Stantec Consulting Services Inc. (Stantec), on behalf of TVA, prepared an Environmental Investigation Plan (EIP) for the CUF Plant to obtain and provide information requested by TDEC. As specified in the TDEC Order, the objective of the EIP was to "identify the extent of soil, surface water, and groundwater contamination by CCR" from onsite management of CCR material in impoundments and landfills. In addition, per TDEC's information requests, the EIP included assessment of CCR management unit structural stability and integrity.

Between 2018 and 2021, TVA and Stantec conducted the TDEC Order environmental investigations (EI) for the CUF Plant CCR management units. The EI included characterization of the site hydrogeology and investigations of CCR material, groundwater, background soils, seeps, surface streams, sediments, and ecology, as well as a supplemental Phase 2 investigation within an unnamed tributary to Wells Creek (herein called the Unnamed Tributary) and the Water Use Survey. EI activities were implemented in accordance with the approved Sampling and Analysis Plans and Quality Assurance Project Plans, including TVA- and TDEC-approved programmatic and project-specific changes made following approval of the EIP. Based on a comprehensive quality assurance review, the EI data are usable and meet the objectives of the TDEC Order.

The EI data were evaluated along with information collected as part of previous investigations and other ongoing regulatory monitoring programs conducted between the 1970s and 2022. The objectives of the TDEC Order are similar to these other programs, including TDEC landfill permit requirements (Chapter 0400-11-01) and the United States Environmental Protection Agency CCR Rule (Title 40, Code of Federal Regulations Part 257, Subpart D) that cover certain CCR management units. Collectively, these data provide a broad-based characterization of the CCR management units to meet the objectives of the EIP. Geotechnical data were used for CCR management unit stability and integrity evaluations. Environmental sample data were used to characterize the extent of potential impacts and were compared to constituent-specific TDEC-approved levels to identify CCR constituents that require further evaluation in the next phase of the TDEC Order, the Corrective Action / Risk Assessment (CARA) Plan.

This Environmental Assessment Report (EAR) describes the extent of surface stream water, sediment, and groundwater contamination from the CUF Plant CCR management units, and provides the information, data, and evaluations used to make those assessments. As described herein, more than 97% of the environmental sample results from over 1,000 samples were below the approved levels. The EI data indicate impacts to limited groundwater areas related to the CCR management units and potential impacts to surface water and sediment quality in the Unnamed Tributary. Supplemental data have been collected for groundwater and within the Unnamed Tributary for further evaluation in the CARA Plan. The EI data also indicate that the CCR management units have had minimal, if any, potential impacts to sediment and surface

[1] The term "CCR management unit" is used in this document generally and is not intended to be a designation under federal or state regulations.

stream water quality, and ecological communities in Wells Creek or the Cumberland River. The EI data will be used to evaluate the basis and methods for CCR management unit closure in the CARA Plan and do not preclude evaluation of closure in place as a viable closure method, nor the continued harvesting of gypsum and fly ash for the manufacture of building materials. The following are overall assessment findings based on data as presented in this EAR:

- Surface stream water quality is within ranges protective of human health and aquatic life in the Cumberland River and Wells Creek. Potential risks associated with surface stream water in the Unnamed Tributary will be further evaluated in the CARA Plan to determine if corrective action is needed.

- Sediment quality is within ranges protective of aquatic life in the Cumberland River adjacent to and downstream of the CCR management units. Potential risks associated with sediment at two locations in Wells Creek and sediments in the Unnamed Tributary will be further evaluated in the CARA Plan to determine if corrective actions are needed.

- The EI data indicate that ecological communities are healthy in the Cumberland River and Wells Creek adjacent to and downstream of the CCR management units.

- The CCR management units have adequate structural stability, and slopes are stable under current static and seismic loading conditions (the Gypsum Storage Area will meet seismic global stability criteria as TVA implements targeted regrading as part of its ongoing gypsum harvesting activities). Additional seismic stability assessments are necessary once closure is defined and will be included in the CARA Plan or in the closure design.

- There are no known active seeps onsite. One seep was identified during the EI and mitigated under the NPDES Permit.

- Most CCR constituent concentrations in groundwater are below TDEC approved groundwater screening levels and groundwater impacts are limited to areas downgradient along the perimeter of the CCR management units. However, additional assessments will be included in the CARA Plan to evaluate methods and design for corrective action for targeted groundwater at well locations with constituents above groundwater screening levels.

- Groundwater flow in the unconsolidated materials and bedrock is bounded to the south, west, and north by the Cumberland River and Wells Creek. A northwest-southeast trending groundwater divide to the northeast of the CCR management units separates groundwater flow northeast of the divide to the Cumberland River from groundwater flow to the southwest toward Wells Creek.

- Based on the overall results of the water use survey, current and historical CCR management associated with the CUF Plant have not affected water supply wells or springs located downgradient of the CUF Plant.

Exhibit ES-1 shows overall findings of the investigation and the locations where the environmental assessments concluded that no further evaluation is needed. It also shows where further evaluation is needed in the CARA Plan for sediment and surface water results, and onsite groundwater. The onsite groundwater impacts will require remediation regardless of the CCR management unit closure method, and groundwater remediation can be accomplished along with closure in place or closure by removal.

This EAR has been revised to include the results and evaluation of the Phase 2 sampling in the Unnamed Tributary, evaluation of groundwater quality east of the Gypsum Storage Area, updated seismic stability analyses, and the results of the Water Use Survey. Upon TDEC approval of the EAR, and in accordance with the TDEC Order, TVA will further evaluate these findings and prepare a CARA Plan for submittal to TDEC. The CARA Plan, which will be subject to a public review and comment process, will evaluate whether unacceptable risks related to management of CCR material exist at the CUF Plant. TVA continues to evaluate additional means to beneficially reuse these materials in a manner consistent with regulatory requirements while maximizing value to the Tennessee Valley. The CARA Plan will also specify the actions TVA plans to take at the CCR management units and the basis of those actions. It also will incorporate other operational changes planned or in progress by TVA, including details for continued CCR beneficial use operations, modification of the CCR management units as needed to meet regulatory standards for seismic stability and long-term closure and monitoring.

Exhibit No.
ES-1

Title
Summary of Environmental Assessment Report Findings Cumberland Fossil Plant

Client/Project
Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location
Stewart County, Tennessee
175568209
Prepared by KB on 2023-03-20

* None of the sediment or surface water sample results in the Cumberland River were above approved levels.

Key Findings

The ecological communities are healthy in the Cumberland River and Wells Creek adjacent to and downstream of the CCR management units based on the results of the environmental study and other ongoing monitoring efforts.

Nearly all of the environmental sample results were below the approved levels.

Based on the overall results of the environmental assessment and water use survey, current and historical CCR management associated with the Cumberland Plant have not affected water supply wells or springs located downstream from the plant.

This means that TVA is managing its CCR units in a way that protects the ecological integrity of the Cumberland River, Wells Creek, and their aquatic communities.

Assessment and Monitoring Findings

These symbols illustrate the findings of the assessment and monitoring:

- No action is needed.
- Further evaluation is required in this area.
- Corrective action is being evaluated for onsite groundwater along the perimeter of the unit in this area.

Next Steps

Based on the Key Findings above, with TDEC approval, TVA will use the findings from the environmental assessment to prepare and submit a corrective action plan and will specify all measures TVA plans to take to address unacceptable risk. This corrective action plan will be released for public comment.

Stantec TVA

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Acronyms and Abbreviations

AOI	Area of Interest
BTV	Background Threshold Value
CARA	Corrective Action/Risk Assessment
CBR	Critical Body Residue
CCR	Coal Combustion Residuals
CCR Parameters	CCR Constituents listed in 40 CFR 257, Appendices III and IV, and the five inorganic constituents listed in Appendix I of Tennessee Rule 0400-11-01-.04
CCR Rule	USEPA Final Rule on Disposal of Coal Combustion Residuals from Electric Utilities
CFR	Code of Federal Regulations
CUF Plant	Cumberland Fossil Plant
CuRM	Cumberland River Mile
CSM	Conceptual Site Model
Cy	Cubic Yards
°F	Degrees Fahrenheit
DMP	Data Management Plan
DSWM	TDEC Division of Solid Waste Management
EAR	Environmental Assessment Report
EDA	Exploratory Data Analysis
EI	Environmental Investigation
EIP	Environmental Investigation Plan
EnvStds	Environmental Standards, Inc.
ESV	Ecological Screening Value
EXD	Exploratory Drilling
ft amsl	Feet Above Mean Sea Level
ft bgs	Feet Below Ground Surface
GEL	GEL Laboratories, LLC
GSL	Groundwater Screening Level
GWPS	Groundwater Protection Standard(s)
HBI	Hilsenhoff Biotic Index
MQA	Material Quantity Assessment
NEPA	National Environmental Policy Act
NOAA	National Oceanic & Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
ORP	Oxygen Reduction Potential
PACE	Pace Analytical® Services, LLC
%	Percent
PLM	Polarized Light Microscopy
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan

Acronyms and Abbreviations

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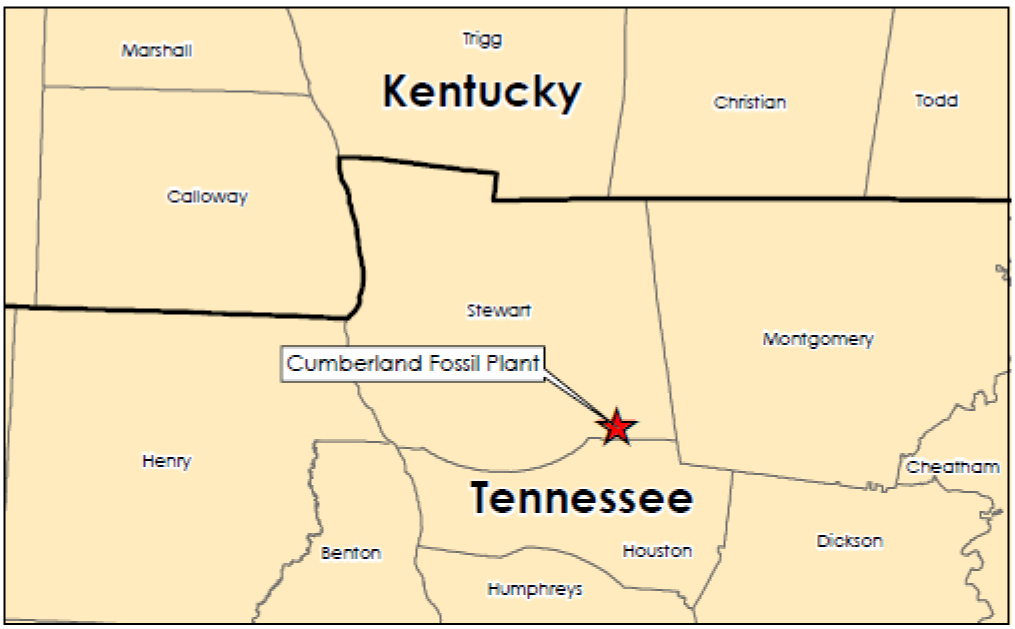
Cumberland Fossil Plant

QC	Quality Control
RBI	Reservoir Benthic Index
RCRA	Resource Conservation and Recovery Act
RFAI	Reservoir Fish Assemblage Index
RJ Lee	RJ Lee Group
SAP	Sampling and Analysis Plan
SAR	Sampling and Analysis Report
SPLP	Synthetic Precipitation Leaching Procedure
SSLs	Statistically Significant Levels
Stantec	Stantec Consulting Services Inc.
TDEC	Tennessee Department of Environment and Conservation
TDEC Order	Commissioner’s Order OGC15-0177
TestAmerica	Eurofins Environment Testing America
TLB	Temporary Lined Basin
TN	Tennessee
TOC	Total Organic Carbon
TVA	Tennessee Valley Authority
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UTLs	Upper Tolerance Limits

Chapter 1 Introduction

The Tennessee Valley Authority (TVA) and Stantec Consulting Services Inc. (Stantec), on behalf of TVA, prepared this Environmental Assessment Report (EAR) to provide an evaluation of the environmental conditions at the Cumberland Fossil Plant (CUF Plant) in Cumberland City, Tennessee, that may have been related to management of coal combustion residuals (CCR) in onsite impoundments and landfills. The CUF Plant is an operational TVA coal-fired power plant in Stewart County, located in the north-central portion of Tennessee (see below and Exhibit 1-1).

CUF Plant Location

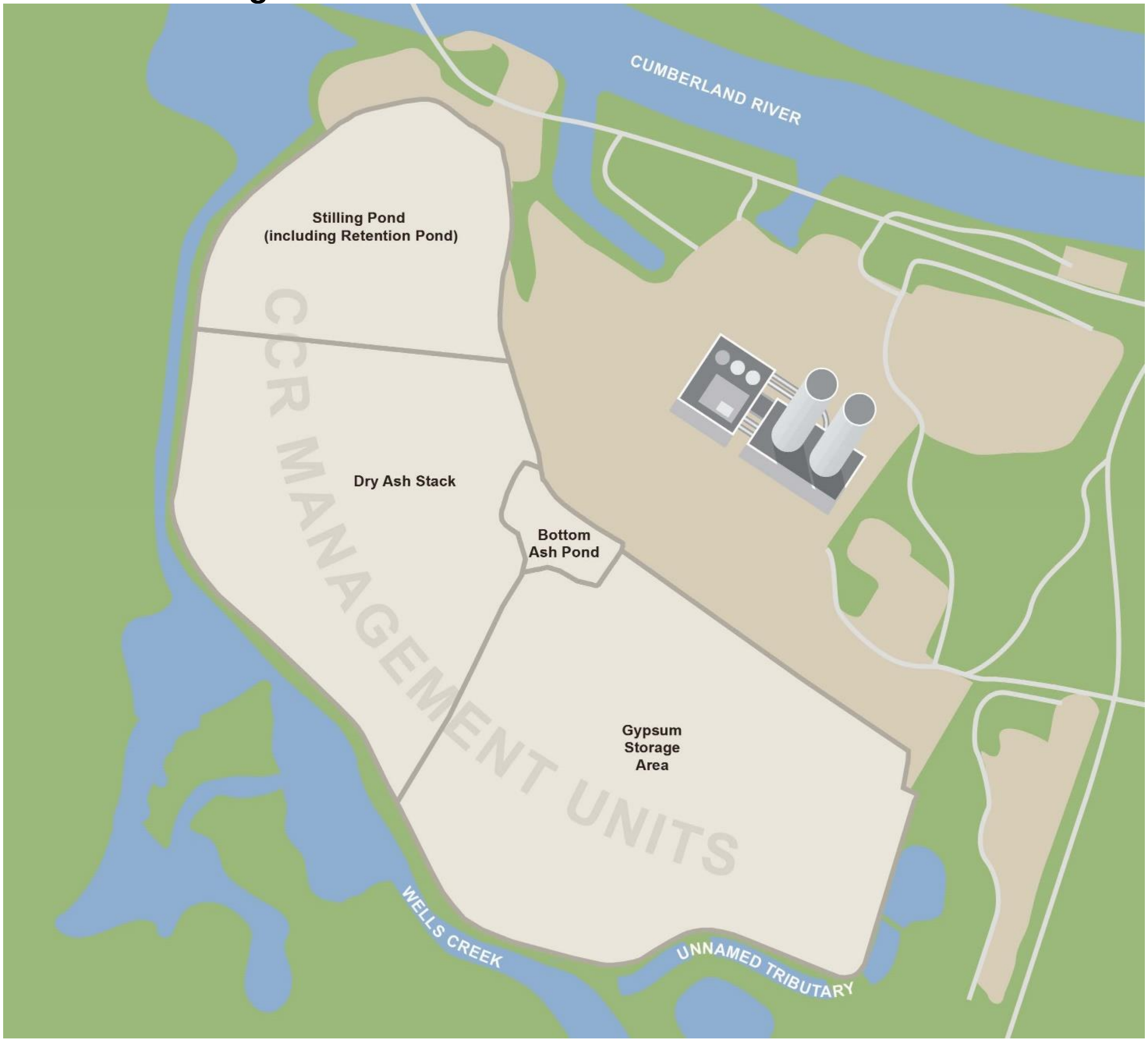


1.1 Background, Scope, and Objectives

On August 6, 2015, the Tennessee Department of Environment and Conservation (TDEC) issued Commissioner's Order No. OGC15-0177 (TDEC Order) to TVA (TDEC 2015, in Appendix A.1). The four CCR management units[2] at the CUF Plant included in the TDEC Order are: Stilling Pond (including Retention Pond) and Bottom Ash Pond, which are surface impoundments, and Dry Ash Stack and Gypsum Storage Area, which are landfills (see below).

[2] The term "CCR management unit" is used in this document generally and is not intended to be a designation under federal or state regulations.

CUF CCR Management Units



In accordance with the TDEC Order, TVA prepared an Environmental Investigation Plan (EIP) for the CUF Plant (TVA 2018a) to obtain and provide information requested by TDEC. Following public review and comment on the draft, the EIP was approved by TDEC on June 28, 2018, and TVA implemented the activities between 2018 and 2021 in accordance with the approved EIP. As specified in the TDEC Order, the objective of the EIP was to "identify the extent of soil, surface water, and ground water contamination by CCR" from onsite management of CCR material in impoundments and landfills. In addition, per TDEC's information requests, the EIP included assessment of CCR management unit structural stability and integrity.

The EIP included characterization of the site hydrogeology and investigations of CCR material, groundwater, background soils, seeps, surface streams, sediments, and ecology at and near the CUF Plant CCR management units to supplement historical data. This EAR presents the results of those investigations and an evaluation of recent and historical data to provide conceptual site models (CSMs) for the CCR management units and overall findings for environmental media at the CUF Plant. CSMs describe sources of CCR constituents, pathways by which they can move, and environment media potentially impacted if they are released. As required by the TDEC Order, this EAR will be revised to address TDEC comments until TDEC determines that the extent of CCR contamination has been defined.

1.2 Regulatory Framework

The onsite management of CCR material at the CUF Plant is subject to the following regulatory programs relevant to this investigation. Data from these programs were considered in the development of the EAR.

1.2.1 TDEC Order

The TDEC Order was issued to establish a process for investigating, assessing, and remediating unacceptable risks from management of CCR at TVA coal-fired plants in the state of Tennessee. The TDEC Order also established a process whereby TDEC would oversee TVA's implementation of the United States Environmental Protection Agency (USEPA) CCR Rule for coordination and compliance with Tennessee's solid waste management program. Information about the USEPA CCR Rule is provided in Section 1.2.2.

Upon TDEC approval of the EAR, TVA will prepare and submit a Corrective Action/Risk Assessment (CARA) Plan to TDEC. The CARA Plan, which will be subject to a public review and comment process, will specify the actions TVA plans to take to mitigate unacceptable risks at the CUF Plant CCR management units, including the basis of those actions. The information provided in this EAR will support TVA's preparation of the CARA Plan and TDEC's decision-making process regarding the actions to be taken at the CUF Plant CCR management units pursuant to the TDEC Order.

1.2.2 CCR Rule

The USEPA CCR Rule sets forth national criteria for the management of CCR, was published on April 17, 2015, and can be found in Title 40, Code of Federal Regulations (40 CFR) Part 257, Subpart D (CCR Rule). The rule includes criteria for monitoring groundwater and assessing corrective measures if constituents listed in Appendix IV of the CCR Rule are detected in samples collected from downgradient groundwater monitoring wells at statistically significant levels (SSLs) greater than established groundwater protection standards (GWPS). Groundwater monitoring results and assessment of corrective measures are reported as required by the CCR Rule. TVA's CCR Rule Compliance Data and Information website is available for the public to view CCR Rule-required documents, including groundwater monitoring reports for the CUF Plant CCR management units, at the following location: Cumberland Coal Combustion Residuals (tva.com).

Additional CCR Rule criteria include closure and post-closure plans, design (including structural stability), location demonstrations, and operating criteria demonstrations which are certified by a qualified professional engineer.

The four CCR management units at the CUF Plant that are included in the TDEC Order are also subject to the CCR Rule, the Stilling Pond (including Retention Pond), Dry Ash Stack, Gypsum Storage Area, and Bottom Ash Pond.

1.2.3 State Programs

In addition to the TDEC Order and CCR Rule, TDEC has issued permits to TVA for ongoing CCR management and wastewater discharges from the CUF Plant CCR management units. Current permits include:

- TDEC Rule 0400-11-01-.04 Division of Solid Waste Management (DSWM) - Class II Landfill Permit No. IDL 81-102-0086 for the Gypsum Storage Area and Dry Ash Stack CCR Landfills
- National Pollutant Discharge Elimination System (NPDES) Permit No. TN0005789. Permitted wastewater discharges are to the Cumberland River via Outfalls 002 (which includes CCR management unit discharges) and 004.

Under permit No. IDL 81-102-0086, records are maintained for groundwater monitoring well sample results and groundwater elevations throughout the life of the unit, including the post-closure care period. Groundwater monitoring results are reported to TDEC at the intervals specified in the permit.

Under the NPDES permit, outfall monitoring results are recorded and submitted monthly to TDEC's Division of Water Resources. Raw water intake samples are taken annually and submitted in the Discharge Monitoring Report following the sampling event. Whole effluent toxicity testing is conducted annually. Perimeter dike inspections are conducted in accordance with the requirements of a Seepage Action Plan. A report of seep inspection results, a listing of seep conditions, and corrective actions completed and in progress are submitted annually. An alternative thermal limit was approved for the permit as a result of biological monitoring data showing that a thermal variance is justified in the near-field area of the plant's final discharge to the Cumberland River.

1.3 Environmental Investigation Overview

The following provides an overview of the environmental investigation (EI) activities conducted in accordance with the EIP that are reported in this EAR. The evaluation of existing data from previous studies conducted at the CUF Plant served as the foundation to support the TDEC Order EI.

1.3.1 Investigation Activities

In June 2018, Revision 3 of the EIP was approved by TDEC (Appendix A.2), which details the proposed EI to be conducted by TVA to provide additional information requested by TDEC. The EIP is comprised of desktop studies, Sampling and Analysis Plans (SAPs), a Quality Assurance Project Plan (QAPP), a Data Management Plan (DMP), a proposed schedule of investigative activities, and responses to TDEC information requests and public comments.

Environmental media samples collected as part of the EI, or other ongoing environmental programs being conducted at the plant, were analyzed for CCR parameters listed in the CCR Rule, Appendices III and IV. Five additional inorganic parameters listed in Appendix I of Tennessee (TN) Rule 0400-11-01-.04 that are not included in the CCR Rule Appendices III and IV were analyzed to maintain continuity with TDEC environmental programs.

CCR Parameters
CCR Rule Appendix III Parameters
Boron
Calcium
Chloride
Fluoride[1] (also Appendix IV)
pH
Sulfate
Total Dissolved Solids
CCR Rule Appendix IV Parameters
Antimony
Arsenic
Barium
Beryllium
Cadmium
Chromium
Cobalt
Lead
Lithium
Mercury
Molybdenum
Radium-226+228
Selenium
Thallium
Additional TDEC Appendix I Parameters
Copper
Nickel
Silver
Vanadium
Zinc

Notes:
[1]Fluoride is both a CCR Rule Appendix III and CCR Rule Appendix IV CCR parameter. In this table, and in the results figures and tables for this report, fluoride has been grouped with the Appendix III CCR parameters only to avoid duplication.

The combined CCR Rule Appendices III and IV parameters and TDEC Appendix I inorganic parameters are referenced collectively herein as “CCR Parameters.” As specified in the SAPs, additional parameter analyses were also performed based on the specific needs of the investigation. Where applicable, additional analyses are described in Chapters 3 through 7 below.

As documented in this EAR, the EI was implemented in accordance with the SAPs, which were updated with TVA- and TDEC-approved programmatic and project-specific changes made after approval of the EIP. EI results are summarized in the executive summary and section by section in this report, with details of each investigation provided in technical evaluation summaries and associated sampling and analysis reports (SARs) included as appendices. The purpose of the SARs was to document the work completed during the investigations and present the information and data collected to meet the objectives of the SAPs. The SARs were prepared and submitted to TDEC for review following completion of the SAP scopes of work. If TDEC provided comments after their initial reviews of the SARs, the comments were addressed, and the SARs were updated and re-submitted to TDEC for final acceptance. After each of the SARs was accepted by TDEC, those EI results, along with historical data collected under other State and/or CCR programs, were evaluated and are presented in this EAR.

The investigations and subsequent assessments completed pursuant to the EIP SAPs at the CUF Plant CCR management units are listed below:

- Background Soil Investigation
- Exploratory Drilling
- CCR Material Characteristics Investigation
- Material Quantity Assessment
- Hydrogeological Investigation
- Groundwater Investigation
- Seep Investigation
- Surface Stream Investigation
- Sediment and Benthic Investigation
- Fish Tissue Investigation.

1.3.1.1 Screening Levels

Sampling results obtained during these investigations are evaluated in this EAR by comparing concentrations of CCR Parameters to TDEC-approved screening levels (Tables 1-1 through 1-5 and Appendix A.2). The purpose of this comparison is to identify CCR Parameters in environmental media that require further assessment in the CARA Plan. The screening levels are generic (not specific to an individual person or ecological receptor) and are protective of human and ecological health. Most screening levels are not regulatory standards and are conservatively based on published health studies. Concentrations above the screening level do not necessarily mean that an adverse health effect is occurring, but rather, that further evaluation is required in the CARA Plan to determine if an unacceptable risk exists, and if corrective action is required.

Groundwater screening levels (GSLs) and surface water screening levels are based on published human health risk-based values considering these media as potential potable water sources (Tables 1-1 and 1-2). Surface water, sediment, and mayfly and fish tissue screening levels are based on published ecological risk-based values drawn from regulatory guidance and published studies (Tables 1-2 through 1-5). In cases where there is more than one applicable screening level for an environmental medium (e.g., surface water), the lowest value, or both values, are compared to the analytical results.

The statistical evaluation conducted for groundwater analytical results in this EAR was for investigatory purposes to characterize the extent of CCR impacts as required by the TDEC Order. It was not conducted for compliance with the CCR Rule or TDEC permitted landfill monitoring programs. Reports for compliance with the CCR Rule can be found on TVA's CCR Rule Compliance Data and Information website. Groundwater monitoring reports for the TDEC permitted landfill monitoring program are submitted to TDEC within 60 days of sampling events.

1.3.1.2 Hydrogeological Terms

For purposes of this EAR, the following hydrogeological terms as they are defined below are used throughout this document.

- Pore water – subsurface water that occurs in pore spaces in CCR material
- Groundwater – subsurface water that occurs in pore spaces in unconsolidated or geologic materials (e.g., soil, bedrock)
- Aquifer – a geologic formation capable of yielding usable quantities of groundwater
- Confined aquifer – an aquifer present between two aquitards when the water level in a well is observed to be above the top of the aquifer due to the confining pressure (see graphic below)
- Aquitard – a geologic formation comprised of less permeable geologic materials that transmit groundwater more slowly than an aquifer
- Saturated – Unconsolidated or geologic materials (e.g., soil, bedrock) or CCR material where all of the pore space is filled with water. The use of the term “saturated” in reference to the moisture content of CCR material does not imply that the pore water is readily separable from the CCR material
- Moisture content – the measure of the amount of water contained within unconsolidated or geologic materials (e.g., soil, bedrock) or CCR material. Moisture content of saturated material can be variable because the characteristics of the material determine the amount of pore space available for water to fill
- Phreatic surface – the surface of pore water at which pressure is atmospheric and below which CCR material may be saturated with pore water. Pore water levels are measured at locations where temporary wells or piezometers were installed within CCR material. The measured pore water levels are used to infer pore water levels between the wells and piezometers to develop the phreatic surface
- Piezometric surface – the surface of groundwater defined by the level to which groundwater will rise in a well completed in a confined aquifer
- Uppermost aquifer – the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within a facility’s property boundary

In a confined aquifer, measured groundwater levels rise above the top of the aquifer, but the actual level of groundwater is constrained by the upper aquitard. A figure showing the relationship between an aquifer and aquitards for a confined aquifer is provided below. The difference between the measured groundwater level within the aquifer and the top of the aquifer is call the pressure head. Because the level of groundwater within a confined aquifer is constrained by the upper aquitard, groundwater in a confined aquifer is not in contact with the geologic unit located above the upper aquitard. The aquitard physically separates them.

Pore Water

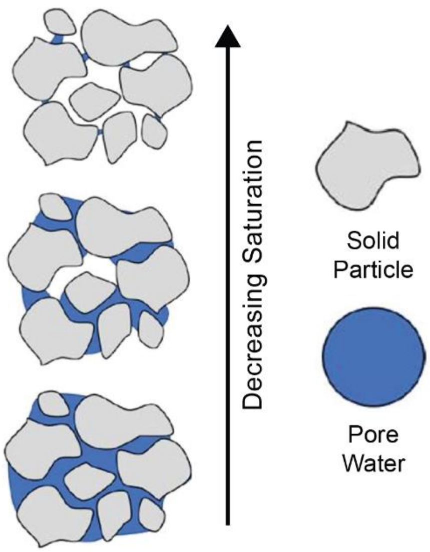
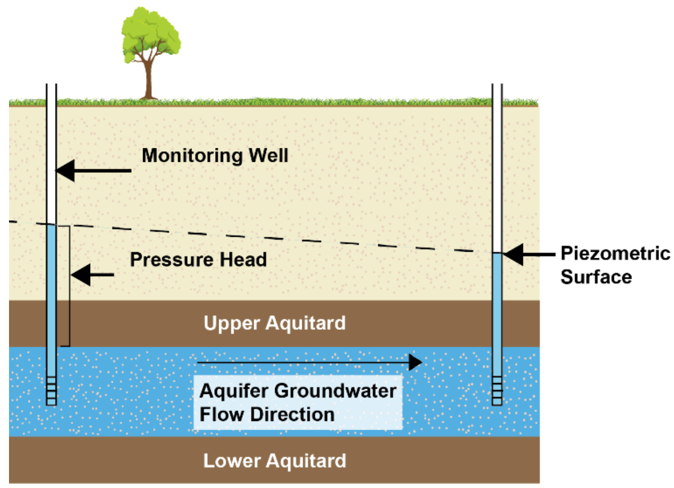


Figure Reference: Benson, C., *Water Flow in Coal Combustion Products and Drainage of Free Water*, Report No. 3002021963, Electric Power Research Institute, Palo Alto, CA.

This figure depicts how subsurface water occurs in the pore spaces in CCR material (referred to as "pore water" in this EAR), and how saturation varies within the CCR material. The phreatic surface is the surface of pore water at which pressure is atmospheric and below which CCR material may be saturated with pore water.

Confined Aquifer



Groundwater is subsurface water that occurs in pore spaces in soil or bedrock. Groundwater level measurements are used to estimate directions of groundwater movement. Groundwater generally flows much more slowly than water in a surface stream or river.

1.3.2 Data Management and Quality Assessment

For the EI, laboratory analytical testing was conducted by the following laboratories:

- GEL Laboratories, LLC (GEL) in Charleston, South Carolina
- Eurofins Environment Testing America Inc.) (formerly known as TestAmerica and referenced herein as TestAmerica), in Nashville, Tennessee; Pittsburgh, Pennsylvania; and St. Louis, Missouri
- RJ Lee Group (RJ Lee) in Monroeville, Pennsylvania
- Pace Analytical Services, LLC (Pace) in Green Bay, Wisconsin.

In addition, quantitative analysis of benthic invertebrate community samples was performed by Pennington and Associates, Inc. in Cookeville, Tennessee (Appendix J.3). Geotechnical laboratory testing and data review was performed by Stantec in Lexington and Louisville, Kentucky.

Data management was performed by Environmental Standards, Inc. (EnvStds). Field data and laboratory analytical data collected under the EI were managed in a database in accordance with the Data Management Plan (DMP) for the TDEC Order (EnvStds 2018b). The DMP was developed for data collected under the TDEC Order. Consolidated management of data related to the TDEC Order allowed for environmental data associated with the investigation to be appropriately maintained and accessible to data end users. The DMP provided a basis for supporting technical data management with an emphasis on completeness, data usability, and defensibility of the data.

To support the EI, a Quality Assurance (QA) program was implemented to verify that environmental data used for decision-making were reliable. The overall QA objective for field activities, laboratory analyses, and data assessment was to produce data of sufficient and known quality to support program-specific objectives and produce high-quality, legally-defensible data. This objective was met by following the QAPP (EnvStds 2018a), included as Appendix C of the EIP.

The QAPP was followed for investigation data quality assessment, where data quality refers to the level of reliability associated with a dataset or data point. The QAPP describes QA procedures and Quality Control (QC) measures applied to EI activities, describes the generation and use of environmental data associated with the investigation, is applicable to sampling and monitoring programs associated with EI activities, and provides quantitative objectives for analytical data generated under the investigation activities.

Data collected during the EI were evaluated for usability by conducting a QA review, per the QAPP. As part of TVA's commitment to generate representative and reliable data, EnvStds performed oversight of field activities, field documentation review, centralized data management, and data validation or verification of laboratory analytical data. In addition, TDEC and TDEC's contractor Civil & Environmental Consultants Inc., were periodically onsite to observe field activities and collect confirmation samples during the investigations. Based on the QA review performed by EnvStds, the EI data collected are considered usable for reporting and evaluation in this EAR and meet the objectives of the TDEC Order. Further documentation of the QA program implemented during the EI is provided in the *Data Quality Summary Report for the Tennessee Valley Authority Cumberland Fossil Plant Environmental Investigation* prepared by EnvStds following completion of the EI (EnvStds 2022).

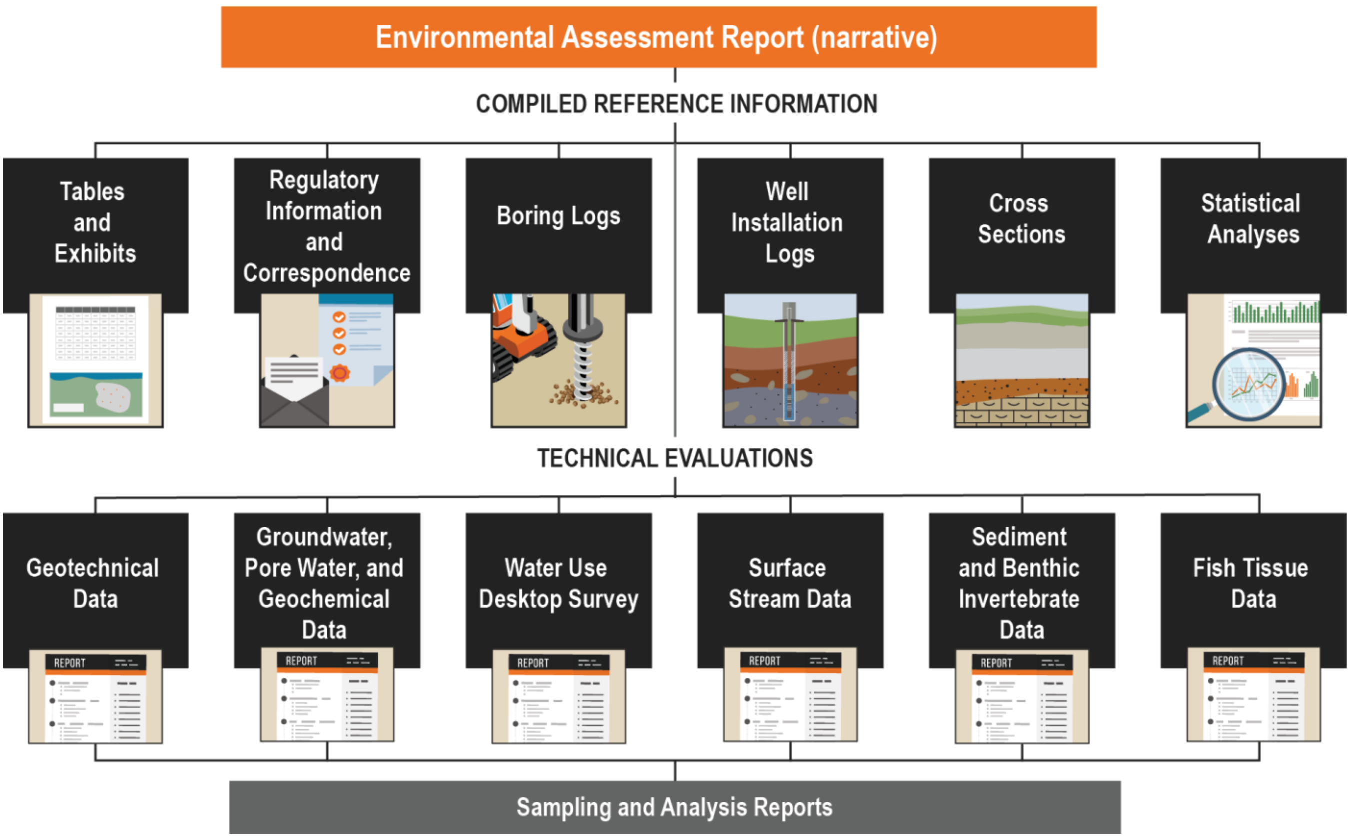
1.4 Key Milestones

A chronology of key milestones and events related to the TDEC Order and implementation of the EIP that occurred following approval of the EIP is provided below. This CUF Plant EAR Revision 2 has been prepared to provide information to TDEC including a limited Phase 2 field investigation and the Water Use Survey. This approach was approved by TDEC to allow initiation of the Water Use Survey.

Date	Event
June 28, 2018	TDEC approval of CUF Plant EIP Revision 3
July 23, 2018	Kickoff meeting held with TVA and TDEC to discuss implementation of EIP
August 20, 2018	Phase 1 EI field activities commence
June 12, 2020	Phase 1 EI field activities substantially complete (excluding Phase 2 Sampling and Water Use Survey)
April 20, 2020	Initial SAR submitted to TDEC
June 23, 2021	Phase 2 field activities commenced (data review ongoing)
January 11, 2022	Last SAR accepted by TDEC
April 29, 2022	Submittal of CUF Plant EAR Revision 0 to TDEC
August 9, 2022	Initiation of Water Use Survey (following TDEC approval of approach)

1.5 Report Organization

This EAR is based on EI data and results from other ongoing environmental programs obtained for the CUF Plant CCR management units through 2021. To facilitate discussion of the interrelationships of the data collected during the EI, the EAR presents evaluation of findings organized in the following principal investigation components: background soils, CCR materials, hydrogeology, seeps, and ecology. Chapters 3 through 8 herein provide a summary of each investigation's scope and presents the evaluation of those data, along with relevant historical or other environmental program data. The summary of findings presented in Chapters 3 through 8 are supported by detailed technical information and analyses presented in appendices as diagrammed below. Details of technical evaluations and information supporting those evaluations are included in appendices organized by subject matter. Field investigation activities sampling results are provided in SARs associated with each subject matter. The structure of the overall document is provided in the diagram below.



This EAR is organized as follows:

- **Executive Summary**: Describes the principal elements and findings of the environmental investigations presented in the EAR
- **Chapter 1 – Introduction:** Describes the background and purpose of the investigation, regulatory framework, an overview of the EI, public and agency involvement, and EAR organization
- **Chapter 2 – Site History and Physical Characteristics:** Presents the operational history, land use, and physical characteristics of the CUF Plant
- **Chapter 3 – Background Soil Investigation:** Summarizes the results of background soil investigation conducted for the CUF Plant
- **Chapter 4 – CCR Material Investigations:** Summarizes the CCR management unit geotechnical investigation results, including exploratory drilling, slope stability, structural integrity, and structural stability (bedrock) evaluations, findings from evaluations of pore water and CCR material characteristics investigation results, and provides information regarding CCR material characteristics and quantities
- **Chapter 5 – Hydrogeological Investigations:** Describes hydrogeologic conditions based on data from historical groundwater sampling and EI activities, and findings from geochemical evaluations of groundwater. Additionally, the findings of the water use survey are presented
- **Chapter 6 – Seep Investigation:** Summarizes the results of the seep investigation
- **Chapter 7 – Surface Streams, Sediment, and Ecological Investigations:** Describes the historical activities and EI results and evaluation of the surface water, sediment, benthic macroinvertebrate community, and mayfly and fish tissue data
- **Chapter 8 – TDEC Order Investigation Summary and Conceptual Site Models:** Presents the CUF Plant CSMs describing the nature and extent of CCR material contained in the CCR management units, and a summary of the associated impacts (if any) to groundwater, soil, seeps, surface stream water, and ecology
- **Chapter 9 – Conclusions and Next Steps:** Presents a summary of, and conclusions based on, the EI conducted at the CUF Plant CCR management units and next steps for activities related to the TDEC Order
- **Chapter 10 – References:** List of documents referenced in the EAR
- **Tables and Exhibits:** Presented following the main text of this report, and are numbered according to the chapter that they are first presented in
- **Appendices:** Includes regulatory information, technical data (i.e., boring logs, well installation logs, cross sections), data and statistical analyses, technical evaluations, and SARs for each investigation. Technical evaluations and supporting information have been grouped into the investigation components described in the main report (e.g., background soils, CCR material, hydrogeology, seeps, surface stream water, sediment, and ecology).

Chapter 2 Site History and Physical Characteristics

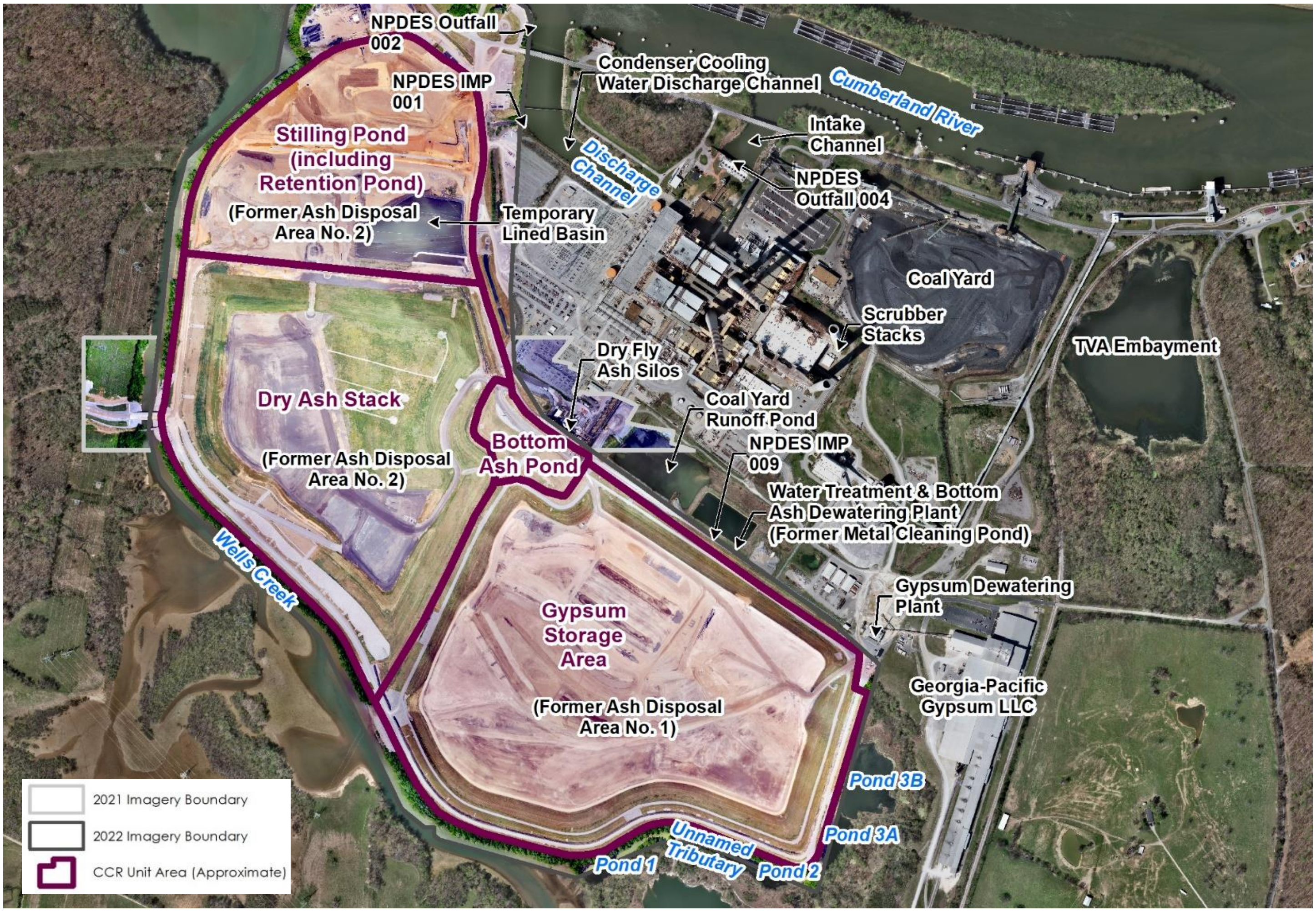
2.1 Site Operations

TVA constructed the CUF Plant between 1968 and 1973, commencing power generation in 1973. TVA operates the two-unit CUF Plant that annually generates approximately 16 billion kilowatt-hours of electricity (i.e., enough to supply 1.1 million homes). Annually, the CUF Plant uses an average of 5.6 million tons of coal and produces approximately 1.2 million tons of CCR in the forms of dry fly ash, bottom ash, and gypsum (TVA 2019b). Both fly ash and gypsum generated from the CUF Plant operations are beneficially reused as raw manufacturing materials (TVA 2019b). Of the approximately 1.2 million tons of CCR produced each year, approximately 1.05 million tons are beneficially used (TVA 2019b). On average, approximately 75 percent (%) of the fly ash generated at the CUF Plant is sold for reuse in the concrete industry where it is used in roads, bridges, buildings, airport runways, dams, precast concrete products, and driveways. Concrete with fly ash is stronger, more durable, lower cost, and environmentally friendly because every ton of fly ash that replaces Portland cement reduces carbon emissions by one ton (TVA 2019b). The CUF Plant supplies fly ash to over 200 concrete plants in nine different states (TVA 2019b). Additionally, approximately 90% of the gypsum generated annually at the CUF Plant is sold to Georgia-Pacific Gypsum LLC for use in the wallboard industry. This type of gypsum is considered synthetic, and it conserves natural resources by replacing mined natural gypsum (TVA 2019b).

The CUF Plant has four CCR management units, as shown on Exhibit 2-1: the Stilling Pond (including Retention Pond) and Bottom Ash Pond, which are surface impoundments, and Dry Ash Stack and Gypsum Storage Area, which are landfills. The total area of the CCR management units is approximately 326 acres.

TVA currently manages CCR material at the CUF Plant in the Gypsum Storage Area and Dry Ash Stack CCR landfills. Fly ash that is not beneficially used is transported by truck to the Dry Ash Stack. Gypsum is either conveyed to Georgia-Pacific Gypsum for wallboard manufacturing or temporarily managed in the Gypsum Storage Area for later beneficial use. Reject gypsum (gypsum fines) are placed in the Gypsum Storage Area. Bottom ash is sluiced to the Bottom Ash Dewatering Facility where it is dewatered and then transported by truck to the Dry Ash Stack. Process water and stormwater flows are conveyed to a Temporary Lined Basin for treatment prior to discharging through a NPDES permitted outfall to the Condenser Cooling Water Channel and ultimately to the Cumberland River.

CUF Plant Features



2.2 CCR Management Unit History and Land Use

As shown on Exhibit 2-2, an initial clay dike was constructed along the southern, western, and northern perimeter to an elevation of 380 feet (National Geodetic Vertical Datum of 1929 [NGVD29]) between 1969 and 1972 to develop the Ash Disposal Area.

CUF Plant discharges were initially routed to the Ash Disposal Area, which discharged to the Cumberland River. In 1976, a divider dike was constructed to divide the Ash Disposal Area into Ash Disposal Area No. 1 and Ash Disposal Area No. 2. In 1977, an additional divider dike was constructed in the northern portion of the Ash Disposal Area No. 2 to form the Stilling Pond and Retention Pond (Exhibit 2-2).

The perimeter dike was raised approximately 15 feet in 1979 and extended around the full perimeter of the CCR management units (Exhibit 2-2). In 1989, dredge cell operations began in Ash Disposal Area No. 1. Between 1991 and 1994, the elevation of the Stilling Pond spillway was raised 10 feet.

TDEC issued Class II Solid Waste Disposal Permit number IDL 81-102-0082 to TVA in 1993 for the operation of the Dry Ash Stack and Gypsum Storage Area. In 1996, a modification was made to the Class II Solid Waste Disposal permit number IDL 81-102-0082 and a new permit number of IDL 81-102-0086 was issued to TVA by TDEC (TDEC 1996). The following operational changes were implemented as part of this modification, as shown on Exhibits 2-1 and 2-2:

- Dry fly ash silos were installed
- The two combustion units were equipped with limestone scrubbers to reduce sulfur dioxide emissions thereby adding a gypsum byproduct
- A divider dike was constructed to divide Ash Disposal Area No. 2 into the Retention Pond and Dry Ash Stack for the placement of dry ash
- TVA began dry fly ash stacking in the Dry Ash Stack
- Ash Disposal Area No. 1 was redeveloped as the Gypsum Storage Area for stacking wet gypsum
- A perimeter ditch was constructed between the initial and raised sections of the perimeter dike to direct drainage from the Gypsum Storage Area to the Stilling Pond (including Retention Pond)
- The Bottom Ash Pond was constructed. Bottom ash was then sluiced to this pond and settled bottom ash was excavated, trucked, and placed in the Dry Ash Stack

In 2009, TVA's board of directors passed a resolution to phase out wet storage coal byproduct facilities and convert them to dry storage facilities (TVA 2021a). As a result, continuous operation of a new gypsum dewatering plant (shown on Exhibit 2-1) began and the pool on top of the Gypsum Storage Area was eliminated in 2009. Dry stacking of gypsum at the Gypsum Storage Area began.

In 2011, Stilling Pond spillway improvements occurred including the construction of an emergency spillway and the installation of siphons. In 2012, lined settling channels were constructed at the Gypsum Storage Area to reduce infiltration into the unit. Drainage and grading improvements occurred at both the Dry Ash Stack and Gypsum Storage Area in 2012 to increase the slope stability factor of safety for both CCR management units. In 2016, the siphon at the Gypsum Storage Area was replaced with a gravity drain and TVA completed downstream improvements to the Bottom Ash Pond discharge channel, including pipe replacement.

TVA proposed harvesting CCR material from the Gypsum Storage Area for processing and beneficial use applications to reduce the overall height and facilitate planned capital drainage improvements prior to closure in the Gypsum Operations Plan (Revision 0; Stantec 2020a). TDEC approved TVA's request to adjust operations at the Gypsum Storage Area as a minor modification to permit number IDL 81-102-0086 on February 21, 2020 (TDEC 2020a; Appendix A.2). Beneficial use of gypsum at the Gypsum Storage Area is underway.

As part of TVA's conversion to dry storage facilities, several projects are underway in the Stilling Pond (including Retention Pond). A Temporary Lined Basin was commissioned in June 2020 to temporarily treat plant process flows and landfill stormwater flows during repurposing of the Stilling Pond (including Retention Pond). Repurposing of the Stilling Pond (including Retention Pond) to lined process water basins started in November 2020. TVA submitted the Source Removal Construction Quality Assurance Plan (SRCQAP) Revision 1, which addresses the removal of CCR material from the Stilling Pond (including Retention Pond), to TDEC for review on February 10, 2021. TDEC found the SRCQAP acceptable with conditions (TDEC 2021; Appendix A.2). TDEC’s comments were addressed in SRCQAP Revision 2 (Stantec 2021a). Decanting of the Stilling Pond and Retention Pond pools has been completed. Source removal and repurposing activities have been completed. To facilitate safe construction, additional pumping activities were conducted. The first permanent process water basin was completed in March 2023. The Bottom Ash Dewatering Facility and gypsum wastewater treatment systems were commissioned in February 2021 and May 2021, respectively. TVA monitored the pore water and groundwater pressures during pumping activities. An evaluation of the effect of pumping on pore water and groundwater levels is presented in Appendix H.1.

In addition, other recent improvements have been made at the Dry Ash Stack to enhance the operation of the CCR management units. The improvements include the construction of a rock buttress to improve slope stability, construction of a new ramp to the top of stack from the west side, installation of a system of headwalls, catch basins and buried pipes to convey stormwater flows to the Stilling Pond, and the widening of the perimeter haul road making the road suitable for large articulated-truck traffic. As part of TVA's best management practices, portions of the top of the stack have been covered with temporary soil cover and vegetated.

The operations of the Gypsum Storage Area were improved by lining the perimeter drainage ditches, constructing all-weather gravel access roads around the exterior toe and actively managing the dry stacking and harvesting operations to provide positive drainage across the top of the stack.

Flows to the Bottom Ash Pond were ceased by April 2021. Stormwater flows from the Gypsum Storage Area were captured into a system of headwalls, catch basins and buried pipes traversing the Bottom Ash Pond. Once the new pipe system was installed, the Bottom Ash Pond was regraded to drain to the new catch basin, covered with temporary soil cover and vegetated.

2.3 Ownership and Surrounding Land Use

The CUF Plant is owned and operated by TVA, a corporate agency of the United States, and is located at the confluence of Wells Creek and the south bank of the Cumberland River (Lake Barkley), as shown on Exhibit 2-1.

Land use surrounding the CUF Plant is primarily undeveloped, and includes forest, agriculture areas, and rural residential with the nearest residence located approximately 0.3 miles east of the CUF Plant in Cumberland City. Additionally, three municipal water departments withdraw water from the Cumberland River for municipal purposes in the vicinity of the CUF Plant, as follows (TVA 2020a).

- The Dover Water Department treatment plant withdraws its drinking water from the Cumberland River and is located approximately 14.4 miles downstream of the CUF Plant
- The North Stewart Utility District withdraws its water from the Brandon Spring, which is within the Cumberland River, and is located approximately 20 miles downstream of the CUF Plant
- The City of Erin Water Department provides potable water to Cumberland City and withdraws water from the Cumberland River at its confluence with Yellow Creek approximately 3.7 miles northeast (upstream) of the CUF Plant.

2.4 Physical Characteristics

2.4.1 Regional and Site Physiography

The CUF Plant is located within the Interior Low Plateaus physiographic province of the Interior Plains physiographic division (National Park Service 2021).

The Interior Low Plateaus province landscape includes rolling limestone plains punctuated with regions of rugged hills with areas of swampy alluvial valleys, deeply entrenched rivers and streams, and expansive karst plains (LandScope America 2021).

The CUF Plant is located within the western side of the Highland Rim section, which is characterized by rolling terrain dissected by sharply incised valleys with numerous streams (Fenneman 1938). Major drainages are the Duck and Buffalo Rivers (tributaries of the Tennessee River), and the west flowing Cumberland River. The elevation ranges from 360 to 650 feet above mean sea level (ft amsl) in the vicinity of the CUF Plant. Exhibit 2-3 overlays the footprints of CCR management units on the 1931 USGS topographic map for the CUF Plant.

As will be discussed in more detail in the next section, the CUF Plant is located within a basin that is believed to have been created by a meteor impact. The following exhibit shows the physiographic setting of the plant within the central part of the meteor impact feature. The key characteristic of the setting is that the plant is situated in the low point of the basin surrounded by the higher elevation inner rim of the meteor crater. Groundwater within the basin moves toward Wells Creek. This limits the potential for effects of CCR management to move outside of the basin by the flow of groundwater.

CUF Physiographic Setting

2.4.2 Regional Geology, Hydrogeology and Surface Water Hydrology

The geology, hydrogeology and surface water hydrology of the Wells Creek Basin are related to each other because of an event that occurred millions of years ago. According to a 1968 study, *Geology of the Wells Creek Structure, Tennessee, Bulletin 68, Tennessee Division of Geology* (Bulletin 68) (Wilson and Sterns 1968), the preferred explanation for the geologic characteristics of the Wells Creek Basin is a meteor impact, referred to as the Wells Creek Structure. The Wells Creek Structure is approximately eight miles in diameter and consists of a series of roughly circular concentric faults surrounding a topographically low area with a central hill. The low area has been named the Wells Creek Basin, within which the CUF Plant is located. In addition to the circular faults, radial faults emanate from the center of the basin.

2.4.2.1 Geology

The geology of the Highland Rim section, in which the Wells Creek Structure is located, consists of relatively intact flat-lying geologic formations, but the bedrock formations within the basin are fractured and inclined at various angles. In some cases, the original beds are oriented vertically. In addition, the bedrock formations within the basin are much older than those first encountered in the undisturbed area surrounding the structure. The bedrock stratigraphy ranges from the Knox Dolomite in the central portion of the structure to the Paint Creek Limestone in the outer portion of the structure. According to Bulletin 68 (Wilson and Sterns 1968), the meteor impact brought older geologic formations that are found at a depth of approximately 2,500 feet in the surrounding Highland Rim section to the current ground surface in the center of the Wells Creek Basin. Away from the center of the structure, there are a series of concentric circular faults that bound inner and outer rings where geological formations have dropped approximately 250 and 200 feet, respectively, in relation to the elevations of the same formations in the undisturbed area around the Wells Creek Structure. The downthrown rings are called grabens. The intervening ring between the grabens that was not downthrown is called a horst. The volume of the rock downthrown in the two grabens has been determined to be approximately equal to the volume of rock uplifted within the center of the basin (Wilson and Sterns 1968). A map showing the regional geologic units in proximity to the CUF Plant is provided on Exhibit 2-4. Exhibit 2-4 also includes a cross section through the Wells Creek Structure. The uplift of the Knox Dolomite is shown in the center along with the flat-lying geological formations of the Highland Rim section on either side of the structure. The arrows on either side of the faults show the relative direction of movement of the geological formations. The displacement of the geological formations across the faults shows the lower elevations of them within the grabens.

The Wells Creek Basin is approximately two miles in diameter and approximately 200 to 300 feet lower in elevation than the surrounding area because the reconsolidated rock has been eroded more than rock surrounding the basin. Flood plain deposits from the Cumberland River consisting of clay, silt, and sand ranging in thickness from 0 to 90 feet overlie bedrock (Wilson and Sterns 1968). Where alluvium is absent, residuum derived from the weathering of bedrock overlies bedrock. The site-specific geology of the CUF Plant is discussed in Chapter 5.

2.4.2.2 Surface Water Hydrology

The most prominent regional surface water drainage feature in proximity to the CUF Plant is the west-flowing Cumberland River (Exhibit 2-1). The Cumberland River is regulated by eight dams upstream of the CUF Plant. Under normal conditions, the Cumberland River flow in the vicinity of the CUF Plant depends primarily upon releases from the United States Army Corps of Engineers' (USACE) Cheatham Dam approximately 46 miles upstream, and to a lesser extent by downstream releases from Barkley Dam and tributary inflows upstream of the CUF Plant.

Within the Wells Creek Basin, Wells Creek (Exhibit 2-1) flows north through the basin and discharges into the Cumberland River near the northwest corner of the CCR management units. Prior to construction of the CUF Plant, Wells Creek followed a meandering course through the CUF Plant footprint (Exhibits 2-3, 2-4 and 2-5); however, during CUF Plant construction circa 1968, most of the Wells Creek stream channel was relocated west of the initial CCR management unit perimeter dike, as shown on Exhibit 2-5.

Exhibit 2-6 provides an overlay of faults and fractures within the Wells Creek Basin on a map that shows the topography of the basin. The faults and fractures were mapped as part of the work conducted for Bulletin 68 (Wilson and Sterns 1968). Wells Creek and its tributaries align with the fractures in most cases indicating that surface streams have formed where they have because of the presence of faults and fractures. This network of surface streams flows into Wells Creek.

Additionally, on the east side of the CUF Plant CCR management units an "unnamed tributary" to Wells Creek (herein referred to as the 'Unnamed Tributary') separates the Gypsum Storage Area from the Georgia-Pacific wallboard plant property. The Unnamed Tributary appears to be a man-made feature rather than a natural stream, and as such, there is some uncertainty about past industrial operations in this area. It is a series of three impounded areas (Ponds 1, 2, 3a and 3b) along the eastern and southern boundaries of the Gypsum Storage Area that flow into Wells Creek, as shown on Exhibit 2-5.

2.4.2.3 Regional Hydrogeology

The Interior Low Plateaus province is underlain by limestone bedrock aquifers known as the Highland Rim aquifer system (USGS 1995). On a regional level, the Highland Rim aquifer system is characterized by bedrock that is either flat lying or gently dipping in most places. The bedrock is covered by unconsolidated materials (alluvium or residuum). The alluvium and residuum can store large quantities of groundwater that subsequently percolate slowly downward to recharge the bedrock aquifers. Groundwater generally flows much more slowly than in surface stream or river water.

Within the Wells Creek Basin, the limestone aquifers do not exist because the meteor impact changed the geology within the basin. There is no continuous geologic formation that is defined as an aquifer, but sand and gravel layers within the alluvium and, where the sand and gravel layers are absent, bedrock have been defined as an aquifer or developed as a source of water. A summary of the hydrogeological characterization of the CUF Plant in the vicinity of the CCR management units is presented in Chapter 5. More detailed discussion of the uppermost aquifer beneath the CCR management units is provided in Appendix H.1.

2.4.3 Local Climate

Locally near the CUF Plant, the average monthly high temperature at weather station USW00003894, Clarksville Outlaw Airport, Tennessee (National Oceanic & Atmospheric Administration [NOAA] 2021) located approximately 20 miles northeast of the CUF Plant, ranges between 45.4 degrees Fahrenheit (°F) in January to 89.1°F in July, and the average monthly low ranges between 26.1°F in January to 67.2°F in July. Average annual precipitation at this location is 50.18 inches, with May being the wettest month, averaging 5.60 inches, and August being the driest month, averaging 3.11 inches.

2.4.4 Cultural and Historical Resources

Since the late seventeenth century, the Cumberland River has served as a vital resource and transportation corridor for European and Euro-American settlement, development, and commerce in Tennessee and the surrounding region (Deter-Wolf, A and Peres, T. M. 2012). However, the history of human activity along the Cumberland River began long before European exploration west of the Appalachians, or proto-historic settlement of the region by the Shawnee, Cherokee, Creek and Chickasaw. Consistent human occupation and reuse of natural levees and adjacent terrace landforms since the late Pleistocene has resulted in the formation of numerous deeply buried, stratified, multicomponent archaeological sites. The density of prehistoric settlement along the Cumberland River and its tributaries is particularly notable within the Middle Cumberland River valley in Tennessee, where archaeological evidence has revealed that initial human occupations occurred by at least 12,100 calendar years before present.

TVA conducted environmental reviews during the planning phase of the EI to comply with the National Environmental Policy Act (NEPA). These reviews included an assessment through the NEPA categorical exclusion process of whether proposed activities, such as drilling soil borings and installing monitoring wells, would impact cultural and historical resources, natural resources, parks, recreation or refuge lands, wilderness areas, natural landmarks, wetlands and floodplains, and other ecological significant or critical areas. No issues were identified during this process. Therefore, additional measures to minimize or avoid adverse environmental impacts were not needed.

Chapter 3 Background Soil Investigation

Constituents in CCR materials are also present in naturally occurring soil. To evaluate potential contributions of CCR Parameters in naturally occurring soil to other environmental media, such as surface water or groundwater, TVA reviewed information from historical studies and completed a background soil investigation as part of the EI. EI field activities were performed in general accordance with the following documents: *Background Soil SAP* (Stantec 2018a), *Hydrogeological Investigation SAP* (Stantec 2018b), and the *QAPP* (EnvStds 2018a) including TVA- and TDEC-approved programmatic and project-specific changes made after approval of the EIP.

The following sections summarize historical studies and EI activities and present overall investigation and statistical evaluation findings for background soils based on data obtained during the EI. Additional information regarding the background soil statistical analyses and EI field activities are provided in Appendices E.1 and F.1, respectively.

3.1 Previous Studies and Assessments

As part of the development of the EIP, historical background soil data were reviewed to evaluate the need for additional data. In 2016, saturated soil samples were collected from within the screened interval of two background monitoring wells, CUF-201 and CUF-202, and analyzed for naturally occurring metals and other constituents (Stantec 2017). The analytical suite included many CCR Parameters; however, sulfate, boron and radium were not analyzed in soils collected at one or both wells as these parameters predate the defined objectives of the EI. These historical data were reviewed in conjunction with the background soils data collected for the EI described in Chapter 3.4 below.

3.2 TDEC Order Investigation Activities

The objective of the TDEC Order background soil investigation was to characterize background soils on TVA property near the CUF Plant CCR management units by sampling locations where naturally occurring, in-place, native soils are present and unaffected by CCR material. A total of 78 samples were collected from 20 background soil boring locations and from within the screened interval of three background well boring locations. For the background soil borings, the sampling team typically collected approximately two-foot grab samples from the mid-point of each five-foot soil run based on recovery. These sampling locations are depicted on Exhibit 3-1.

Background soil borings were advanced and sampled using a direct push technology rig. Background well borings were advanced and sampled using a hollow stem auger drill rig. The average depth of the borings was approximately 13 feet below ground surface. Samples were analyzed for CCR Parameters. Surficial soil samples were collected from each background soil boring location and analyzed for the presence of ash (% ash) to evaluate the presence or absence of CCR material. Soil samples were also tested for pH in the field.

3.3 Lithology

Boring logs for the background soil borings and background monitoring well borings are provided in Appendix B.1. Review of the background soil boring logs, the Geologic Map of the Wells Creek Area, Tennessee (Tennessee Division of Geology, Bulletin 68, Plate 1), 1968, and the Geologic Map of Wells Creek Basin (Tennessee Division of Geology, Bulletin 68, Plate 2), 1968 (Wilson and Sterns 1968) indicated that the borings and monitoring wells were installed in nine different geologic units. These units and the associated borings are summarized in Table 3-1.

3.4 Background Soil Investigation Results Summary

The EI background soils data were reviewed and evaluated to support the source removal construction project that addresses removal of CCR material from the Stilling Pond (including Retention Pond) and are presented in a report prepared by Haley & Aldrich, Inc. (2021), included as Attachment C of the *SRCQAP Revision 2* report (Stantec 2021a). To support this project, background threshold values (BTVs) were developed following a statistical evaluation and have been accepted by TDEC (TDEC 2021; Appendix A.2). A summary of the evaluation performed to develop BTVs is presented below. The background soils data, resulting summary statistics, and calculated BTVs are presented in Appendix E.1. One soil sample was excluded from the statistical evaluation because it was collected from a saturated interval and two samples were excluded because they were collected from non-native materials.

The background soils data collected from unsaturated intervals in native soils were statistically evaluated for potential outliers and anomalous data and overall data variability. The concentrations of metals observed across background soil sampling locations were highly variable and multiple potential outliers were identified and flagged in the dataset. However, given the complex geology at the CUF Plant and heterogeneity of naturally occurring inorganic compounds in soils, statistical outliers were not removed prior to statistical analysis. The highest background soil concentrations observed at the CUF Plant were generally not observed in the surficial soils, but deeper in the borings suggesting that observed concentrations are representative of background conditions.

BTVs are estimates of constituent concentrations in samples collected from unimpacted naturally occurring soils. Specifically, 95% one-sided upper tolerance limits (UTLs) with 95% coverage (95% UTLs) were used to calculate BTVs, representing that there is a 95% confidence on average that 95% of the data are below the UTL and no more than 5% of the data are expected to exceed the UTL. The 95% UTLs calculated for each CCR Parameter were used to establish estimates of background soil concentrations near the CUF Plant CCR management units. The BTVs and the statistical distribution and methods used to calculate the UTLs are identified for each CCR Parameter for depths combined in Appendix E.1, Table 2 – Background Soil Data Statistical Evaluation. BTVs and statistics were calculated using ProUCL v. 5.1.002.

CCR Parameter BTV concentrations in naturally occurring soils in the vicinity of the CUF Plant have been characterized and are available if needed for other future evaluations in the CARA Plan.

Chapter 4 CCR Material Investigations

To evaluate the extent, structural stability, characteristics, and quantities of CCR material in the management units, TVA reviewed information from historical studies, and performed investigations as part of the EI. EI field activities were performed in general accordance with the following documents: *Exploratory Drilling (EXD) SAP* (Stantec 2018c), *CCR Material Characteristics SAP* (Stantec 2018d), *Material Quantity SAP* (Stantec 2018e), and the *QAPP* (EnvStds 2018a), including TVA- and TDEC-approved programmatic and project-specific changes that were made after approval of the EIP. Field work included drilling 24 borings, installing four piezometers, installing six temporary wells, collecting 110 CCR material samples and six pore water samples, and performing surface and downhole geophysics.

The following sections summarize the geotechnical stability evaluation findings, CCR material characteristic results, and CCR material quantity estimates based on the data obtained during previous investigations and the EI at the CCR management units at the CUF Plant. Additional details regarding these investigations are provided in Appendix G.

4.1 Geotechnical Investigation

The purpose of the geotechnical investigation component of the EI was to further characterize and evaluate subsurface conditions for three CCR management units at the CUF Plant, including the Stilling Pond (including Retention Pond), Dry Ash Stack and Gypsum Storage Area. For this investigation, TVA reviewed information from previous representative studies and assessments, completed an exploratory drilling field program, and conducted evaluations for slope stability, structural integrity and structural stability (bedrock).

The following sections summarize the previous studies and present overall geotechnical investigation and evaluation findings based on data obtained during previous studies and the EI for the CUF Plant CCR management units.

4.1.1 Exploratory Drilling

4.1.1.1 Previous Representative Studies and Assessments

Through the various information requests, as well as TDEC comments on the EIP, a need was identified for an evaluation of existing geotechnical data (borings, piezometric data, laboratory data, material parameters, analyses, etc.). The Evaluation of Existing Geotechnical Data (Appendix F of the EIP) was prepared to review the existing data and evaluate its adequacy with respect to responding to the various TDEC information requests. Additionally, since the EIP was approved in 2018, several additional (i.e., non-TDEC Order) explorations have been performed at the CUF Plant CCR management units, and these data have been evaluated for the EAR. Evaluating the adequacy of existing data, in accordance with the QAPP, depends on both the type of data and its intended use. Where applicable, existing geotechnical data were used to support the subjects addressed throughout the EAR.

4.1.1.2 TDEC Order Investigation Activities

The primary objective of the EXD was to perform borings, install temporary wells, install piezometers, and perform surface and downhole geophysics to further characterize subsurface conditions at the CUF Plant CCR management units. The EXD SAP included activities at three CCR management units: Dry Ash Stack, Gypsum Storage Area, and Stilling Pond (including Retention Pond).

Boring, cone penetration testing and surface geophysical survey layouts are shown on Exhibits 4-1 and 4-2. For additional details on the EXD activities, refer to Appendices G.1 and G.2 (Technical Evaluation of Geotechnical Data and the CUF EXD SAR, respectively).

4.1.1.3 Results and Discussion

At each boring location, the uppermost foundation soil was predominantly lean to fat clay, with single occurrences of clayey gravel, clayey sand, or silt. This is generally consistent with historical borings across the CUF Plant.

The *Evaluation of Existing Geotechnical Data* (Appendix F of the EIP) included a detailed discussion of historical information about the underdrain systems in the Dry Ash Stack and Gypsum Storage Area. At the Dry Ash Stack, seven EXD borings were designed to provide additional data. The underdrain system within the Dry Ash Stack was encountered where expected, except for one boring (CUF-TW09) where no obvious underdrain layer was identified. However, the materials and thickness of the underdrain were not fully consistent with the available historical information. The material in three borings was coarse-grained CCR as expected but was non-CCR gravel fill in three other borings. The underdrain layer was thinner (1.5 to 4.5 feet) than indicated in the Operations Manual (4 to 7.5 feet). The presence of a geotextile beneath the underdrain layer was not expected but was encountered in one boring.

At the Gypsum Storage Area, the underdrain system also was encountered where expected. However, the materials and thickness of the underdrain were not fully consistent with the available historical information. The material in all six borings was non-CCR gravel fill as expected, but geotextiles were only encountered in three of the borings and a layer of coarse sand (which was indicated in the Operations Manual) was not encountered in any of the borings. The underdrain layer was thinner (0.6 to 1.9 feet) than indicated in the Operations Manual (at least 2.5 feet).

These findings do not imply that the Dry Ash Stack and/or Gypsum Storage Area underdrain layers are deficient. When assessing the performance of the underdrain layers, it is more informative to consider how pore water is transmitted through or along the layers. Refer to Appendix G.1 for multiple lines of evidence to demonstrate how the underdrain layers influence pore water movement. As it relates to static and seismic slope stability of the Dry Ash Stack and Gypsum Storage Area, it is important to note that the actual construction of and actual performance of the underdrain systems are accounted for in the stability analyses presented in Chapter 4.1.2. Also, the actual pore pressures, as measured by TVA's instrumentation, are accounted for in the stability analyses.

At the Gypsum Storage Area, three shallower temporary wells were planned to be screened in gypsum, just above the underdrain. The purpose was to allow for pore water sampling within the gypsum. However, upon reaching the planned termination criteria, water levels in these borings were found to have insufficient depth of water to facilitate pore water sampling. Therefore, temporary wells were not installed in these three borings.

In the two perimeter areas of pre-construction channels of Wells Creek and in an area of historical grouting, the geophysical anomalies targeted by TVA and TDEC were successfully explored with supplemental borings. Based on historical information and the results of surface geophysics and borings, no significant preferential seepage pathways were identified beneath the perimeter dike system.

4.1.2 Slope Stability

The load cases evaluated in the stability analyses are based on conventional practice and appropriate industry standards for landfills and surface water impoundments, as applicable, and are noted below:

- Static, long-term (i.e., normal operation conditions) global stability
- Static, long-term veneer (i.e., final cover) stability
- Seismic, pseudostatic global stability
- Seismic, pseudostatic veneer stability
- Seismic, post-earthquake global stability (includes a preceding liquefaction triggering assessment).

As described in the CUF Plant EIP, including the *Evaluation of Existing Geotechnical Data* (EIP Appendix F), the existing data are sufficient to establish appropriate shear strengths and stability results for static and seismic load cases. The summaries of existing geotechnical data (plus additional analyses completed after the EIP was approved) demonstrate that existing data are representative and suitable to support the stability analyses. The additional analyses include updated seismic global stability analyses (Geocomp 2023; provided for reference as Attachment G.1-A) for the Dry Ash Stack and Gypsum Storage Area. For the CUF EIP, a Stability SAP was not necessary because no new analyses were required within the scope of the EIP.

4.1.2.1 Results and Discussion

The static and seismic stability results for the CUF Plant CCR management units are summarized and compared to criteria in Appendix G.1. This included updated analyses to quantify the improvements in seismic global stability for the Gypsum Storage Area due to recent surface water management improvements (lining perimeter ditches to reduce infiltration, regrading on top of the stack to promote positive drainage) and future targeted gypsum harvesting in critical areas. This targeted harvesting includes cutting back (i.e., flattening) the outslope of the uppermost perimeter dike, Dike 3 (Geocomp 2023; Attachment G.1-A). As stated in Geocomp (2023): “At [Gypsum Storage Area] after the completion of the proposed regrading of Dike 3 and improved pore water pressure conditions, the resulting factors of safety for global stability meet or exceed all required minimum values.” The global stability and the veneer stability for each analyzed section meet the established factor of safety criteria for the static and seismic load cases.

For purposes of the EAR, TVA and TDEC agreed that the referenced historical analyses are adequate, knowing that future additional analyses will be performed when closure design is defined. Given that the closure configurations have yet to be determined, TVA and TDEC agreed not to address these cases in the EAR but to defer the evaluations until the CARA Plan or the closure design. The closure design would meet the same slope stability acceptance criteria applied for the TDEC Order.

4.1.3 Structural Integrity

“Structural integrity” considers structural potential failure modes that could lead to a release of CCR material, other than those evaluated for slope stability and structural stability of bedrock.

For the CUF Plant CCR management units, the EIP summarized historical reports that would be leveraged to address structural integrity. After the EIP was approved by TDEC, several recent design and construction projects at the CUF Plant also provided information regarding structural integrity, and those are referenced in Appendix G.1. There was no SAP specifically required under the TDEC Order program to address this subject.

4.1.3.1 Results and Discussion

Based on the historical reports and recent design and construction projects at the CUF Plant no significant deficiencies were identified with respect to structural integrity of the CCR management units. In addition, TVA further promotes structural integrity of the CCR management units by performing routine inspections and other compliance activities, in accordance with TVA policies, state regulations and federal regulations.

4.1.4 Structural Stability (Bedrock)

“Structural stability (bedrock)” considers stability of bedrock below fill areas—that is, evaluation of the bedrock with respect to voids/cavities and faults/joints of significant lateral or vertical extent that could be large enough to lead to loss of structural support and potential release of the overlying CCR material.

For the CUF Plant CCR management units, the EIP, including the *Evaluation of Existing Geotechnical Data* (EIP Appendix F), summarized historical reports that would be leveraged to address structural stability of the bedrock. In addition, the EXD SAR includes new information specifically required under the TDEC Order program to address this subject.

4.1.4.1 Results and Discussion

As part of the EXD field activities, two geotechnical borings were advanced at the southeastern perimeter of the Gypsum Storage Area where previous surface geophysics had identified a potential bedrock discontinuity. Based on the similarities in the bedrock of these two borings, there does not appear to be a significant discontinuity in bedrock between the two borings.

Given the geologic setting of the CUF Plant within the Wells Creek Structure, the bedrock beneath the CCR management units is highly variable with respect to top of rock elevations, fractured and brecciated rock, and soil-filled features between large rock blocks/boulders. Limestone and dolomite that can be subject to solutioning underlie much of the CCR management unit footprints. However, based upon the CUF Plant-specific geologic mapping, rock core borings, surface geophysics, and CCR management unit operational performance, there is no evidence of voids/cavities that could lead to loss of structural support and potential release of the overlying CCR material. While there are a small number of borings that encountered voids, the vertical and lateral extents of such features appear to be localized. This conclusion is based on a review of the available data, overall understanding of the geologic setting, CCR management unit operational performance, and professional engineering judgement.

Regarding vertical and lateral extents of voids being localized, this is based upon the site-specific geologic mapping, rock core borings (i.e., lack of vertical/horizontal continuity of voids across adjacent borings), surface geophysics, and CCR management unit performance. Regarding operational performance, TVA performs quarterly site inspections to look for signs of tension cracking, settlement, depressions, erosion, and/or deformations at the crest, slope and toe of the perimeter dikes. TVA also performs formal (five-year) inspections that include document reviews for evaluation of unit design and construction, operations and maintenance, instrumentation, potential failure modes, and historical inspection reports. The formal inspection report also documents a field inspection, which includes general conditions, interior slopes, exterior slopes, dike crests, and outlets. Finally, there are no records of treatment for karstic conditions since the CCR management units were constructed.

4.2 CCR Material Characteristics

TVA reviewed information from historical studies and completed a CCR material characteristics investigation as part of the EI to characterize leachability of CCR constituents within three CCR management units at the CUF Plant: Dry Ash Stack, Gypsum Storage Area, and Stilling Pond (including Retention Pond). EI field activities were performed in general accordance with the following documents: *CCR Material Characteristics SAP* (Stantec 2018d), *Exploratory Drilling (EXD) SAP* (Stantec 2018c), and the *QAPP* (EnvStds 2018a), including TVA- and TDEC-approved programmatic and project-specific changes made after approval of the EIP.

The following sections summarize historical studies and EI CCR material characterization activities, and present overall investigation and statistical evaluation findings. Additional information regarding the CCR material and pore water statistical analyses and the investigation are provided in Appendix E.2 and G.3, respectively. Further evaluation of the CCR material and pore water results is provided in Appendix G.1. Additional evaluation in context of the hydrogeologic conditions at the CUF Plant is provided in Chapter 5.1 and Appendix H.1.

4.2.1 Previous Studies and Assessments

In 2012, 2013, and 2016, TVA conducted chemical characterization studies of the CCR material produced by operations at the CUF Plant (AECOM 2016). CCR material samples were collected and tested for physical and chemical characteristics, including leachability and total metals. The collected samples included dry fly ash, bottom ash, gypsum, and gypsum fines.

The historical studies did not include collecting CCR management unit pore water. Therefore, a more comprehensive investigation was conducted as part of the EI which included collection and analyses of pore water, as summarized in Chapter 4.2.2.

4.2.2 TDEC Order Investigation Activities

The objective of the TDEC Order CCR material characteristics investigation was to characterize the leachability of CCR Parameters by collecting pore water and CCR material samples (saturated and unsaturated) from within the Gypsum Storage Area, the Dry Ash Stack, and the Stilling Pond (including Retention Pond). 110 CCR material samples were collected from nine temporary well borings and 10 retained geotechnical borings. These were analyzed for CCR Parameters (defined in Chapter 1.3) and additional parameters of interest for the CCR material characteristics investigation. The additional parameters of interest and analyses included total organic carbon (TOC), iron and manganese. TVA also performed Synthetic Precipitation Leaching Procedure (SPLP) analyses for metals and radiological parameters. During sampling, CCR material present at each boring was visually characterized using the Unified Soil Classification System, which classifies material by grain size distribution followed by the material’s textural properties.

Following temporary well installation and development, pore water levels were measured prior to sampling, hydraulic conductivity testing was performed, and pore water samples were collected from each well. The temporary well locations are depicted on Exhibit 4-3.

4.2.3 CCR Material Characteristics Evaluation

This section presents a summary of the evaluation of the CCR material and pore water analytical results to assess the presence of constituents in and their susceptibility to leach from CCR material. In addition, SPLP analysis of CCR material was conducted to assess whether SPLP can be used to predict pore water concentrations.

4.2.3.1 Statistical Evaluation Summary

Statistical evaluations were conducted to evaluate whether the total concentrations of metals in CCR material could be used as a reliable predictor of leachable concentrations as represented by SPLP concentrations. The evaluations included comparison of total metals concentrations in CCR material to SPLP concentrations. The results indicated that the total concentrations of metals in CCR material are not a reliable predictor of the magnitude of the potentially leached concentrations using SPLP. Additional discussion of the evaluations is provided in Appendices E.2 and G.1.

TVA also compared pore water results to SPLP results for the CCR material to evaluate whether SPLP could be used as a predictor of pore water concentrations. CCR constituent concentrations were generally higher in pore water samples than in SPLP results. These findings indicate that SPLP analysis of CCR material is not a good predictor of pore water concentrations. The results indicate that direct measurement of pore water concentrations is the most accurate method of characterizing potential leachability of CCR constituents from CCR material. Additional discussion of the evaluations is provided in Appendices E.2 and G.1.

4.2.3.2 Pore Water Phreatic Surface

TVA measured pore water levels in the temporary wells on a monthly frequency for six months. In addition, the wells were gauged during bi-monthly groundwater sampling events. This information was combined with available information from other instruments to develop phreatic surface maps for the Dry Ash Stack and Gypsum Storage Area. The phreatic surface is the surface of pore water at which pressure is atmospheric and below which CCR material may be saturated with pore water. The use of the term “saturated” or references to the moisture content of CCR material does not imply that the pore water is readily separable from the CCR material. Saturated CCR material can have a range of moisture contents based on the characteristics of the material. A representative map developed for gauging information from EI Groundwater Sampling Event #2 (July 2019) is shown in Exhibit 4-4. Table G.1-4 (Appendix G.1) provides a summary of the pore water gauging data from EI Groundwater Sampling Event #2. The data for other gauging events can be found in Appendices H.3, H.5, H.6, H.7, and H.8. Normal pool elevations for the Stilling Pond (including Retention Pond) are provided on Exhibit D-3.

The pore water levels reported herein may not represent long-term conditions or correspond to a closed condition if the CCR management units were to be closed with CCR material in place, nor do they reflect recent pumping activities to facilitate safe construction as part of Stilling Pond (including Retention Pond) repurposing, or other recent operational changes near the CCR management units. The phreatic surface would be expected to decrease in elevation after improving storm water drainage or capping of CCR management units if the units were to be closed with CCR material in place.

4.2.3.3 Pore Water Quality Evaluation

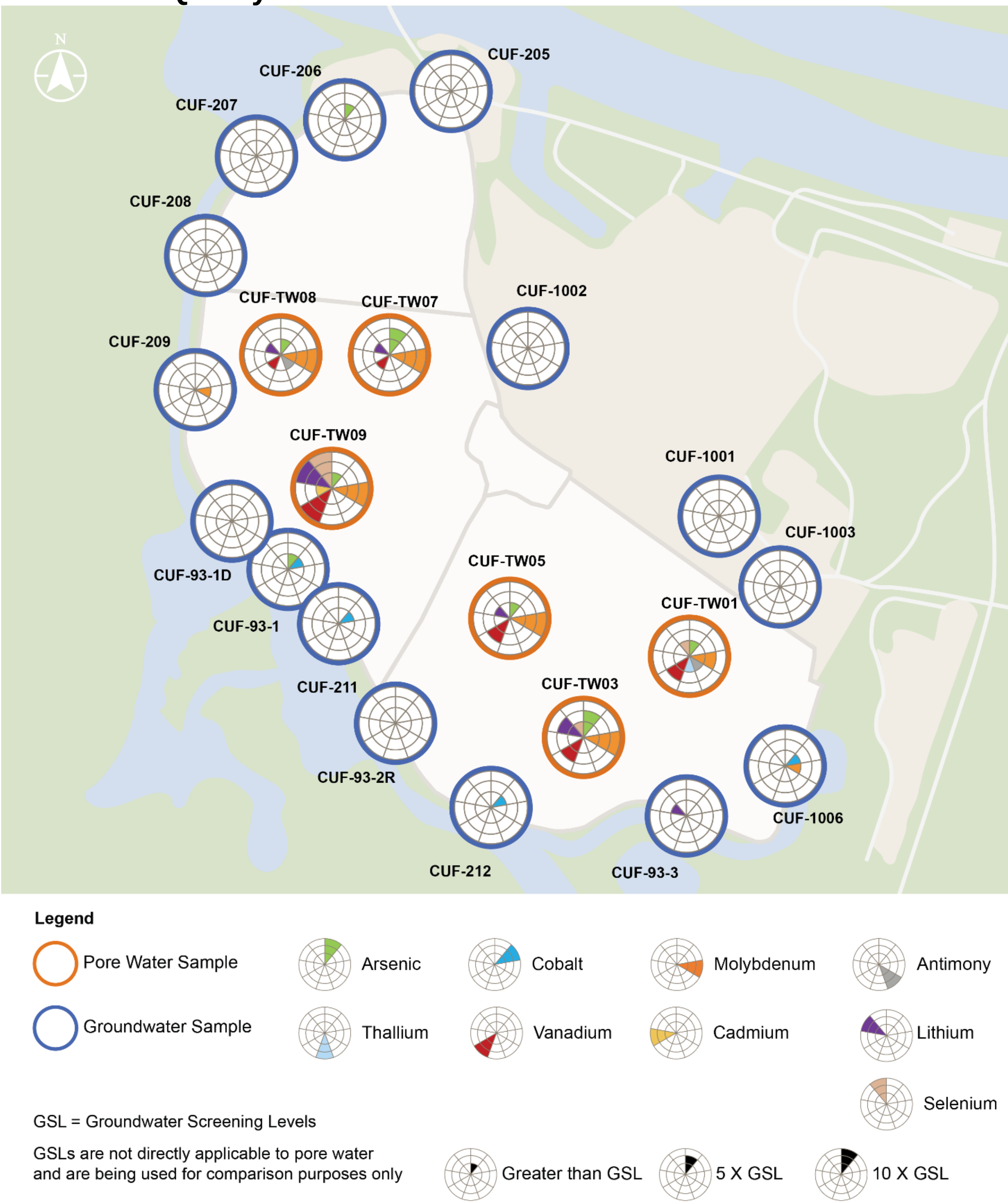
This section provides a summary of the analytical results for pore water samples collected from temporary wells installed as part of the EI. The pore water quality evaluation is based on an evaluation of constituents listed in Appendix I of TDEC

Rule 0400-11-01-.04 (TDEC Appendix I) and Appendices III and IV of the CCR Rule. Pore water samples were collected during three sampling events. The first sampling event was conducted as part of the EI in June 2019. The second and third sampling events were conducted as part of other investigative activities in March 2021 and April 2021.

The pore water characterization evaluation is based on a comparison of pore water concentrations to groundwater concentrations and GSLs across the CUF Plant. GSLs are not applicable to pore water. The comparison to GSLs provides a basis to identify CCR constituents that have the potential to be detected in groundwater downgradient of the CCR management units at concentrations above a GSL if pore water were to impact groundwater. Comparison of pore water to GSLs was conducted for constituents listed in Appendix I of TDEC Rule 0400-11-01-.04 (TDEC Appendix I) and Appendix IV of the CCR Rule because these are the constituents that would require corrective measures to remediate groundwater.

Eight CCR Rule Appendix IV or TDEC Appendix I constituents had reported concentrations in pore water above a GSL. Of these, four constituents had statistically significant concentrations in groundwater above a GSL. Generally, suspended solids did not materially affect reported concentrations for total metal analyses. The figure below provides a summary of reported pore water analytical results and a comparison of them to reported groundwater analytical results. The locations of temporary pore water wells are shown as symbols with an orange outer ring. The colored slices in each symbol indicate CCR constituents detected in pore water above a GSL in each temporary pore water well. The number of colored sections within each slice represents the magnitude of the reported concentrations relative to the GSL. The legend on the exhibit provides further explanation of the colors and sections.

Pore Water Quality



Groundwater monitoring wells are represented by symbols with a blue outer ring. The seven groundwater monitoring wells that had statistically significant concentrations above a GSL are represented by colored slices in the symbols. The colors and number of colored sections have the same meanings as for the pore water symbols discussed above. Many constituents detected above a GSL in pore water samples were below the applicable GSLs in groundwater samples. There is a distinct difference between pore water and groundwater quality.

4.2.4 CCR Material Characteristics Summary

The CCR material and pore water data collected during the EI are evaluated, along with historical data and data collected from other programs.

The following are the key findings of the CUF Plant CCR material characteristics investigation:

- The total concentrations of metals in CCR material are not reliable predictors of the magnitude of the potentially leached concentrations represented by SPLP results, and SPLP analysis was not a good predictor of pore water concentrations. The results indicate that direct measurement of pore water concentrations is the most accurate way of characterizing potential leachability of CCR constituents from CCR material.
- Pore water levels reported herein may not represent long-term conditions or correspond to a closed condition if the CCR management units were to be closed with CCR material in place. The phreatic surface would be expected to decrease in elevation after improving storm water drainage or capping of CCR management units if the units were to be closed with CCR material in place.
- Within the Gypsum Storage Area CCR management units, some pore water flows laterally through the underdrain layers to the perimeter ditches and then to the Temporary Lined Basin. This may limit the elevation to which the phreatic surface rises to approximately the elevation of the underdrain layer. Below the underdrain layers, the low permeability of the perimeter dikes limits lateral flow, and the clays and silts at the base of the units impede vertical flow of pore water. The use of the term flow, or other terms such as “saturated” or references to the moisture content of CCR material, does not imply that the pore water is readily separable from the CCR material.
- There is a distinct difference between pore water and groundwater quality.

4.3 CCR Material Quantity Assessment

TVA completed a Material Quantity Assessment (MQA) to estimate CCR material quantities and other properties in support of fulfilling the requirements for the TDEC Order. MQA activities were performed in general accordance with the *Material Quantity SAP* (Stantec 2018e). The following sections summarize historical studies and EI activities, and present overall evaluation findings for material quantity based on data obtained during previous studies and the EI for the CUF CCR management units.

4.3.1 Previous Studies and Assessments

Previous material quantity assessments were completed by TriAD Environmental Consultants, Inc. (TriAD) of Nashville, Tennessee, as part of their Historical Ash Volume Calculations (TriAD 2017). The Historical Ash Volume Calculations by TriAD were completed for the Stilling Pond (including Retention Pond), Dry Ash Stack, Gypsum Storage Area, and Bottom Ash Pond. The TriAD historical ash volume calculations are provided in Appendix G.4.

4.3.2 TDEC Order Investigation Activities

The objectives of the MQA, conducted pursuant to the *Material Quantity SAP*, were to describe CCR management unit geometry, CCR material quantity, phreatic surface elevations, and subsurface conditions for the following CCR management units at the CUF Plant for the units subject to the TDEC Order: Gypsum Storage Area, Dry Ash Stack, Bottom Ash Pond, and Stilling Pond (including Retention Pond) (MQA Study Area).

Three-dimensional models of the MQA Study Area were developed using data from existing borings installed under different environmental or geotechnical programs, as well as pre-construction topographic information, historical drawings, and survey information for the MQA Study Area. The existing information was supplemented with data from borings drilled per the *EXD SAP*. For additional details regarding the development of the models, refer to the *MQA SAR* (Appendix G.5).

The three-dimensional models were analyzed using AutoDesk® AutoCAD® Civil 3D surface volumes to estimate CCR material volumes. Pore water level and pore water pressure measurements recorded in the temporary wells and piezometers per the *Material Quantity*, *CCR Material Characteristics* and *Groundwater Investigation SAPs* and summarized in Table 4-1, were compared to the three-dimensional models to estimate the quantity of CCR material below the phreatic surface in the CCR management units. Specifically, pore water level and pore water pressure measurements from Groundwater Investigation Event #3 shown on Exhibit A.3 (Appendix H.5) were used to estimate the quantity of CCR material below the phreatic surface in the Dry Ash Stack and Gypsum Storage Area. Pore water pressure measurements recorded on June 23, 2021 from temporary piezometers installed to monitor construction decanting activities were used to estimate the quantity of CCR material below the phreatic surface in the Stilling Pond (including Retention Pond).

4.3.3 Material Quantity Assessment Results

4.3.3.1 Cross Sections

Cross sections developed using the three-dimensional models are provided in Appendix D. As shown on Exhibit D-1, Section A-A’ is a cross section of the Gypsum Storage Area, Section B-B’ is a cross section of the Dry Ash Stack, Section C-C’ is a cross section of the Stilling Pond (including Retention Pond), and Section D-D’ is a cross section of the Bottom Ash Pond. The cross sections profile the CCR management units from the groundline based on 2019 and 2021 aerial surveys to below the top of rock surface.

4.3.3.2 CCR Material Limits and Thickness

Exhibit 4-5 shows estimated limits and thickness ranges of CCR material within the MQA Study Area. The CCR limits shown on Exhibit 4-5 and the cross sections (Sections A-A’, B-B’, C-C’, and D-D’) correspond to the inside crest of the starter dike. Estimated CCR material thickness ranges from 0 to 108 feet. Table 4-2 provides the range of estimated CCR material thickness and aerial extent for each CCR management unit.

4.3.3.3 CCR Material Volumes

CCR material volumes summarized in Table 4-2 were estimated using the three-dimensional models and AutoDesk® AutoCAD® Civil 3D volume surfaces. The volumes were also compared to the pore water elevation contours shown on Exhibit 4-6 to estimate the volume of CCR material below the phreatic surface. As explained in Chapter 1.3.1, the phreatic surface is the level below which CCR material is saturated with pore water. The use of the term “saturated” and/or references to the moisture content of CCR material does not imply that the pore water is readily separable from the CCR material. Saturated CCR material can have a range of moisture contents based on the characteristics of the material.

The total acreage of the CCR limits is approximately 326 acres. The estimated total volume of CCR material is approximately 25.3 million cubic yards. Approximately 43% of the estimated total volume of CCR material is below the estimated phreatic surface. Decanting of the Stilling Pond and Retention Pond pools has been completed and approximately 3% of the total volume of CCR material in the Stilling Pond (including Retention Pond) is below the estimated phreatic surface in this unit. It should be noted that the volumes reported herein do not correspond to a closed condition or reflect recent decanting (to facilitate Stilling Pond and Retention Pond construction), drainage or partial closure activities, and the phreatic surface would be expected to decrease after capping of CCR management units if the units were to be closed with CCR material in place. Multiple methods are regularly utilized to sufficiently stabilize saturated CCR material to facilitate safe construction and support of a final cover system.

4.3.3.4 Comparison to Previous MQA

TriAD previously computed material quantity volumes for the MQA Study Area, as discussed in Chapter 4.3.1. TriAD's estimated total aerial extent and volume of CCR material were approximately 327 acres and 21.5 million cubic yards, respectively. A comparison of the two volumetric models indicates that the EI CCR material volume estimates are approximately 14% to 25% higher for the Gypsum Storage Area and the Dry Ash Stack, respectively. These differences are likely because the EI volumetric models incorporated more recent as-built construction surveys of the active CCR landfills which account for the CCR material that has been placed since the TriAD study as well as consideration of additional data collected during EXD and CCR Material Characteristics activities conducted at the CUF Plant between 2018-2020.

4.3.3.5 Secondary Volume Estimates and Verification Method

The CCR material quantity analyses completed in AutoDesk® AutoCAD® Civil 3D were verified with the Trimble Terramodel 3D™ software package (Terramodel). The top and bottom of the CCR material surfaces were imported into Terramodel to perform secondary CCR material volume estimates. The Terramodel analyses confirmed the Civil 3D volumes with a deviation of less than 5%. Terramodel CCR material volume estimate summaries are provided in Appendix G.4.

4.4 CCR MATERIAL INVESTIGATIONS SUMMARY

CCR material investigations provided geotechnical and analytical data to evaluate the extent, structural stability, characteristics, and material quantities in the CCR management units. CCR material characteristics data were also further evaluated in the hydrogeological evaluations. Primary investigation findings are:

- The global slope stability and the veneer slope stability for each of the four CCR management units meet the established factor of safety criteria for the static and seismic load cases. Future, additional slope stability analyses will be performed for the Gypsum Storage Area and the Dry Ash Stack CCR management units when closure design is defined.

- The four CCR management units have adequate structural integrity, and there is no evidence of voids/cavities in bedrock that could lead to loss of structural support and potential release of overlying CCR material.

- CCR material and pore water have been characterized as specified in the EIP, and CCR material and phreatic surfaces have been estimated for each of the four CCR management units. CCR material and estimated thickness ranges are depicted in plan view on Exhibit 4-5 and in cross-sections in Appendix D.

- Estimated CCR material volumes and areas for the four CCR management units are provided in Table 4-2. The total area of the CCR material within the CCR management units is approximately 326 acres, and the estimated total volume is approximately 25.3 million cubic yards. Approximately 43% of the estimated total volume of CCR material within the four units is below the estimated phreatic surface which is explained in Section 4.3.3.3. Decanting of the Stilling Pond (including Retention Pond) pools has been completed and approximately 3% of the total volume of CCR material is below the estimated phreatic surface within this unit. It should be noted that the estimated volumes reported herein do not correspond to a closed condition or reflect recent decanting (to facilitate Stilling Pond [including Retention Pond] construction), drainage, or partial closure activities. The elevations of phreatic surfaces would be expected to decrease after capping of CCR management units if the units were to be closed with CCR material in place. Multiple methods are regularly utilized to sufficiently stabilize saturated CCR material to facilitate safe construction and support of a final cover system.

Chapter 5 Hydrogeological Investigations

To evaluate hydrogeological conditions and to characterize groundwater quality, TVA reviewed information from previous studies, integrated data and findings from previous and other ongoing environmental programs and conducted hydrogeological and groundwater investigations as part of the EI (see Appendices H.1 and H.10 for additional details). EI field activities were conducted in general accordance with the following documents: *Hydrogeological Investigation SAP* (Stantec 2018b), *Groundwater Investigation SAP* (Stantec 2018f), *Water Use Survey SAP* (Stantec 2018g) and the *QAPP* (EnvStds 2018a), including TVA- and TDEC-approved programmatic and project-specific changes that were made after approval of the EIP. Field work included installing permanent wells and borings to collect samples of groundwater for analysis of CCR Parameters and geochemistry evaluation parameters.

The following sections summarize findings based on evaluation of the information collected from implementation of the EI and data collected under other TDEC permitted landfill and CCR Rule programs at and near the CUF Plant CCR management units. Additional details regarding these investigations and evaluations are provided in Appendices E.3 and H.1 through H.10.

5.1 Groundwater and Hydrogeological Investigations

The purpose of the groundwater and hydrogeological investigations was to further characterize and evaluate subsurface conditions in proximity to four CCR management units at the CUF Plant, including the Stilling Pond (including Retention Pond), Dry Ash Stack, Gypsum Storage Area and Bottom Ash Pond. For this investigation, TVA reviewed information from previous representative studies and assessments, completed field sampling programs, and conducted evaluations related to geology, hydrogeology, and groundwater quality as part of the EI.

5.1.1 Previous Studies and Assessments

Exploratory drilling at the CUF Plant began in 1958 to evaluate the suitability for the foundation for a proposed power plant. Since that time, several exploratory drilling and hydrogeological investigations have been conducted. Groundwater monitoring has been underway at the CUF Plant since approximately 1993. Monitoring well networks were previously installed to evaluate groundwater conditions as part of the TDEC permitted landfill and CCR Rule groundwater monitoring programs. Appendix H.1 provides summaries of informative studies related to the hydrogeology of the CUF Plant.

Groundwater data from the TDEC permitted landfill and CCR Rule programs follow quality assurance programs similar to that developed for the TDEC Order. Data from these historical and ongoing groundwater monitoring programs are included in the evaluation summarized below.

5.1.2 TDEC Order Investigation Activities

The objectives of the TDEC Order groundwater and hydrogeological investigations were to characterize groundwater quality and evaluate groundwater flow conditions in the vicinity of the CUF Plant CCR management units. Well installation and sample location selection, sample collection methodology, sample analyses, and QA/QC completed for the investigations are provided in the *Hydrogeological Investigation SAR* (Appendix H.2) and the *Groundwater Investigation SARs* for the six sampling events (Appendices H.3 through H.8).

Monitoring well CUF-1000 was repeatedly dry and is not considered a viable well; therefore, it was removed from analysis. Proposed background well (CUF-1004) was planned at a location south of the CCR management units; however, none of the three borings advanced at this location was completed as a well because groundwater was not encountered in the unconsolidated materials. Exhibit 5-1 shows the locations of wells installed as part of the EI.

Wells CUF-1002 and CUF-1003 were proposed as downgradient wells to investigate groundwater in unconsolidated materials above bedrock between the CCR management units and the CUF Plant but, based on the evaluation of measured groundwater elevations, they are considered to be upgradient of the CCR management units. Certain CCR constituents were detected in these wells at statistically significant concentrations above GSLs; therefore, analytical results of groundwater samples collected from these wells are not considered to be representative of background groundwater quality.

Based on the location of CUF-1005 and results of polarized light microscopy (PLM) of retained cores from the borehole for well CUF-1005 that indicate the presence of CCR material within the screened interval, it was concluded that well CUF-1005 was installed within the Gypsum Storage Area and analytical results of samples collected from this well are representative of pore water, not groundwater. Because the analytical results are representative of pore water, they are not included in the groundwater quality evaluation below. On March 18, 2021, TVA installed additional well CUF-1006 approximately 75 feet east of CUF-1005 and outside of the CCR management unit. Analytical results of groundwater samples collected from well CUF-1006 are included in the discussion of groundwater quality and groundwater elevation data from the EI sampling events are summarized in Table H.1.2 (Appendix H.1).

5.1.3 Hydrogeological Investigation Results

Several soil boring and well installation projects at and in the vicinity of the CUF Plant CCR management units yielded information about the geology, groundwater elevations, groundwater flow direction, and groundwater quality. This section provides an evaluation of the hydrogeological setting of CUF Plant CCR management units. Details of the evaluations are provided in Appendix H.1.

5.1.3.1 Well Construction and Presence of CCR Material

Because of the results of PLM testing of solid material samples collected from the boring for well CUF-1005, a review of boring logs and additional PLM testing was conducted for previously existing monitoring wells installed at similar locations between the dikes constructed at elevations 380 feet above mean sea level (amsl) and 395 feet amsl. The PLM investigation was conducted as part of compliance with the CCR Rule. The findings of this evaluation indicated that a few previously existing monitoring wells were installed in borings that were drilled through CCR material. This creates uncertainty about the representativeness of groundwater samples collected from these wells and may lead to a re-evaluation of the certified groundwater monitoring systems for compliance with the CCR Rule and the TDEC permitted landfill groundwater monitoring programs. Details of the evaluation of the PLM results are provided in Appendix H.1.

5.1.3.2 Lithology and Hydrostratigraphic Units

Chapter 2.4 of the EAR provides a discussion of the regional geologic setting for the CUF Plant, including the Wells Creek Structure. The following discussion is about the site-specific geology in the vicinity of the CCR management units. The CUF Plant is located within the Wells Creek Basin, which is the result of a meteor impact that changed the geology within the basin. The meteor impact caused bedrock formations that exist at a depth of approximately 2,500 feet below ground in the area surrounding the crater to be brought to ground surface in the center of the crater. Parts of the CCR management units are located above these geologic formations.

The lithologies of the CUF Plant primarily consists of residuum and alluvium overlying bedrock. Residuum is the material that remains after bedrock has weathered to a point that it is no longer considered rock. Residuum commonly consists of clay or silt but can have layers of coarser materials such as sand and gravel. Alluvium refers to natural materials that are deposited by moving water. The alluvium can be further differentiated into clays and silts that overlie sands and gravels. Alluvium is underlain at some locations by a layer of residuum primarily consisting of clay and silt. The unconsolidated materials are underlain by bedrock formations that primarily consist of limestone, dolomite, or shale.

Generally, alluvium is the first unconsolidated material encountered where the base of the CCR management units is below an elevation of approximately 360 feet above mean sea level. Shallow alluvial deposits typically consist of clays and silts grading downward to coarser sands and gravels. The alluvium averages less than 25 feet in thickness beneath the CCR management units but may be as great as 45 feet thick in the abandoned channel of Wells Creek. Alluvium is underlain at some locations by a layer of residuum soils primarily consisting of clay and silt.

Residuum is generally the first unconsolidated material encountered where the base of the CCR management units is above an elevation of approximately 360 feet above mean sea level. The residuum typically consists of clay with thin layers of sand and gravel.

The following figures show the distribution of the various geological formations. The first figure shows the fine-grained alluvial silts and clays and residuum colored brown. The second figure shows the coarse-grained alluvial sands and gravels colored light yellow. The third figure shows the bedrock surface colored gray. The dikes surrounding the CCR management units are shown in the brighter yellow color.

CUF Plant CCR and Unconsolidated Materials

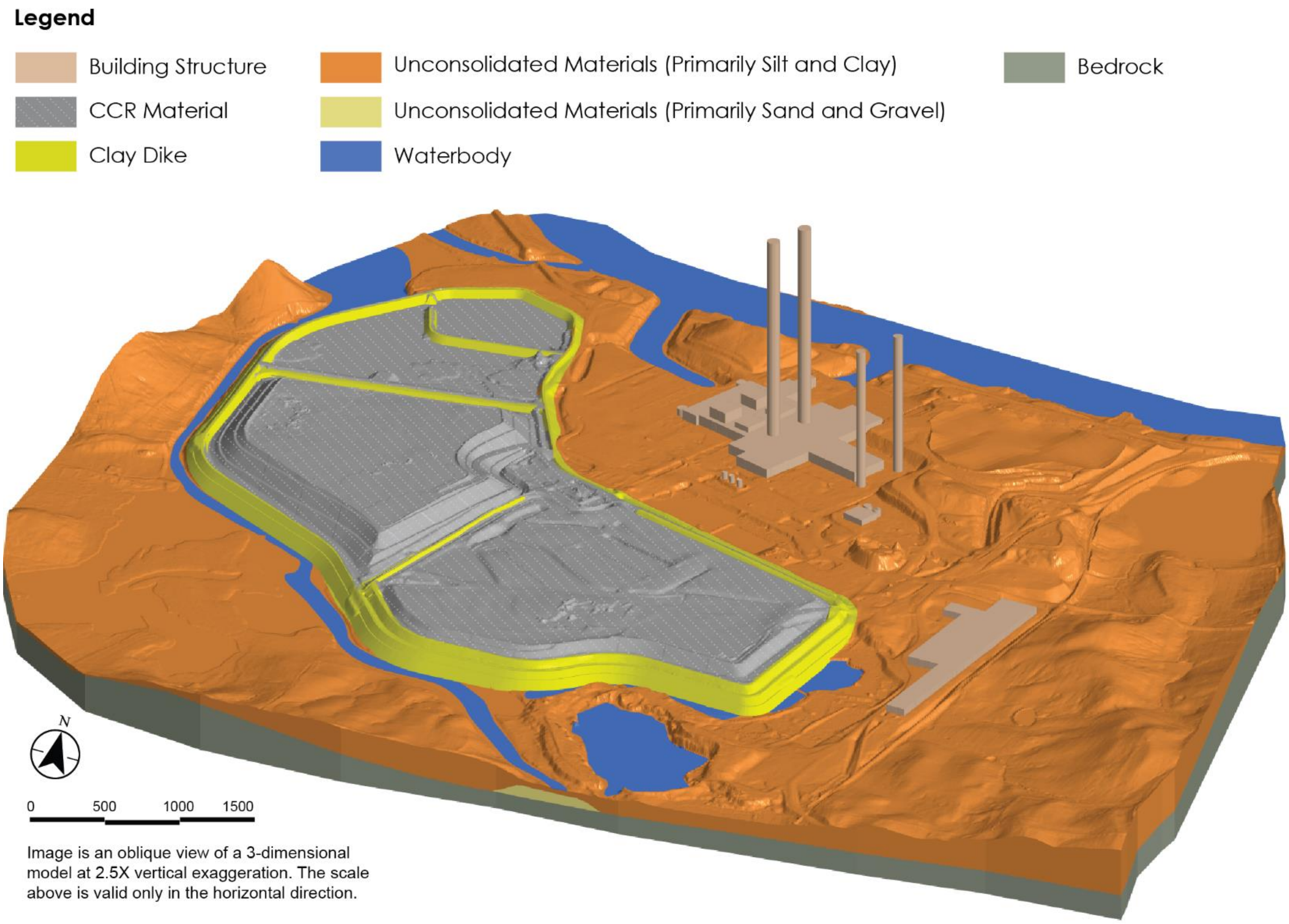


Image is an oblique view of a 3-dimensional model at 2.5X vertical exaggeration. The scale above is valid only in the horizontal direction.

CUF Plant Unconsolidated Materials – Silt and Clay

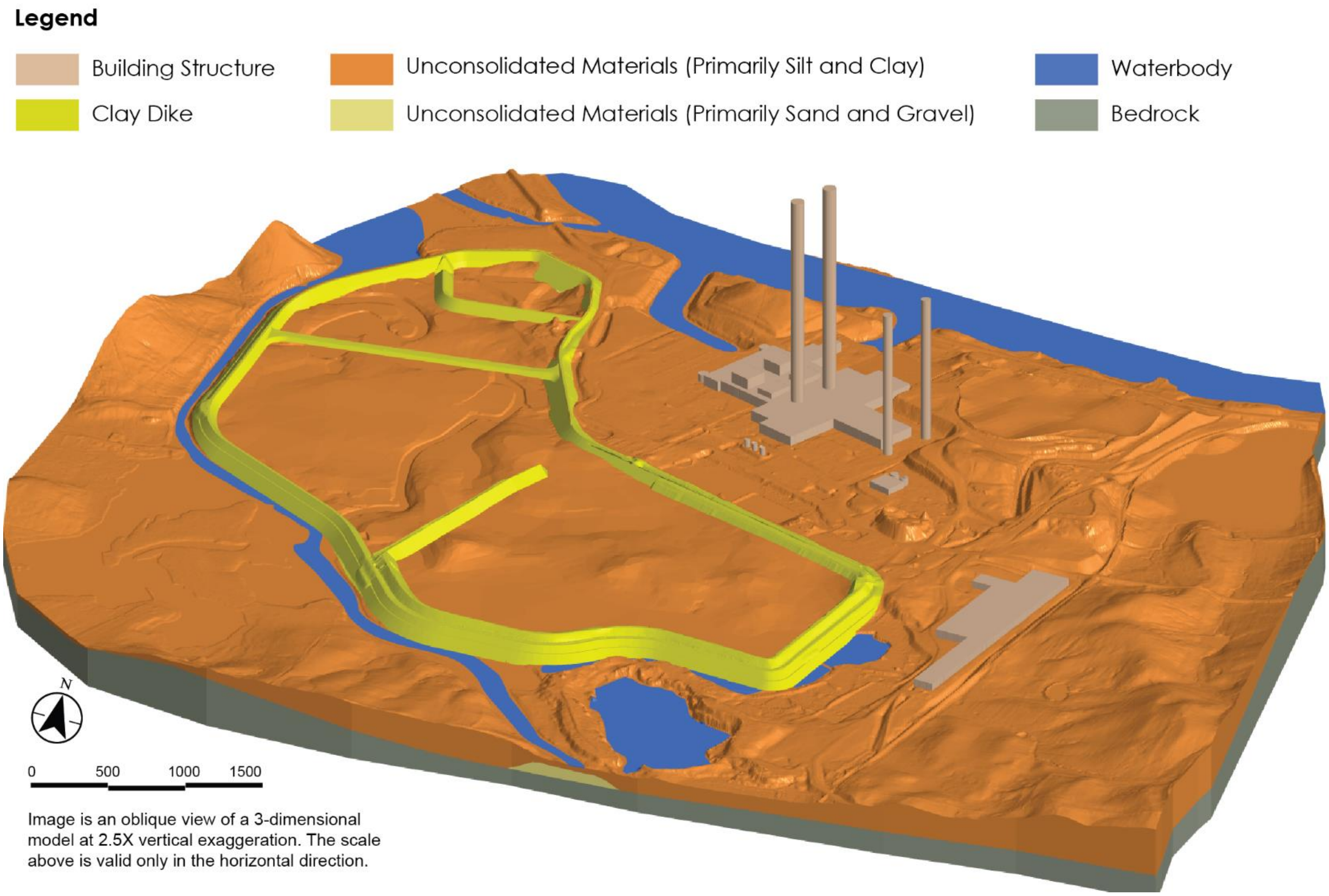


Image is an oblique view of a 3-dimensional model at 2.5X vertical exaggeration. The scale above is valid only in the horizontal direction.

CUF Plant Unconsolidated Materials – Sand and Gravel

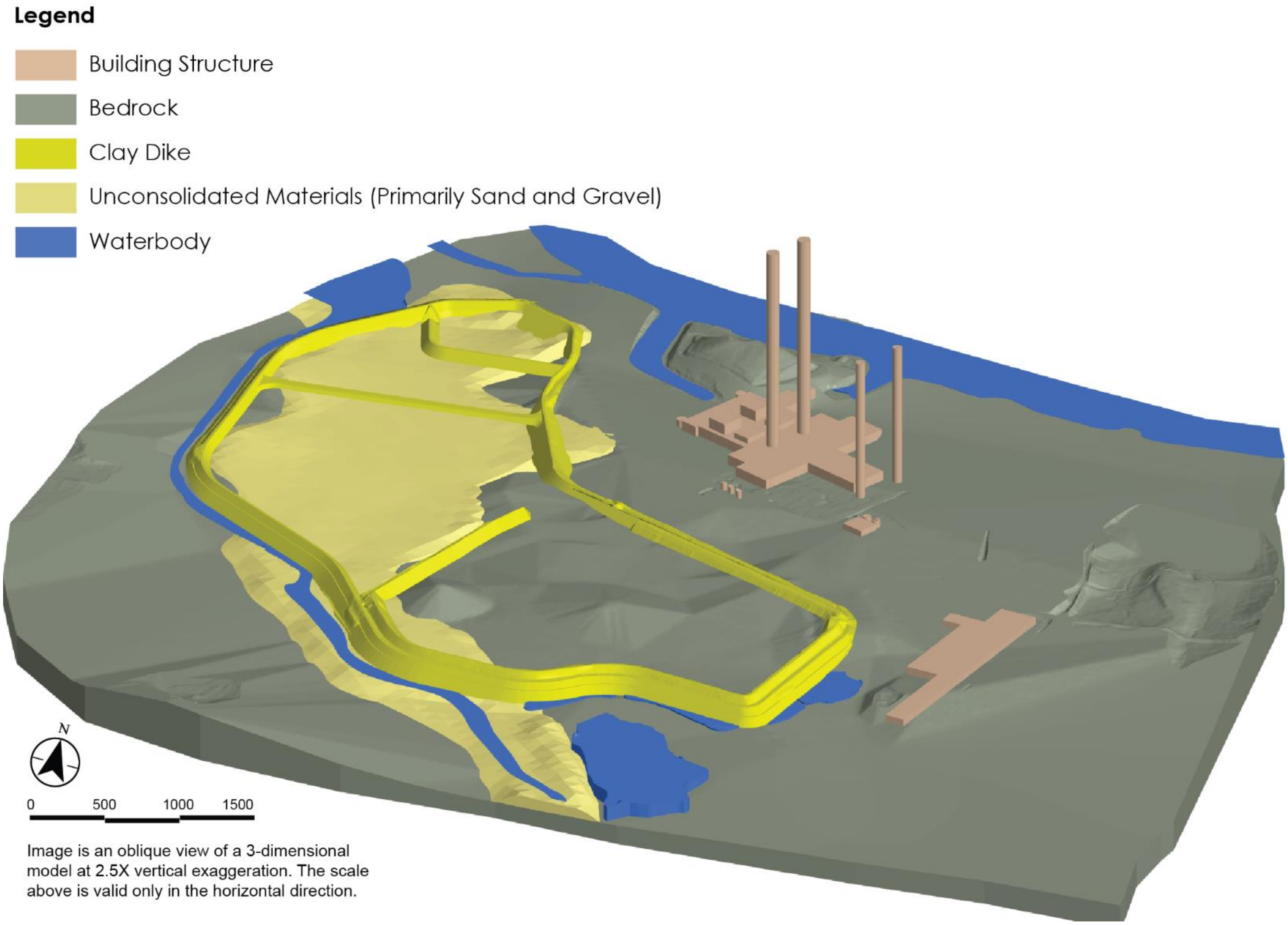


Image is an oblique view of a 3-dimensional model at 2.5X vertical exaggeration. The scale above is valid only in the horizontal direction.

CUF Plant Bedrock Surface

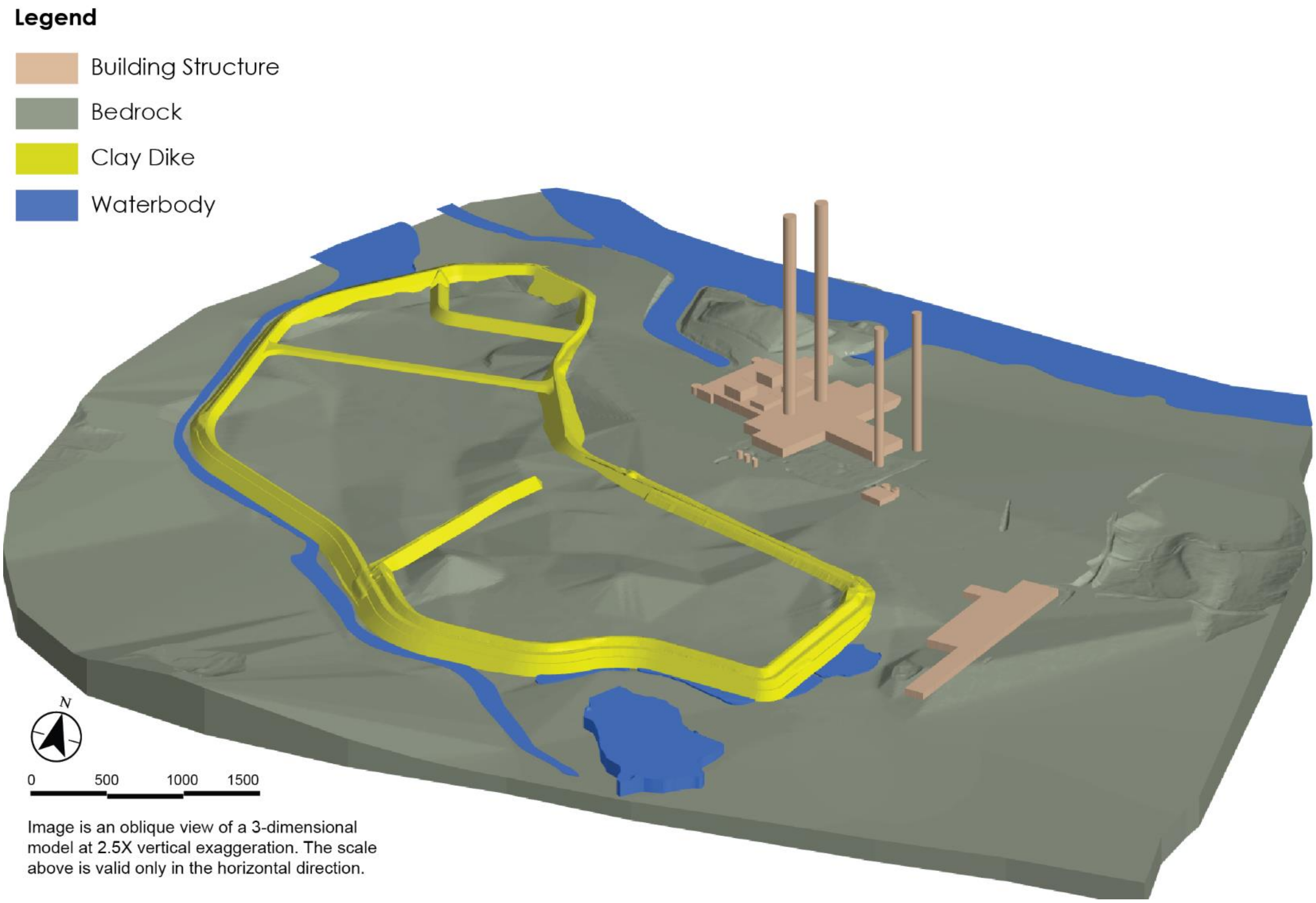


Image is an oblique view of a 3-dimensional model at 2.5X vertical exaggeration. The scale above is valid only in the horizontal direction.

Representative cross sections showing the underlying lithologic units and CCR material are provided in Appendix D. Exhibit D-1 is a transect location map for the cross sections. Exhibit D-2 depicts the profiles across the Dry Ash Stack and Gypsum Storage Area. Exhibit D-3 depicts profiles across the Stilling Pond (including Retention Pond) and Bottom Ash Pond.

Hydrostratigraphic units are geological formations that have been defined to characterize the hydrogeology of the CUF Plant to understand where and how groundwater is flowing. In saturated geological formations that have higher permeability than adjacent formations, groundwater flows in a mostly horizontal direction. In saturated geological formations that have lower permeability than adjacent formations, groundwater flows in a more vertical direction. The more permeable geological formations capable of yielding useable quantities of groundwater are called aquifers. Aquifers are targeted for development as water sources by property owners. The less permeable geological formations are called aquitards.

The hydraulic characteristics of aquifers are used to classify them. If an aquifer is located between two aquitards, then the aquifer is called a confined aquifer. Groundwater can flow through aquitards into underlying aquifers, but the rate of flow is commonly much slower than the rate of flow within the aquifer. Aquifers can be considered confined even if they are not completely covered by an aquitard. For example, the Memphis aquifer in western Tennessee is a confined aquifer, yet it is known that the aquitard above the Memphis aquifer is thin or absent in some areas (Parks and Carmichael 1990).

In a confined aquifer, measured groundwater levels rise above the top of the aquifer. The difference between the measured groundwater levels within the aquifer and the top of the aquifer is called the pressure head. For confined aquifers, groundwater is not encountered in the interval shown as pressure head above the top of the aquifer because it is bounded by an upper aquitard, which also physically separates the groundwater from the geologic unit located above the upper aquitard.

In state and federal regulations, the term uppermost aquifer is used. This is the aquifer closest to ground surface. Regulations are designed to protect the groundwater in the uppermost aquifer because it could be used by property owners as a source of water. The term uppermost aquifer is used in this report.

5.1.3.3 Uppermost Aquifer and Groundwater Flow

This section provides a discussion of how groundwater flows at the CUF Plant. Groundwater flow occurs because gravity moves groundwater from areas of higher groundwater elevations to areas of lower elevations along flow paths that are generally perpendicular to groundwater elevation contours. Physiographic and hydrogeological features affect how groundwater flows. Hydrogeological barriers (i.e., rivers and surface streams) and divides (i.e., ridges that form watershed boundaries) bound the extent of groundwater flow. Groundwater flows toward, but not across, hydrogeological barriers and away from hydrogeological divides.

The sands and gravels above bedrock are defined as the uppermost aquifer. Where the sands and gravels are absent in the eastern part of the CCR management unit area, the underlying bedrock has been defined as the uppermost aquifer. The uppermost aquifer is overlain by less permeable clays and silts that are defined as an aquitard; therefore, the uppermost aquifer is a confined aquifer. Groundwater in the confined aquifer is not in contact with the CCR material inside the CCR management unit where the aquitard is present because the aquitard physically separates them. Other observed lithologies (e.g., clays and silts) typically have not produced usable amounts of water but are monitored at certain locations for spatial distribution where the sands and gravels are laterally absent. Appendix H.1 provides additional details regarding the characterization of the uppermost aquifer and the distribution and thickness of the aquitard.

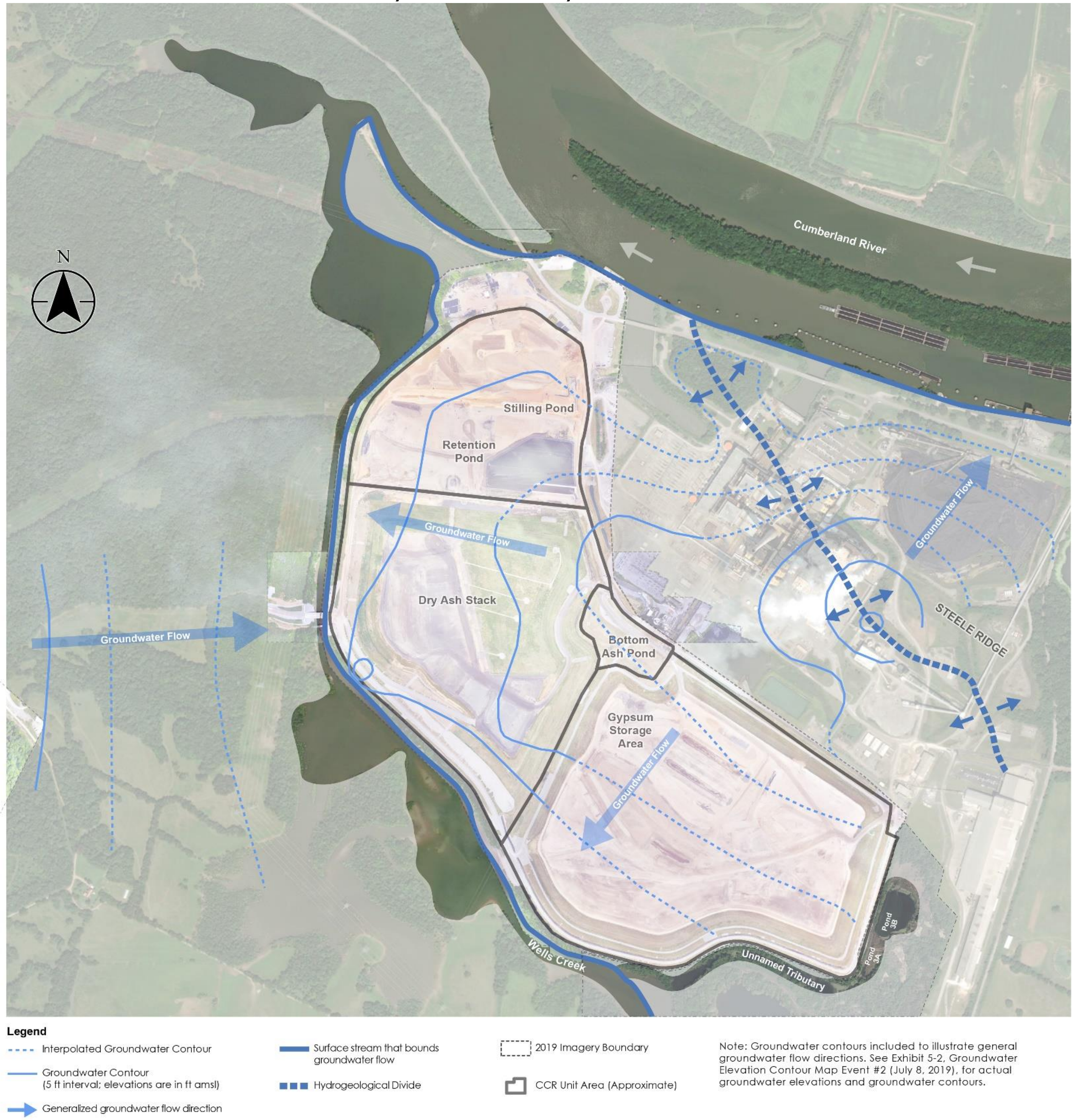
Hydrogeological Investigations

During the EI, groundwater levels were measured within the uppermost aquifer, the overlying clays and silts, and the underlying bedrock prior to the six groundwater sampling events to evaluate the direction and rate of groundwater flow in the uppermost aquifer. Surface water elevations were measured at the Cumberland River because the elevations of surface streams affect groundwater flow.

The available data indicated that groundwater flows downward through the clays and silts of the aquitard into the alluvial sands and gravels or bedrock that comprise the uppermost aquifer. Groundwater elevations within bedrock were similar to those measured in the sands and gravels suggesting that these geological formations are hydraulically connected. Groundwater flow within the uppermost aquifer beneath the central and southern part of the CCR management units is generally horizontal to the west and southwest towards Wells Creek. In the northern part of the CCR management units, groundwater flow is to the northwest toward Wells Creek and the north toward the Cumberland River. There may be limited reversal of ground water flow (sometimes called mounding) near the Stilling Pond (including Retention Pond), but it does not extend past the groundwater divide discussed below. Calculated groundwater flow rates ranged from approximately 250 feet/year to 700 feet/year, which is generally much slower than water flow in surface streams or rivers. Flow rates in surface streams or rivers generally are measured in feet per second (USGS 1999). Exhibit 5-1 is a representative groundwater contour map.

Physiographic features that affect groundwater flow in the vicinity of the CUF Plant include the Cumberland River to the north, Steele Ridge through the plant, and Wells Creek to the south and west of the CCR management units (see the graphic below). Groundwater in the vicinity of the CUF Plant on the southwest side of Steele Ridge flows toward Wells Creek, except for a small area in the vicinity of the Stilling Pond (including Retention Pond) that flows to the Cumberland River. Groundwater northeast of Steele Ridge flows to the Cumberland River. In the vicinity of the CCR management units, groundwater flow is bounded to the north by the Cumberland River and to the south and west by Wells Creek. Groundwater flow directions, boundaries and the groundwater divide are shown in the following graphic. Additional discussion of the hydrogeology and groundwater flow is provided in Appendix H.1.

Groundwater Flow Directions, Boundaries, and Divides



5.1.3.4 Groundwater Flow and Relationship to Pore Water

TVA measured pore water levels within the temporary wells monthly for six months. In addition, the wells were gauged during bi-monthly groundwater sampling events. This information was combined with available information from other instruments to develop maps of the phreatic surfaces for the Dry Ash Stack and Gypsum Storage Area at the time of gauging. The phreatic surface is the surface of pore water at which pressure is atmospheric and below with CCR material may be saturated with pore water. The use of the term “saturated” or references to the moisture content of CCR material does not imply that the pore water is readily separable from the CCR material. Saturated CCR material can have a range of moisture contents based on the characteristics of the material. In addition, some of the other instruments that measure pore water, groundwater, and surface stream levels have been automated to provide time-series data, which has been plotted to evaluate the relationships of the elevations of pore water, groundwater, and surface streams. Detailed discussion of these relationships is provided below in Appendix H.1.

Generally, the available groundwater level data indicated that pore water levels were up to 20 feet higher than groundwater levels in the uppermost aquifer. This suggests that the low permeability of the perimeter dikes and the clays and silts that comprise the aquitard at the base of the units impedes lateral and vertical flow of pore water.

Groundwater, pore water, and surface stream level fluctuations were compared to each other to evaluate the correlations of changes in water levels between the three media. The surface stream level of the Cumberland River was used as a proxy for Wells Creek because initially the latter did not have a gauging station established during the EI groundwater sampling events. A gauging station has since been installed in Wells Creek. A comparison of Well Creek stage elevations to the Cumberland River stages elevations indicated that Wells Creek is affected by the seasonal fluctuations of the Cumberland River because of the damming of the Cumberland River, and the Cumberland River stage is a reasonable proxy for Wells Creek stage.

Pore water levels within the CCR management units and groundwater levels within the uppermost aquifer responded differently to hydraulic stresses. Pore water levels dropped in response to pumping from within the Dry Ash Stack, but the pumping did not appear to affect groundwater levels within the uppermost aquifer. In addition, fluctuations in water levels in surface streams and responses to pumping from within the uppermost aquifer were observed in monitoring wells and piezometers that monitor the uppermost aquifer, but pore water levels did not respond or only showed limited responses to these stresses. These results demonstrate that the aquitard provides separation between the CCR management units and the uppermost aquifer for hydraulic stresses.

Within the Gypsum Storage Area CCR management units, the pore water phreatic surface was at an elevation near the constructed underdrain layers within the units. In addition, available data suggest that some pore water flows laterally through the underdrain layers to perimeter ditches. This may limit the elevation to which the phreatic surface rises to approximately the elevation of the underdrain layer. Below the underdrain layers, the low permeability of the perimeter dikes limits lateral flow and the low permeability of the clays and silts at the base of the units impedes vertical flow of pore water.

It should be noted that the pore water levels reported herein may not represent long-term conditions or correspond to a closed condition if the CCR management units were to be closed with CCR material in place. The phreatic surface would be expected to decrease in elevation after improving storm water drainage or capping of CCR management units if the units were to be closed with CCR material in place.

The effects on pore water levels due to the decanting, pumping of temporary wells screened within both CCR material and the sand and gravel layer, and other construction activities in the Stilling Pond (including Retention Pond) are illustrated in Exhibits D-2 and D-3. As is expected, the decreases in pore water levels are greater closer to the construction activities and pumping wells. These projects may have both short-term (i.e., temporary) and long-term effects on the pore water in the CCR management units. TVA is continuing to monitor the pore water levels, as they relate to current conditions and potential future conditions.

5.1.3.5 Groundwater Quality Evaluation

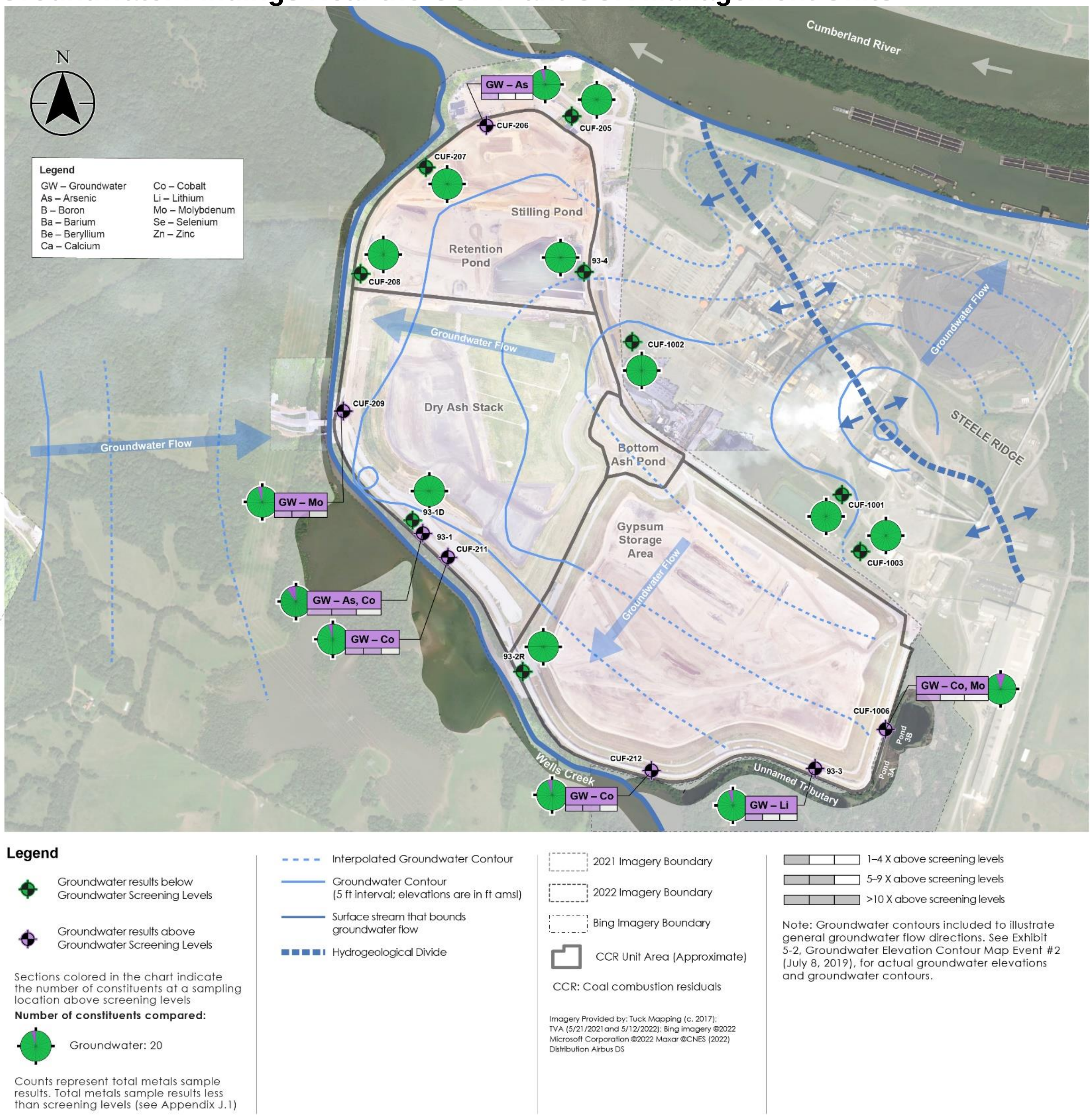
This section provides a discussion of the analytical results for groundwater samples collected from monitoring wells installed as part of the EI and previously installed wells monitored as part of the TDEC permitted landfill and CCR Rule monitoring programs. The groundwater quality evaluation is based on a statistical evaluation of constituents listed in Appendix I of TDEC Rule 0400-11-01-.04 (TDEC Appendix I) and Appendices III and IV of the CCR Rule. The analytical results were compared to GSLs approved by TDEC (see Appendix A.2). The statistical evaluation of groundwater analytical data is provided in Appendix E.3. Additional discussion of the results of the statistical evaluation are provided in Appendix H.1.

The dataset compiled for statistical analysis includes available analytical data for groundwater samples collected between November 2016 and December 2020, although the specific start date and frequency of sampling may vary between wells based on date of well installation and the applicable monitoring program. This time period was selected because it coincides with modifications that were made to the monitoring program at the CUF Plant in 2016.

Downgradient of the CCR management units, four TDEC Appendix I or CCR Rule Appendix IV CCR constituents had statistically significant concentrations in onsite groundwater above a GSL in seven wells that require further evaluation in the CARA Plan to determine the need for corrective action that will be based on statistically significant concentrations above an established GWPS. These constituents include arsenic (93-1, CUF-206), cobalt (93-1, CUF-211, CUF-212, and CUF-1006), lithium (93-3), and molybdenum (CUF-209 and CUF-1006). Five wells had only one constituent with a statistically significant concentration above a GSL, and two wells had two constituents with a statistically significant concentration above a GSL. The groundwater impacts described above are limited to areas along the perimeter of the CCR management units. Exhibit 8-6 shows the locations of the wells and constituents that will require further evaluation in the CARA Plan.

The following figure shows the results of the statistical evaluation of CCR Rule Appendix IV and TDEC Appendix I constituents. Each monitoring well is represented by a symbol that is divided into 20 slices within a circle. The slices are colored green for each of the 20 CCR constituents that was detected at concentrations below the GSLs. Slices colored purple represent constituents that were detected above GSLs. The small boxes provide the constituents that were detected above the GSL. The bars below the boxes provide a gauge for how much the concentrations were above the GSL. See the legend in the figure for further explanation of the symbols. Additional discussion of the results of the statistical evaluation are provided in Appendix H.1.

Groundwater Findings Near the CUF Plant CCR Management Units

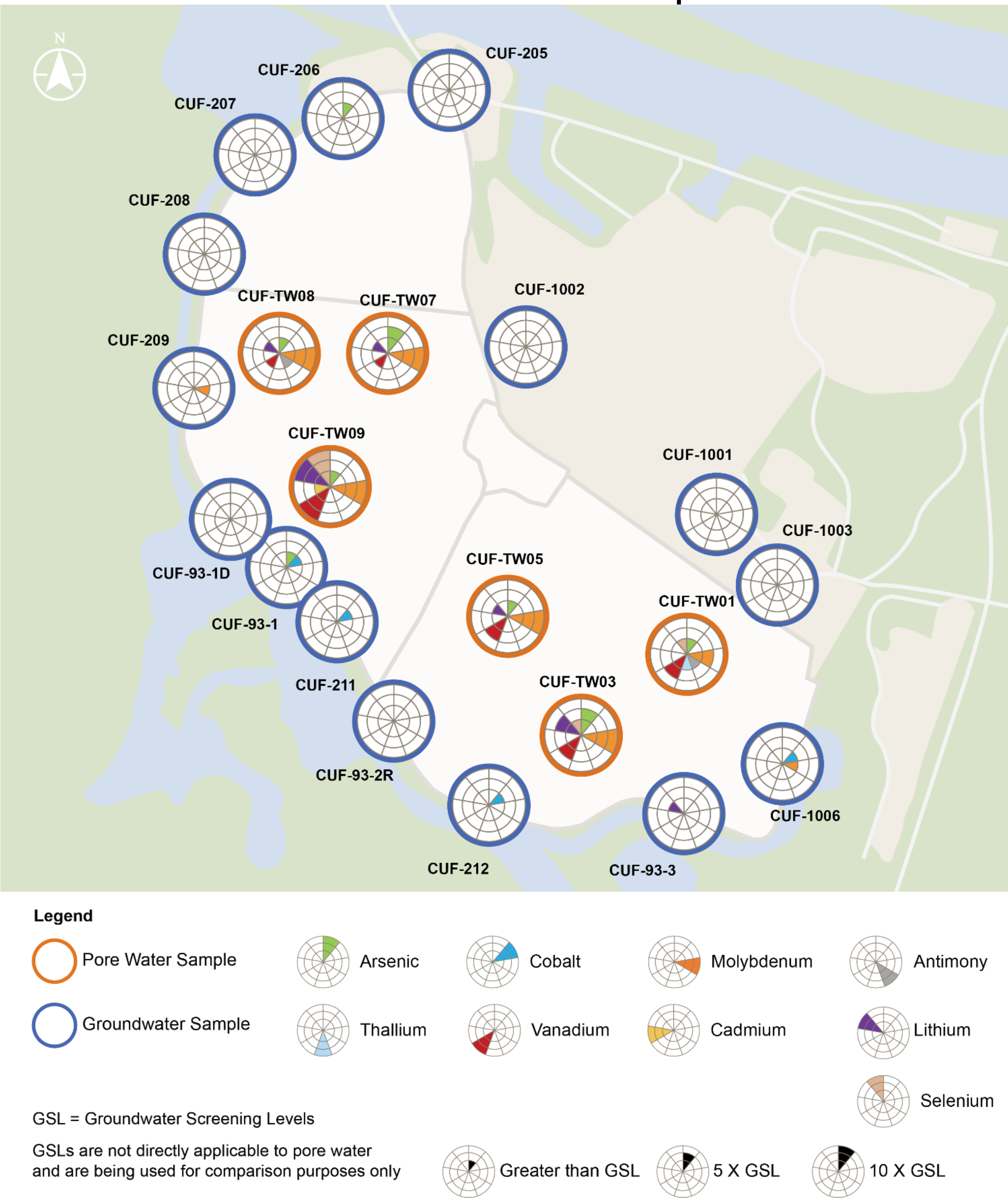


The figure shows that most constituents were detected below the GSLs. Seven wells had constituents with statistically significant concentrations above a GSL.

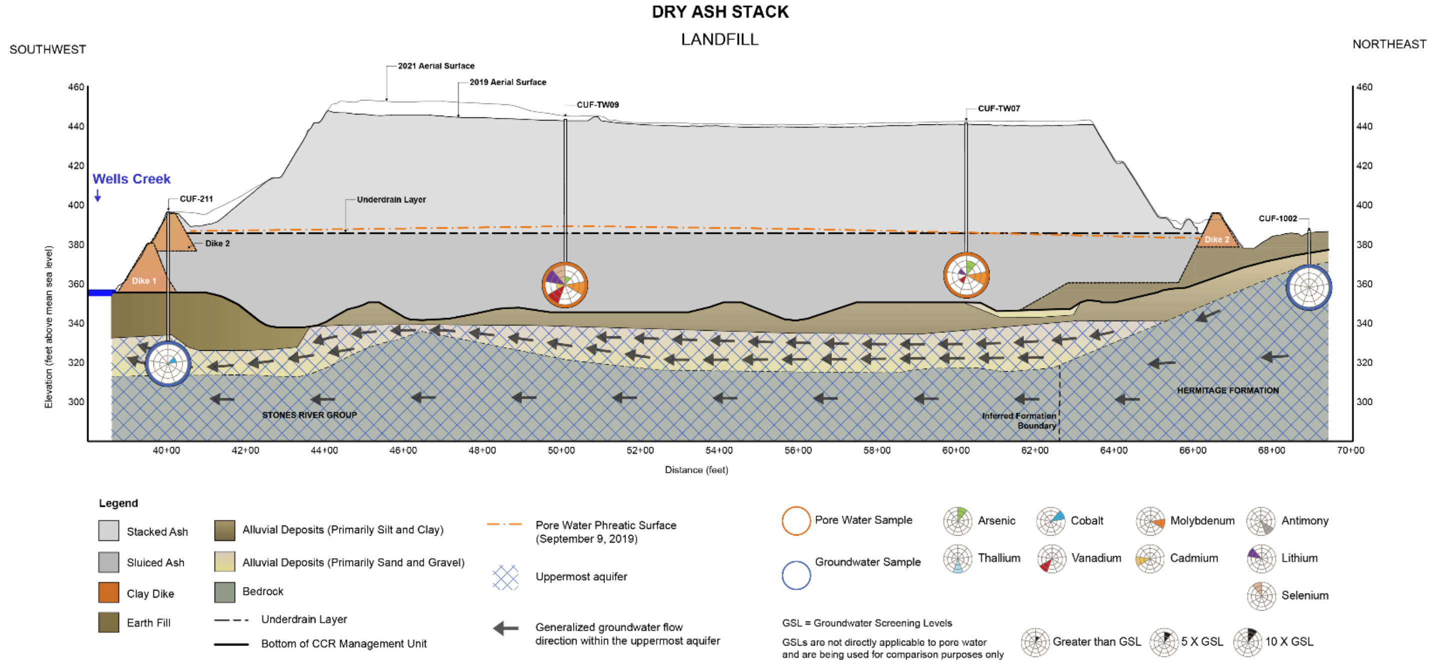
In addition, the quality of pore water was compared to groundwater quality. The following two figures illustrate the difference between pore water quality (symbol with purple outer ring) measured within the CCR management units and groundwater quality (symbol with green outer ring) measured at the edge of the CCR management units. The first figure is a plan view showing the differences in water quality by comparison of the colors within the symbols. The CCR constituents detected are represented by different colors, as shown in the legend. The relative concentration of the constituent detected compared to the GSLs is represented by the number of colored sections within each slice.

The second figure is a cross section that also shows the same differences in water quality. These two figures show that generally the constituents detected downgradient along the edge of the CCR management units are different than those detected in pore water within the CCR management units or that they were detected at lower concentrations. This difference between pore water and groundwater quality can be explained by geochemical reactions that can occur as water flows through natural geological materials.

Pore Water and Groundwater Concentration Comparison



Cross Section View of Pore Water and Groundwater Comparison



5.2 GEOCHEMICAL EVALUATION OF GROUNDWATER DATA

Groundwater quality is affected by numerous geochemical processes during groundwater flow through geological materials. The distinct difference between the chemical characteristics of pore water within the CCR material, presented in Chapter 4, and the characteristics of groundwater quality downgradient of the CCR management units at the CUF Plant is difficult to explain without the aid of geochemistry. It is well documented in the literature that certain CCR constituents that are detected in pore water (typically at higher concentrations than in groundwater) can be affected by geochemical processes that occur between constituents dissolved in groundwater and geological materials through which it flows. The effects of these geochemical processes, which often result in the attenuation of CCR constituents (i.e., reduced concentrations) can explain observed differences between the characteristics of pore water and groundwater. The extent of the interactions between dissolved constituents in groundwater and geological materials ranges from limited interaction for constituents such as boron, chloride, and sulfate, to strong interactions for constituents such as arsenic and cobalt.

Observations of groundwater and pore water chemistry can indicate the extent to which geochemical processes chemically change groundwater and influence groundwater quality at the CUF Plant. Boron, chloride, and sulfate commonly occur in high concentrations in pore water and are minimally attenuated by geochemical processes. Thus, they can be used to infer locations in the groundwater monitoring program where there is an influence from pore water. In contrast, those CCR constituents most likely to be influenced by interactions between geological materials and groundwater (e.g., arsenic, lithium, and molybdenum) typically show concentrations in groundwater monitoring wells that are much different than those observed in pore water, indicating that groundwater is being chemically changed relative to pore water by some physical or geochemical process (or a combination of both) occurring as it flows through geological materials.

Understanding the geochemistry of geological materials is important in interpreting the processes influencing current conditions of groundwater chemistry at the CUF Plant and evaluating effects of activities, such as drainage modifications or groundwater remediation, on the evolution of groundwater quality. Further evaluation of the geochemical processes acting in the upgradient system at the CUF Plant to influence groundwater quality will be included in the CARA Plan during assessments of remedies, where needed.

5.3 WATER USE SURVEY

The objectives of the EI water use survey are to identify and sample usable private water supply wells and surface water sources potentially being used for domestic purposes within 0.5-mile of the boundary of the CUF Plant. herein referred to as the Survey Area, as outlined in the EIP and shown in the graphic below. For this study, TVA defined a usable water well to be one that will house a pump (even if a pump is not currently present) and does not contain an obstruction or defective construction that would prevent the insertion or operation of a pump. A detailed discussion of the water use survey is provided in Appendix H.10.

5.3.1 Desktop Survey

The first step of the water use survey was a desktop survey (the Survey) to identify usable private wells and springs. This included a review of registered well information obtained from TDEC, historical hydrogeologic reports, aerial photographs, and contacting public water supply providers in the vicinity of the CUF Plant. The goal of the Survey was to identify potential and known wells or springs within the Survey Area.

5.3.1.1 Desktop Survey Results

Based on the results of the Survey, six parcels were identified in the Survey Area that may have up to five potentially usable wells and two springs used for domestic or business purposes. These six parcels and associated potentially usable wells and springs are shown on the graphic below.

5.3.1.2 Usable Water Well and/or Spring Identification

In addition to conducting the Survey, the CUF Water Use Survey SAP outlines a process to identify offsite areas where groundwater has the potential to be affected by the CUF Plant CCR management units using results of investigative activities required as part of the EI. This process includes consideration of geologic and hydrogeological conditions (i.e., hydrogeological barriers [rivers/streams], topography, groundwater flow direction, and watershed boundaries).

Groundwater flow in the unconsolidated materials and bedrock at the CUF Plant CCR management units is bounded to the north by the Cumberland River and to the south and west by Wells Creek. There is a groundwater flow divide in the northeast portion of the CUF that separates flow to the Cumberland River to the northeast from flow to the southwest toward Wells Creek as shown in the graphic below. Groundwater movement toward surface streams is shown on the following figure.

Hydrogeological Investigations

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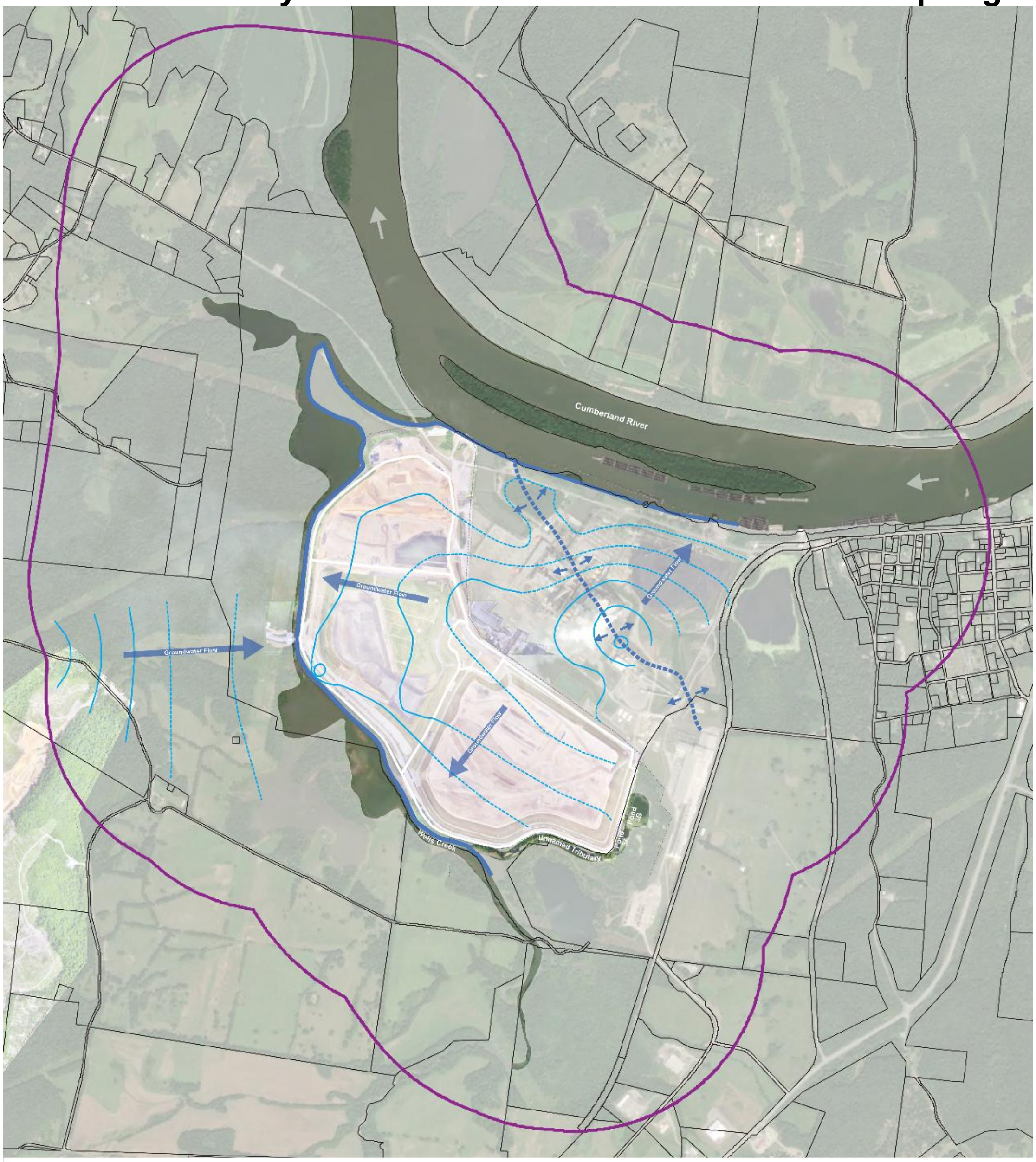
Water Use Survey Area and Parcels with Wells and/or Springs



Legend

- Interpolated Groundwater Contour
- Groundwater Contour (5 ft interval; elevations are in ft amsl)
- Surface stream that bounds groundwater flow
- Hydrogeological Divide
- CCR Unit Area (Approximate)
- WUS Survey Area
- Parcel Identified for Water Use Survey

Note: Groundwater contours included to illustrate general groundwater flow directions. See Exhibit 5-2, Groundwater Elevation Contour Map Event #2 (July 8, 2019), for actual groundwater elevations and groundwater contours.

- 2021 Imagery Boundary
- 2022 Imagery Boundary
- Bing Imagery Boundary

Imagery Provided by: Tuck Mapping (c. 2017); TVA (5/21/2021and 5/12/2022); Bing imagery ©2022 Microsoft Corporation ©2022 Maxar ©CNES (2022) Distribution Airbus DS

Because of the hydraulic barriers represented by Wells Creek, the Cumberland River, and the groundwater divide, groundwater in areas located offsite south or west of Wells Creek, and north of the Cumberland River and the groundwater divide would have a very low likelihood of being impacted from CCR management units based on the current groundwater flow pattern. Additional information regarding groundwater flow conditions is included in the Appendix H.1.

Considering the geologic and hydrogeologic conditions present at and in the vicinity of the CUF Plant, 13 parcels located south/southeast of the CUF Plant, referred to as the area of interest (AOI), have a greater potential of being impacted by CCR management operations. These parcels are listed in Table H.10-5 (Appendix H.10). Using the results of the desktop survey, one spring is believed to be present on one of the thirteen parcels. No potential wells were identified on any of the 13 parcels. The other potential wells and springs identified in the desktop survey were located outside the 13 parcels.

To confirm the results of the desktop survey, the parcel owners were contacted through correspondence or by telephone between October and November 2022. The owner responses indicated that no water supply wells were identified within the AOI. However, one spring located on one of the parcels was identified. Details of the parcel owner outreach efforts are provided in Appendix H.10.

5.3.1.3 Water Use Survey Investigation Summary

The owners of 13 parcels located within the AOI south/southeast of the CUF Plant were contacted for information regarding the presence of wells or springs on their property resulting in the positive identification of one spring (identified as CUFPV 002 and also known locally as Rye Spring). No other wells or springs were identified on any parcel within the AOI. Access to sample the spring was granted by the parcel owner and the spring was sampled on January 4, 2023.

Evaluating groundwater quality results associated with Upper Wells Creek, monitoring wells included in the CUF monitoring program, and other historical groundwater monitoring data, elevated boron, chloride, and sulfate concentrations reported in the sample collected from Rye Spring are similar to historical background concentrations and do not indicate a connection with CCR management units at the CUF Plant. In addition, the measured discharge location of Rye Spring is 28 to 30 feet above groundwater elevations measured in monitoring wells associated with the CUF Plant. Based on this information, the elevated boron, chloride, and sulfate concentrations reported in Rye Spring are not attributable to CCR management activities at the CUF Plant. A letter informing the parcel owner of the results of the sampling was delivered to the parcel owner. Based on the overall results of the water use survey, current and historical CCR management associated with the CUF Plant have not affected water supply wells or springs located downgradient of the CUF Plant. Details of the spring sampling activities are provided in Appendix H.10.

5.4 Hydrogeological Investigation Summary

The objectives of the TDEC Order hydrogeological and groundwater investigations were to characterize the hydrogeology and groundwater quality and evaluate groundwater flow conditions in the vicinity of the CUF Plant CCR management units. The key findings of the CUF Plant hydrogeological and groundwater investigations are summarized below:

- TVA evaluated analytical results for groundwater in support of the EAR based on data collected under three groundwater monitoring programs (some of which overlap), including the EI, CCR Rule, and TDEC permitted landfill monitoring programs. Monitoring well locations and CCR constituents that will require further evaluation in the CARA Plan are provided below.

Summary of Findings Requiring Further Evaluation in the CARA Plan	
CCR Management Unit	**Groundwater**
Gypsum Storage Area	Lithium (Well 93-3*) Cobalt (Well CUF-212* and CUF-1006) Molybdenum (Well CUF-1006)
Dry Ash Stack	Molybdenum (Well CUF-209) Arsenic (Well CUF-93-1*) Cobalt (Wells CUF-93-1* and CUF-211)
Bottom Ash Pond	Included in Gypsum Storage Area and Dry Ash Stack findings
Stilling Pond (Including Retention Pond)	Arsenic (Well CUF-206)

* Monitoring wells installed in borings drilled through CCR material.

- Drainage improvements, closure activities, or potential corrective actions are expected to reduce concentrations of CCR constituents to below GSLs in groundwater at downgradient monitoring locations.

- Pore water within the CCR material has specific chemical characteristics that are different from the characteristics of groundwater downgradient of the CCR management units. Certain CCR constituents that have been detected in pore water are affected by geochemical processes during groundwater flow through geological materials. The effect of these geochemical processes, which can result in the attenuation of CCR constituents and reduced dissolved groundwater concentrations, can explain the observed differences between the characteristics of pore water and groundwater quality.

- The pore water levels reported herein may not represent steady-state conditions. Within the Dry Ash Stack and Gypsum Storage Area CCR management units, some pore water flows laterally through the underdrain layers to the ash pond or to perimeter ditches. This may limit the elevation to which the phreatic surface rises to approximately the elevation of the underdrain layer. Below the underdrain layers, the low permeability of the perimeter dikes limits lateral flow, and the clays and silts that comprise the aquitard at the base of the units impede vertical flow of pore water. The use of the term flow, or other terms such as “saturated” or references to the moisture content of CCR material does not imply that the pore water is readily separable from the CCR material.

- The alluvial sands and gravels are considered to be the uppermost aquifer where they are present. Bedrock is considered to be the uppermost aquifer where sands and gravels are absent. The sands and gravels and bedrock are interpreted to be hydraulically connected. The uppermost aquifer is considered to be under confined conditions and is typically overlain by clays and silts that act as an aquitard. Available water level data, including the effects of river stage and pumping from the uppermost aquifer, indicate that the aquitard provides a hydraulic separation between the uppermost aquifer and the CCR material.

- The groundwater flow direction within the uppermost aquifer beneath the CCR management units is generally to the west and southwest towards Wells Creek. In the northwestern part of the CCR management units, groundwater flow is to the northwest toward Wells Creek and north toward the Cumberland River. Groundwater flow in the vicinity of the CCR management units is bounded to the north by the Cumberland River and to the south and west by Wells Creek. There is a groundwater flow divide in the area of the CUF Plant that separates flow to the Cumberland River to the northeast from flow to the southwest toward Wells Creek.

TVA will continue to monitor the trends of arsenic, cobalt, lithium, and molybdenum and conduct further evaluation in the CARA Plan to determine if corrective actions are needed. The influence of geochemical processes on groundwater quality will be further evaluated in the CARA Plan as part of the assessment of remedies, where needed.

Chapter 6 Seep Investigation

To evaluate potentially active seeps and collect data to assess potential seepage to surface water streams adjacent to the CUF Plant CCR management units, TVA reviewed historical seep management information and conducted a seep investigation as part of the TDEC Order EI. A summary of the historical seep information for the CUF Plant CCR management units is presented in Chapter 6.1. Because historical seep management at the CCR management units did not include collecting soil or surface water for analysis, samples of these media were obtained and analyzed for the EI as described in Chapter 6.2. The overall evaluation of the EI seep investigation results, including relevant historical data, are presented in Chapter 6.3. Additional information regarding the investigation field activities and sampling results is provided in the *Seep SAR* (Appendix I.1).

6.1 Historical Information

This section provides a brief summary of the historical information available that formed the basis of scope of the EI seep investigation. A detailed compilation of historical seep locations, remedial actions, and monitoring actions is presented in Appendix S of the EIP.

TVA has conducted annual CCR management unit dike inspections since 1972. TVA currently performs quarterly visual inspections of the dikes and toe areas in accordance with NPDES Permit No. TN0005789. TVA also maintains a Seepage Action Plan (TVA 2018b) which identifies areas of concern (AOC) by a unique number and documents the date of discovery, description, size, mitigation status, and current status. Historical reports and inspections identified seeps, evaluated potential impacts, and documented remedial activities as summarized in the EIP. Historically, TVA addressed wet areas and potential seepage areas in a conservative manner to anticipate possible structural concerns at the CCR management units. Identified wet areas were classified as seeps unless observational evidence suggested an alternative water source such as poor drainage or precipitation. Seventeen historical seeps, Seep A, and AOC1 are identified on Exhibit 6-1 for a total of 18 historical seeps and one AOC.

Historical Seep Nos. A, 1, 3, 7, 8, 9, 10, 11, 12, and 13 are above the perimeter dike, and potential drainage is captured by the perimeter drainage ditch and discharges via a NPDES-permitted outfall. Historical seep locations below the perimeter dike (Historical Seep Nos. 6 and 15) are in exposed areas between the riprap and waterline, and Historical Seep No 2 is located above the riprap; no active seeps were observed at these locations during the EI. Historical Seep Nos. 16 and 17 are not located adjacent to surface water and were not included in the EI. Historical Seep Nos. 4, 5, and 14 and AOC1 were located adjacent to Wells Creek or the Unnamed Tributary to Wells Creek and were included in the EI (Appendix I.1).

6.2 TDEC Order Investigation Activities

The primary objectives of the TDEC Order EI seep investigation at the CUF Plant CCR management units were to identify and collect information regarding the potential presence of active seepage, and if identified, evaluate the data obtained to assess potential movement of groundwater or pore water with dissolved CCR constituents into adjacent surface water streams. Seep investigation field activities and statistical evaluation of the data collected were performed in general accordance with the *Seep SAP* (Stantec 2018h) and the *QAPP* (EnvStds 2018a), including TVA- and TDEC-approved programmatic and project-specific changes made following approval of the EIP. Sample location selection, collection methodology, analyses, and QA/QC completed for the investigation are provided in the *Seep SAR* included in Appendix I.1.

The seep investigation consisted of inspecting accessible areas by foot or vehicle; investigating inaccessible areas (i.e., structural mitigation areas covered by riprap) by boat; observing exposed shoreline in areas where historical seep locations could only be accessed by boat; measuring field parameters in surface water in areas monitored by boat; collecting soil and water samples associated with potentially active seeps, referred to herein as areas of interest (AOIs); and conducting weekly inspections at applicable AOIs.

6.3 Seep Investigation Results Summary

Based on the investigation findings and subsequent corrective action for AOI2 described below, there are no known active seeps at the CUF Plant.

Accessible Area Inspections

During the visual walkdown inspection conducted by TVA and TDEC in October 2019, two AOIs were identified (Exhibit 6-1):

- AOI1 – Identified as a change in vegetation (common reed) at the southeastern toe of the Gypsum Storage Area between the CCR management unit dike and the western bank of the Unnamed Tributary Pond 3A. Visual observations were obscured due to dense vegetation; however, no signs of wetness or discoloration were noted.
- AOI2 – Identified as a change in vegetation (common reed) and clear flowing water approximately 50 feet downslope of riprap at historical Seep Nos. 2 and 15 located near the southwestern extent of the Gypsum Storage Area and adjacent to Wells Creek.

No samples were collected at AOI1 because of lack of signs of wetness or discoloration. Per TDEC request, water quality parameters were measured adjacent to this AOI in Ponds 3A and 3B of the Unnamed Tributary. Soil and water samples were collected at AOI2 for analysis of CCR Parameters.

Based on the weekly observations, observed flow at AOI2 did not appear to be associated with precipitation and thus, this area was identified as a seep. As such, CCR Parameter concentrations measured in AOI2 water were compared to the lowest applicable (i.e., waterbody-specific) ecological surface water screening levels for the EAR provided in Appendix A.2 (human health screening levels were not applied since AOI water would not be used for drinking water). Boron and calcium were detected in AOI2 water at concentrations above their respective screening levels. Data results for AOI2 water samples are provided in Appendix I.2.

Based on weekly observations and analytical results, TVA prepared a Corrective Action Plan for AOI2 under the CUF Plant NPDES permit that was approved by TDEC (TDEC 2020b). As part of this plan, TVA installed and operated two dewatering wells at the Gypsum Stack until January 2021. As reported in the 2021 annual NPDES report (TVA 2021c), quarterly inspections verified that the corrective action plan of dewatering, along with installation of a liner and piping in the perimeter ditch, has eliminated the seepage from AOI2. TVA will continue inspecting AOI2 per the CUF Seepage Action Plan.

Inaccessible Area Inspections

Three historical seeps, AOC1 were investigated further by boat. AOI1 identified during the accessible area inspections was further investigated as well. These locations are adjacent to Wells Creek banks or Ponds 3A and 3B of the Unnamed Tributary to Wells Creek (Exhibit 6-1). Water quality parameters were measured in surface water adjacent and upstream of these locations, and a statistical analysis of the results was performed to evaluate whether there were statistically significant differences between areas adjacent to and upstream of potential seep locations. As detailed in Appendix E.4, the statistical results indicated that there were no adjacent locations where the four measured water quality parameters indicated statistically significant differences when compared with upstream locations. Based on the statistical analysis of water quality parameter measurements, no additional AOIs were identified for further investigation or data collection in the EI, nor is there a need for further evaluation of these results in the CARA Plan.

Chapter 7 Surface Streams, Sediment, and Ecological Investigations

To characterize environmental conditions and evaluate potential impacts to surface streams, sediments, and associated ecological receptors in the vicinity of the CUF Plant, TVA reviewed information from historical studies, and performed surface water, sediment, benthic macroinvertebrate community, mayfly tissue, and fish tissue investigations as part of the EI. EI field activities were performed in general accordance with the following documents: *Surface Stream SAP* (Stantec 2018i), *Benthic SAP* (Stantec 2018j), *Fish Tissue SAP* (Stantec 2018k), and the *QAPP* (EnvStds 2018a), including TVA- and TDEC-approved programmatic and project-specific changes made after approval of the EIP. TVA also conducted mayfly and fish tissue sampling in 2018 prior to EIP development that supplements the EI. In addition, results of sediment samples collected in August 2019 triggered Phase 2 of the *Benthic SAP*. The Phase 2 supplemental sampling consisted of additional sediment and surface stream water sample collection in June and July 2021. Phase 2 sampling activities were conducted to further evaluate CCR constituents in general accordance with the *Benthic and Surface Streams Sampling and Analysis Plans Addendum 1* (Stantec 2021). As described below, the scopes of these investigations varied, but environmental media generally were sampled upstream, adjacent, and downstream of the CUF Plant CCR management units.

The following sections summarize historical and EI activities, and present overall investigation and evaluation findings for surface stream water, sediment, benthic invertebrate community, mayfly tissue, and fish tissue based on data obtained during previous studies and the EI. Statistical analyses of the surface stream water, sediment, mayfly tissue, and fish tissue data are provided in Appendices E.5 through E.8, respectively. A detailed technical evaluation of these results and associated SARs are provided in Appendices J.1 through J.7.

7.1 Previous Studies and Assessments

7.1.1 Surface Stream Studies and Ongoing Monitoring Activities

From 1994 through 2015, the USACE collected surface stream water quality samples (surface stream samples) from the Cumberland River near the CUF Plant (USACE 2018) at Cumberland River Mile (CuRM) 100.1 that included analysis of some CCR constituents (Appendix J.1). The CUF Plant is located at CuRM 102.8.

In 2016, TVA collected surface stream samples from the Cumberland River to help support TVA's request to TDEC and USEPA for approval of alternative technology-based effluent limitations for selenium and nitrate/nitrite (TVA 2016). Those samples were collected upstream, proximate to, and downstream of the CUF Plant, and included analyses of total and dissolved selenium (TVA 2016).

Currently, TVA is conducting ongoing monitoring of surface stream water quality at the CUF Plant in compliance with other regulatory requirements as described below:

- From 2009 to the date of this EAR, TVA has conducted quarterly surface stream sampling in Wells Creek at state compliance sampling points upstream and downstream of the CUF Plant (TVA 2020b) under the Solid Waste Disposal Permit

- Regular monitoring and sampling of the CUF Plant outfall discharge and annual whole effluent toxicity testing is conducted in accordance with NPDES permit requirements (TDEC 2018).

7.1.2 Sediment and Benthic Invertebrate Studies

TVA has conducted biological assessments by periodically monitoring aquatic communities (fish and benthic invertebrates) to evaluate their status upstream and downstream of the CUF Plant as detailed in Appendix J.3. These assessments began in the 1970s and have varied in scope and periodicity. Since 2008 through the date of this EAR, benthic invertebrate assessments have been conducted in accordance with the CUF Plant NPDES permit. In addition to biological assessments, TVA collected sediment samples in Wells Creek in 2002, and the USACE collected sediment samples near the CUF Plant in 1997, 2002, 2007, and 2012.

The 1970s data related to benthic invertebrate communities showed the following key findings (TVA 2019c):

- The assemblages of benthic invertebrates were diverse and, in general, relatively abundant and consistent with biota of an impounded river
- The benthic communities at sample locations were similar.

Additionally, since initiation of benthic sampling in 2008 in support of the alternative thermal limit, the CUF Plant benthic sample results have continued to show overall similarities in numbers of species, mean densities, and relative compositions of functional feeding groups across the seasons and between upstream and downstream locations (TVA 2019c). Stable upstream and downstream reservoir benthic index (RBI, further discussed in Appendix J.3) scores throughout the period of monitoring demonstrate the capacity of the benthic community to sustain itself through cyclic seasonal changes (TVA 2019c). Generally, the benthic macroinvertebrate community structure, based on Balanced Indigenous Population Element 1 (diversity at all trophic levels), Element 2 (sustain through seasonal changes), and Element 3 (food chain species), demonstrates that a seasonally abundant and diverse community is present both downstream and upstream of the CUF Plant (TVA 2019c).

Mayfly collections during previous studies were limited to those incorporated into the RBI sampling.

7.1.3 Fish Community and Fish Tissue Studies

As noted above, TVA has conducted biological assessments by periodically monitoring aquatic communities (fish and benthic invertebrates) to evaluate their status upstream and downstream of the CUF Plant. Historical fish population assessments were completed in the mid-1970s, 1980s, and annually during 2001-2003, 2005, and 2007-2019, as detailed in Appendix J.5. Since 2008, assessments have been conducted in accordance with the CUF NPDES Permit. Additionally, sport fish surveys and fish impingement monitoring and entrainment studies were conducted, with one historical study including collection and analysis of fish tissue. Conclusions based on previous fish population assessments and tissue studies near the CUF Plant are as follows:

Fish Population Monitoring. The 1970s fish population monitoring showed that species were abundant and diverse, and that the thermal discharge was not adversely affecting fish reproduction or other health factors, or fish movement (TVA 2019c).

Overall, the 2000s fish community sampling events and Reservoir Fish Assemblage Index (RFAI) results showed that:

- The total numbers of fish species and fish abundance during the summer season has increased at both upstream and downstream sample locations since 2007, a period of reduced flows and drought (TVA 2017a)
- The numbers of species and fish abundance during autumn have been similar upstream and downstream of the CUF Plant
- Comparison of the 2019 fish community metrics to historical sampling data indicates that the fish community within the thermally affected reach downstream has exhibited a trend of continued improvement, and that in autumn 2019 the fish community structure in the thermally affected reach downstream was similar to that in the unaffected reach upstream (TVA 2019c).

Therefore, in the context of USEPA's interpretation of the regulatory definition of a balanced indigenous population, TVA maintains that a balanced indigenous population is currently being demonstrated in Barkley Reservoir (i.e., in the Cumberland River in the vicinity of the CUF Plant). This position is supported by TDEC's removal of the segment of the Cumberland River in the vicinity of the CUF Plant from the Clean Water Act Section 303(d) list of impaired waters, which includes streams and lakes that are water quality limited and/or threatened by pollutants.

Fish Impingement Monitoring. Results of the 1970s and 2000s impingement monitoring, in conjunction with the RFAI results, show that impingement at the CUF Plant does not adversely impact the fish community of Barkley Reservoir (TVA 1977 and 2007).

Fish Entrainment Studies. The 1970s and 2000s entrainment studies indicate there is no significant adverse environmental impact from entrainment of fish eggs and larvae in the CUF Plant intake (TVA 1977, TVA 2017b).

2016 Fish Tissue Collection. In 2016, species-specific (bluegill, redear, largemouth bass, and channel catfish) composite samples of ovary tissues and fillet tissues were collected and analyzed solely for selenium and % moisture (TVA 2016). The tissue sample results were below the USEPA fish tissue criteria for selenium.

7.2 Pre-EIP Ecological Investigation Activities

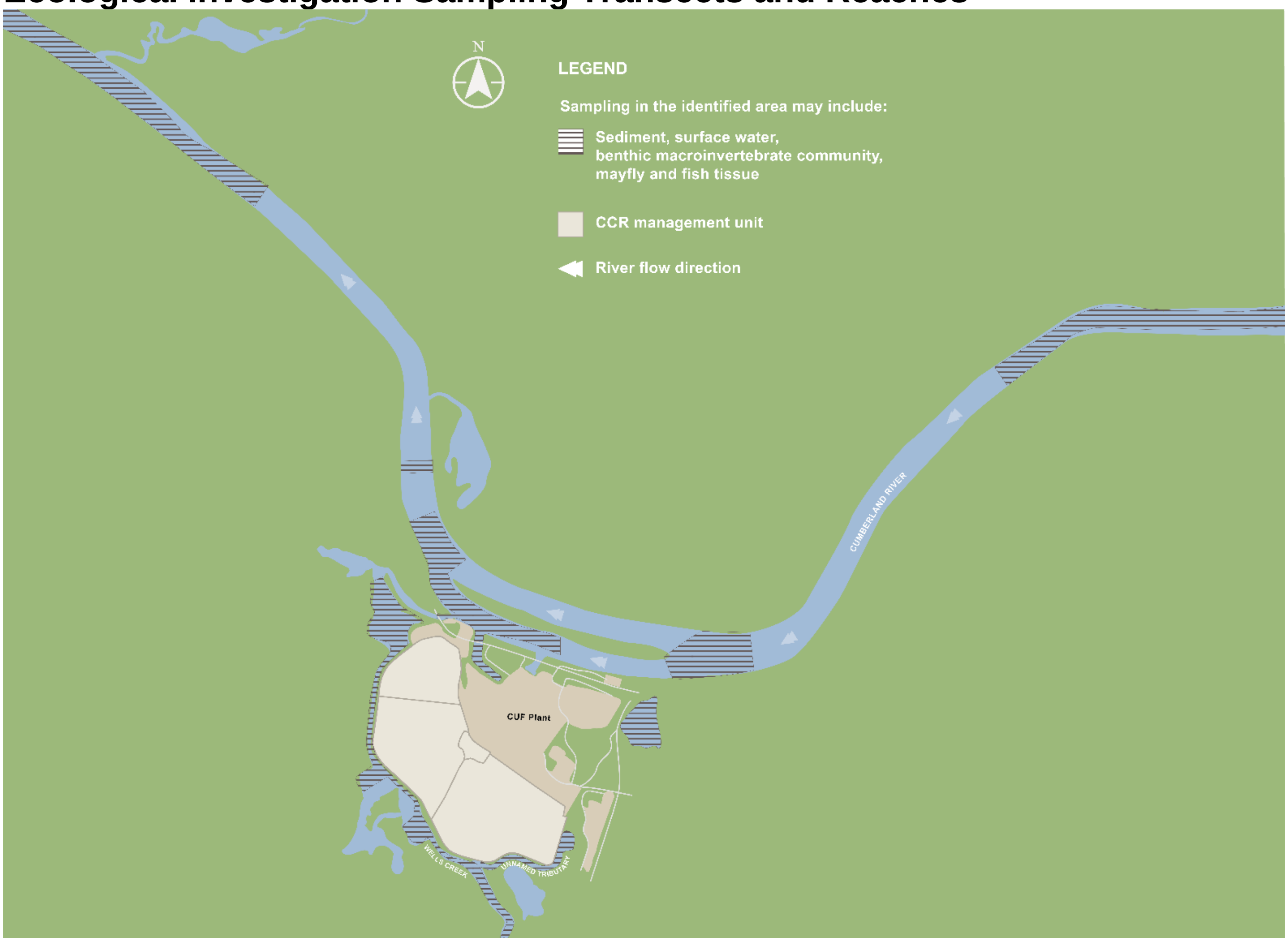
Prior to EIP approval, fish tissue samples were collected in April/May 2018, and mayfly tissue samples were collected in June 2018, in general accordance with the *Fish Tissue* and *Benthic SAPs* (Stantec 2018k and 2018j). The 2018 sampling events occurred in the same Cumberland River and Wells Creek reaches as the data collected for the EI. As such, the 2018 ecological data are considered supplemental to the EI and are included for evaluation in the EAR. A comparative analysis of the data collected during the 2018 supplemental and 2019 EI sampling events showed similar fish tissue and mayfly results for the Cumberland River and Wells Creek for both years as described in Appendices J.3 and J.5, respectively.

7.3 TDEC Order Investigation Activities

The objectives of the ecological investigations were to characterize water quality, sediment chemistry, benthic macroinvertebrate community composition, mayfly tissue, and fish tissue in the vicinity of the CUF Plant and to provide information to evaluate if CCR material and/or dissolved CCR constituents have moved from the CCR management units, potentially impacting these environmental media. In addition, sediment, mayfly, and fish tissue data were collected to evaluate potential bioaccumulation impacts.

The EI field activities were performed in 2018, 2019 and 2020 in general accordance with the *Surface Stream SAP, Benthic SAP, Fish Tissue SAP,* and the *QAPP*, including TVA- and TDEC-approved programmatic and project-specific changes made following approval of the EIP. Surface stream and sediment samples were collected from transects located upstream, adjacent, and downstream of the CCR management units in the Cumberland River and Wells Creek, at representative locations within the Unnamed Tributary adjacent to the CCR management units, and at single locations within the TVA Embayment and Discharge Channel. Mayfly (*Hexagenia*) and fish tissue samples were collected in sampling areas and reaches located in similar areas as the surface stream and sediment transects within the Cumberland River and Wells Creek (see below).

Ecological Investigation Sampling Transects and Reaches



In summary:

- A total of 234 primary surface stream samples were collected during EI activities: 130 from the Cumberland River, 73 from Wells Creek, and 31 from the Unnamed Tributary (Exhibit 7-1). 15 additional samples were collected from the Discharge Channel. Results for the Discharge Channel samples are presented and discussed below for completeness, but they are not evaluated further in this EAR since conditions in the Discharge Channel are not representative of natural surface stream conditions. Instead, they are managed under TVA's NPDES permit.

Technical evaluation of these sampling results is presented in the *Technical Evaluation of Surface Stream Data* (Appendix J.1), and investigation sampling information is provided in the *Surface Stream SAR* (Appendix J.2).

- A total of 68 shallow sediment samples and 57 deeper sediment samples were collected during EI activities from transects located in the Cumberland River (36 samples), Wells Creek (55 samples), Unnamed Tributary (20 samples), the TVA Embayment (six samples), and the Discharge Channel (eight samples) (Exhibit 7-2). Technical evaluation of these sampling results is presented in the *Technical Evaluation of Sediment and Benthic Invertebrate Data* (Appendix J.3), and investigation sampling information is provided in the *Benthic SAR* (Appendix J.4).

- A total of 29 composite mayfly tissue samples were collected during EI and Pre-EIP activities from three individual reaches in the Cumberland River and two reaches in Wells Creek (Exhibit 7-3). Technical evaluation of these sampling results is presented in Appendix J.3, and investigation sampling information is provided in Appendix J.4.

- Five fish species consisting of bluegill, redear sunfish, largemouth bass, channel catfish, and shad were targeted for EI and Pre-EIP sampling in sampling reaches located in the Cumberland River and Wells Creek (Exhibit 7-6). The fish were resected and composited to provide a total of 130 fish tissue samples (78 in the Cumberland River and 52 in Wells Creek) comprised of muscle, liver, and ovary tissue samples for the gamefish, and whole fish for the shad. Technical evaluation of these sampling results is presented in the *Technical Evaluation of Fish Community and Fish Tissue Data* (Appendix J.6), and investigation sampling information is provided in the *Fish Tissue SAR* (Appendix J.7).

- A total of 11 composite benthic macroinvertebrate community samples were collected from five transects located in the Cumberland River and six transects in Wells Creek. The five samples collected along each transect were processed individually by the laboratory, and individual sample taxa lists (and counts) were composited to generate a comprehensive taxa list for each sampled stream segment. Technical evaluation of these sampling results is presented in Appendix J.3, and investigation sampling methods are provided in Appendix J.4.

As noted above, because some sediment samples in the Unnamed Tributary collected during 2019 were above the 20% ash threshold in the *Surface Stream and Benthic SAPs* (Stantec 2018i and 2018j), triggering further investigation, Phase 2 supplemental surface stream and sediment sampling was performed in the Unnamed Tributary and immediately downstream of its confluence with Wells Creek in June/July 2021 pursuant to the *Surface Stream and Benthic SAP Addendum* (Stantec 2021). Phase 2 sampling included:

- In June 2021, surface stream water samples were collected along two transects in the Unnamed Tributary, at seven individual (single-point) locations in the Unnamed Tributary, and at one transect in Wells Creek downstream of the confluence with the Unnamed Tributary. During the Phase 2 investigation, 14 samples were collected from the Unnamed Tributary and three samples were collected from Wells Creek. Technical evaluation of these sampling results is presented in Appendix J.1, and investigation sampling information is provided in Appendix J.5.

- In June and July 2021, sediment samples were collected along three transects in the Unnamed Tributary, at seven individual (single-point) locations in the Unnamed Tributary, and at one transect in Wells Creek. During the Phase 2 investigation, 18 sediment samples were collected from the Unnamed Tributary and three samples were collected from Wells Creek. Technical evaluation of these sampling results is presented in Appendix J.3, and investigation sampling information is provided in Appendix J.5.

7.4 Results and Discussion

The following summarizes the results of the surface stream water, sediment, benthic macroinvertebrate community, mayfly tissue, and fish tissue investigations for the CUF Plant CCR management units. Sampling results for these media are presented in Exhibits 7-1 through 7-6.

Sampling data obtained during these investigations were evaluated by comparing measured concentrations to TDEC-approved screening levels for the EAR (Tables 1-2 through 1-5 and Appendix A.2). As described in Chapter 1.3.1, most screening levels are not regulatory standards, and are used to identify CCR Parameters in environmental media that require further evaluation in the CARA Plan to determine if an unacceptable risk exists and corrective action is required. In this section and the supporting technical evaluation appendices, screening values are used to evaluate potential impacts related to measured CCR Parameter concentrations. Screening values are conservative and protective of human and ecological health. Because they are conservative, sampling results above these levels do not necessarily indicate there are impacts to aquatic organisms or the environment, but rather, that the results require further evaluation in the CARA Plan.

Surface water screening levels for human health, which are based on use of surface water as a drinking water supply source, are applied only to surface stream results for the Cumberland River, as it is the only potable surface water source potentially affected by the CUF Plant CCR management units. Ecological screening levels, based on published studies of CCR Parameters health effects on ecological receptors, are applied to surface stream, sediment, mayfly tissue, and fish tissue results.

The ecological data evaluation approach utilized a two-step process. First, an exploratory data analysis (EDA) identified CCR Parameters present at concentrations higher than the EAR Ecological Screening Values (ESVs) (Tables 1-2 and 1-3 and Appendix A.2) in surface stream water and sediment samples. Second, when CCR Parameters were detected above surface water and sediment ESVs, fish and mayfly tissue concentrations for those constituents were compared to TDEC-approved Critical Body Residue (CBR) values. Due to their potential for bioaccumulation effects, mercury and selenium were evaluated in fish and mayfly tissue samples even if these constituents were not detected above ESVs in surface stream water and sediment samples.

7.4.1 Surface Stream, Sediment, Mayfly and Fish Tissues Analyses

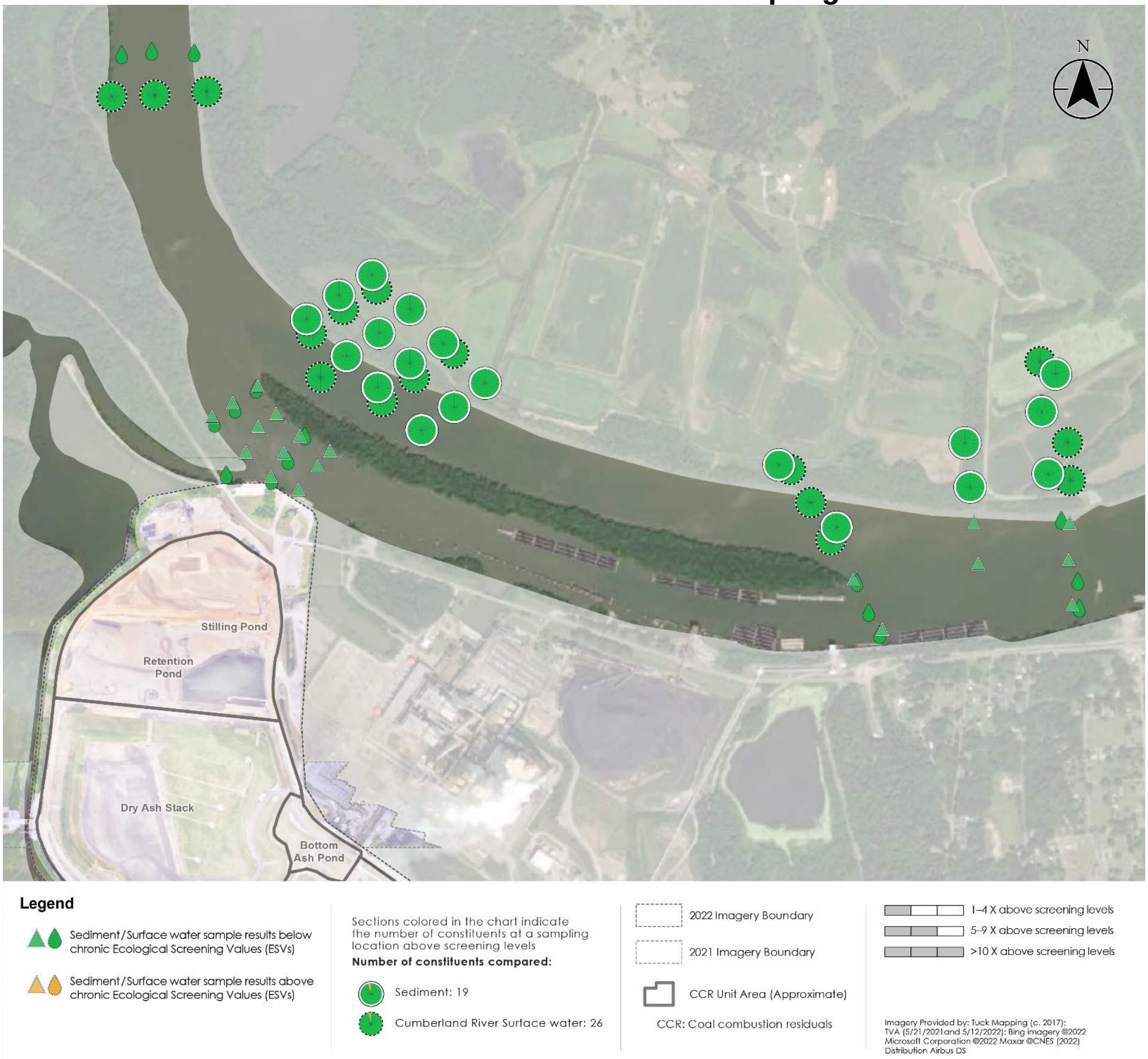
7.4.1.1 Cumberland River

CCR Parameter concentrations in surface stream samples from the Cumberland River were below human health screening levels and consistently below acute and chronic ESVs.

None of the PLM results for sediment samples from the Cumberland River were above 3% ash, well below the 20% ash threshold that would trigger Phase 2 supplemental sampling. Additionally, none of the CCR Parameter concentrations in sediment samples collected from the Cumberland River were above their respective ESVs as shown in the graphic below and on Exhibit 7-2.

Selenium and mercury concentrations in mayfly and fish tissue samples were detected above CBR values but showed very little variability in results upstream, adjacent, and downstream of the CUF Plant CCR management units (Exhibits 7-3 and 7-6). These data result from a sampling design formulated to minimize overlapping fish home ranges and to include different feeding guilds. The similar results for all reaches, in combination with results from historical fish community assessments and both historical and EI benthic community data, indicate that mayfly and fish tissue concentrations greater than CBR values, regardless of the source, are not impacting the fish or benthic communities in this area. Also, selenium and mercury were not detected at concentrations above their chronic or acute ESVs in either surface stream water or sediment within the Cumberland River.

Cumberland River Sediment and Surface Stream Sampling Locations



7.4.1.2 Wells Creek

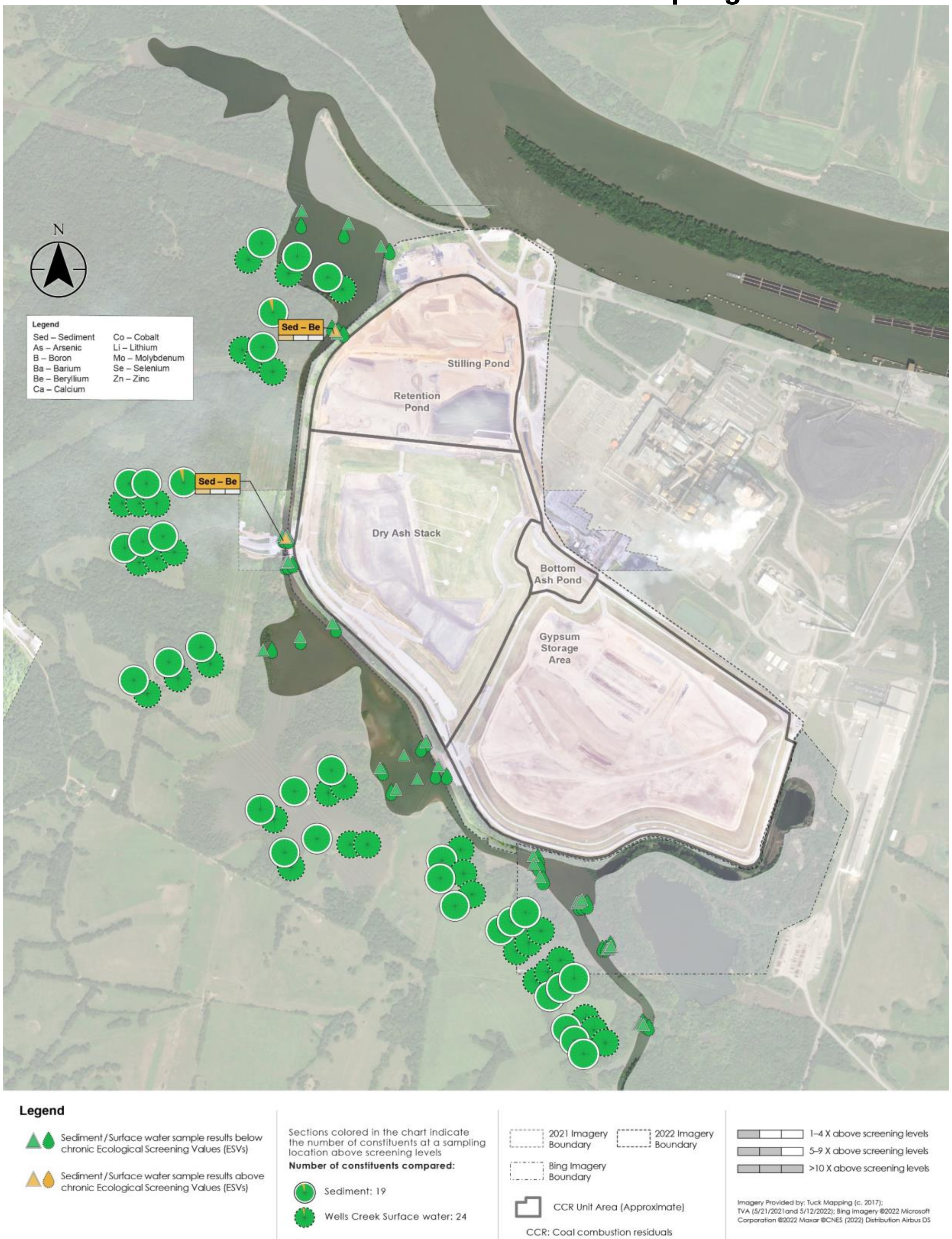
CCR Parameter concentrations in surface stream samples from Wells Creek were consistently below acute and chronic ESVs.

None of the PLM results for sediment samples from Wells Creek were above 4% ash, well below the 20% ash threshold that would have triggered Phase 2 supplemental sampling. Beryllium was detected in sediment at concentrations above its chronic ESV at two center channel locations adjacent to the CUF Plant CCR management units as shown in the graphic below and Exhibit 7-2. There are no applicable CBR values for comparison to mayfly tissue sample results. However, beryllium concentrations were below the CBR values for the tested whole fish samples.

Mercury concentrations were below CBR values in the mayfly tissue samples collected from the sampling locations in Wells Creek. Of the 52 fish tissue samples collected from Wells Creek, mercury concentrations were above CBR values in 33 of the samples and selenium concentrations were above CBR values in 16 of the samples. Selenium concentrations measured in the 11 mayfly tissue samples were above CBR values (Exhibit 7-3). Both fish tissue and mayfly results were similar in the two Wells Creek sampling reaches, and both were similar to the Cumberland River reaches. Overall, and in combination with the benthic community results discussed in Section 7.4.2, these results do not indicate potential impacts from the CCR management units to the fish or benthic invertebrate communities in the vicinity of the CUF Plant.

Based on the above evaluation, beryllium in sediment will be further evaluated in the CARA Plan.

Wells Creek Sediment and Surface Stream Sampling Locations



7.4.1.3 TVA Embayment and Discharge Channel

None of the PLM results for sediment samples from the TVA Embayment and the Discharge Channel were above the 20% ash threshold, and none of the CCR Parameter concentrations in surface stream water or sediment samples were above their respective ESVs. As noted above, as the Discharge Channel is not representative of natural surface stream conditions and is managed under the TVA's NPDES permit, the Discharge Channel results are not further discussed or evaluated in the EAR.

7.4.1.4 Unnamed Tributary

In the Unnamed Tributary, surface stream water samples contained boron and calcium concentrations above chronic ESVs, with concentrations of both parameters decreasing downstream. Potential surface stream water quality impacts are localized since the downstream receiving waters of Wells Creek have consistently low concentrations of boron and calcium below their respective ESVs.

PLM results for multiple sediment samples collected from Ponds 3A and 3B, the two farthest upstream impoundments of the Unnamed Tributary, were above the 20% ash threshold. The % ash results were above the 20% Phase 2 trigger in 9 of 10 sediment samples collected from transects UT01 and UT01.5 in Pond 3B and transects UT02 and UT03 in Pond 3A. The values above the threshold ranged from 21% to 41% as shown on Exhibit 7-2. PLM results for samples collected further downstream in the Unnamed Tributary were below the 20% ash threshold. Because of the PLM results above the 20% ash threshold value in Ponds 3A and 3B of the Unnamed Tributary, Phase 2 supplemental sampling was implemented in June/July 2021. Phase 2 sampling included analyzing for the CCR Parameters in the retained deeper sediment samples collected during Phase 1 and conducting additional sediment sampling in the Unnamed Tributary, as well as at a location in Wells Creek directly downstream from its confluence with the Unnamed Tributary.

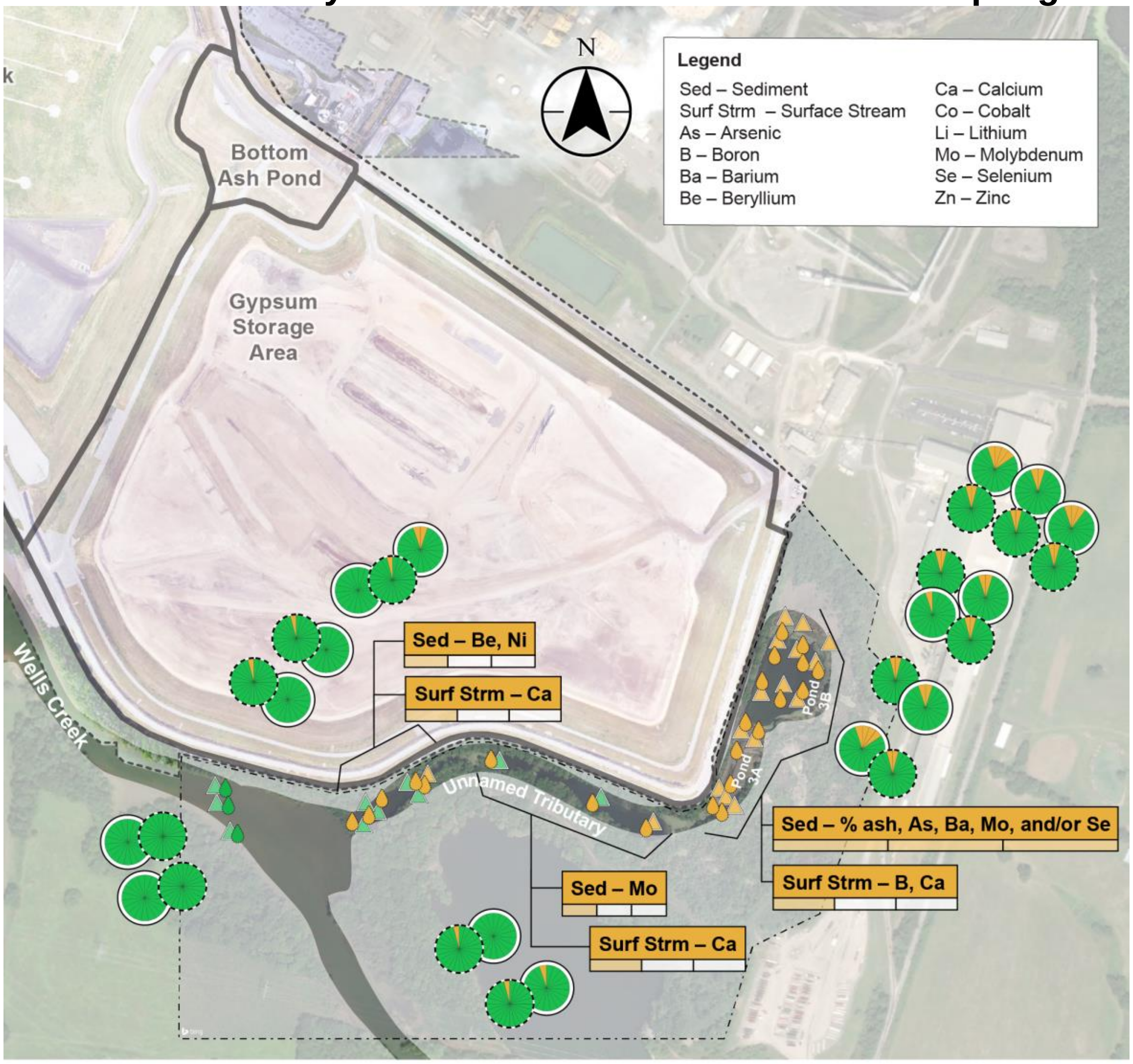
The Phase 1 and Phase 2 EDA identified no sediment results for the CCR Parameters at concentrations above their respective acute ESVs. The Phase 1 EDA identified arsenic, barium, molybdenum, and selenium concentrations above their respective chronic ESVs for one or more locations in Ponds 3A and 3B. Concentrations of the remaining CCR Parameters were below their respective chronic and acute ESVs in Phase 1 sediment samples from Ponds 3A and 3B. The Phase 2 EDA identified % ash results above 20% in all sediment samples collected from transect UT0.5. The values ranged from 24% to 40% as shown on Exhibit 7-5. The Phase 2 EDA identified concentrations of arsenic, barium, and molybdenum above their respective chronic ESVs for one or more locations in Pond 3B, concentrations of molybdenum above its chronic ESV for one or more locations in Ponds 2 and 3A, and concentrations of beryllium and nickel at concentrations above their respective chronic ESVs for one location in Pond 1. Concentrations of the remaining CCR Parameters were below their respective chronic and acute ESVs in Phase 2 sediment samples from the Unnamed Tributary. CCR Parameter concentrations in Phase 1 and Phase 2 sediment samples collected farther downstream were below chronic or acute ESVs. Surface Stream and Sediment sample results for the Phase 1 and Phase 2 EDA in the Unnamed Tributary are shown in the graphic below and on Exhibits 7-4 and 7-5.

Fish tissue and mayfly sampling was not performed in the Unnamed Tributary, nor required in the EI SAP, because physical habitat limitations in this waterbody prevent sustained mayfly and sportfish communities (e.g., anoxic sediment conditions, lack of appropriate substrate, appreciable depth of organic materials, lack of depth, and volume of water).

In conjunction with the PLM results, the detected concentrations of arsenic, barium, beryllium, molybdenum, nickel, and selenium in sediment samples from the Unnamed Tributary suggest that CCR material is present within these impoundments, indicating a potential CCR material source from one or more adjacent operation areas. As described in

Chapter 2.4.2.2, historical industrial operations by TVA and adjacent landowners in this area are uncertain, and as such, potential sources, processes, and pathways will be further evaluated. Based on the Phase 1 and Phase 2 sampling results, downstream sediment sampling results indicate concentrations above ESVs are limited within the Unnamed Tributary, and results above ESVs are not present further downstream in Wells Creek. The Phase 1 and Phase 2 data are being further evaluated; those results and evaluations will be provided in the CARA Plan.

Unnamed Tributary Sediment and Surface Stream Sampling Locations



Legend

Sediment/Surface water sample results below chronic Ecological Screening Values (ESVs)

Sediment/Surface water sample results above chronic Ecological Screening Values (ESVs)

Sections colored in the chart indicate the number of constituents at a sampling location above screening levels

Number of constituents compared:

Sediment: 19

Unamed Tributary Surface water: 24

2021 Imagery Boundary

2022 Imagery Boundary

Bing Imagery Boundary

CCR Unit Area (Approximate)

CCR: Coal combustion residuals

1–4 X above screening levels

5–9 X above screening levels

>10 X above screening levels

Imagery Provided by: Tuck Mapping (c. 2017); TVA (5/21/2021and 5/12/2022); Bing imagery ©2022 Microsoft Corporation ©2022 Maxar ©CNES (2022) Distribution Airbus DS

7.4.2 Benthic Macroinvertebrate Community Analysis

Benthic macroinvertebrate community sampling was conducted in the Cumberland River and Wells Creek. Ponar dredge sampling was performed at locations upstream and adjacent to the CUF Plant CCR management units in Wells Creek, and at upstream, adjacent, and downstream locations in the Cumberland River. The benthic community sample data were composited by transect to capture a comprehensive cross section of the existing benthic community in each representative stream segment. Community metrics were then used as indicators of biological integrity and water quality, including an RBI Total Score and supplemental metrics as described below.

Generally, the benthic macroinvertebrate community metrics were corroborative and demonstrated spatially consistent relationships among indicators. The RBI results for the Cumberland River and Wells Creek, representative of overall biological integrity, generally showed Total Scores increasing from upstream to downstream, and healthier communities adjacent to and downstream of the CUF Plant in comparison to upstream control transects. This relationship was also observable in historical data from the Cumberland River, particularly from 2014 to the most recent monitoring in 2019 and does not reflect negative impacts associated with CUF Plant CCR management units.

In addition to the inclusive multi-metric RBI results, supplemental metrics were calculated and are included in Appendix J.3, where the results are discussed in greater detail. Of these, select metrics that offer corroborative information for discussion in this EAR include Total Taxa Richness and the Hilsenhoff Biotic Index (HBI). Total Taxa Richness is a count of the number of different types of organisms (typically as genera or next lowest practicable identification level) observed within the benthic community samples collected from each transect. This evaluation indicates benthic communities adjacent to and downstream of the CUF Plant CCR management units are approximately equivalent in richness to upstream control transects, and that the two farthest downstream transects support the richest aquatic communities. The HBI is a metric that reflects environmental stress tolerance for the community as a whole. The HBI evaluation indicates that environmental stressors adjacent to the CCR management units appear to be roughly equivalent or slightly less severe than conditions at upstream control locations. The evaluation of these metrics corroborates the findings of the RBI evaluation.

Additionally, in support of these benthic macroinvertebrate community results, RFAI scores were reviewed from historical NPDES biological monitoring studies. RFAI scores from 2007 through 2019 indicated consistent and balanced indigenous fish populations, with minor seasonal variations over a 13-year period. These findings are also consistent with EI benthic community results described above.

In summary, benthic communities within adjacent and downstream areas appear to be at least as healthy, rich, and sensitive as unimpacted control locations upstream of the CUF Plant CCR management units. Potential impacts from the CCR management units in surface streams are not reflected in the benthic community data.

7.5 Surface Streams, Sediment, and Ecological Investigation Summary

The evaluation of EI surface stream, sediment, benthic macroinvertebrate community, mayfly tissue, and fish tissue sampling results indicates that potential impacts to water quality and aquatic life are predominantly limited within Ponds 3A and 3B of the Unnamed Tributary as summarized below.

- Surface stream water quality in the Cumberland River and Wells Creek is within ranges protective of human health and aquatic life. Sampling results were below chronic ESVs (Table 1-2) and indicate no potential water quality impacts from the CCR management units. Within the Unnamed Tributary, boron, and calcium results above chronic ESVs were highest within Ponds 3A and 3B but decrease downstream and were not above ESVs in the receiving waters of Wells Creek (Exhibit 7-1).

- Sediment quality is within ranges protective of aquatic life in the Cumberland River. Sampling results for % ash and CCR Parameter concentrations in sediment samples from the Cumberland River and Wells Creek were below the % ash screening level and chronic ESVs (Table 1-3), respectively, except for two beryllium results in Wells Creek. These results indicate that sediment quality in the Cumberland River and Wells Creek are generally within ranges that are protective of aquatic life. Sampling results for % ash and CCR Parameter concentrations in sediment samples from the lower reaches of the Unnamed Tributary were below the % ash screening level. Phase 1 sediment sampling results identified arsenic, barium, molybdenum, and selenium above chronic ESVs in Ponds 3A and 3B of the Unnamed Tributary (Exhibit 7-2). Phase 2 sediment sampling results from the Unnamed Tributary identified arsenic, barium, and molybdenum above chronic ESVs in Pond 3B, molybdenum above its chronic ESV in Ponds 2 and 3A, and beryllium and nickel above their respective chronic ESVs at one location in Pond 1 (Exhibit 7-5).

- The adjacent and downstream mayfly and fish tissue sampling results for both the Cumberland River and Wells Creek were similar to upstream control locations. The similar results for all reaches in combination with results from historical fish community assessments and benthic community data indicate there are no potential ecological impacts or bioaccumulation effects within these populations related to the CUF Plant CCR management units.

- The adjacent and downstream benthic communities appear to be at least as healthy, rich, and sensitive as unimpacted upstream control locations, and collectively, the benthic community data reflect no potential impacts from the CCR management units.

Overall, the EI sample results in conjunction with historical benthic community and fish population data demonstrate healthy and consistent ecological communities within the investigation area and indicate that the CUF Plant CCR management units have had minimal, if any, potential impacts to sediment and surface stream water quality or ecological communities of the Cumberland River or Wells Creek. Within the Unnamed Tributary, surface stream water and sediment results above screening levels suggest that CCR material is present primarily in Ponds 3A and 3B. Potential sources, processes, and pathways will be further evaluated.

Based on the EI findings, % ash and sampling results above ESVs will be further evaluated within the context of the overall EI results in the CARA Plan, including specific evaluations of boron and calcium in surface stream water and % ash, arsenic, barium, beryllium, molybdenum, nickel, and selenium in sediment in the Unnamed Tributary, and beryllium in sediment in Wells Creek.

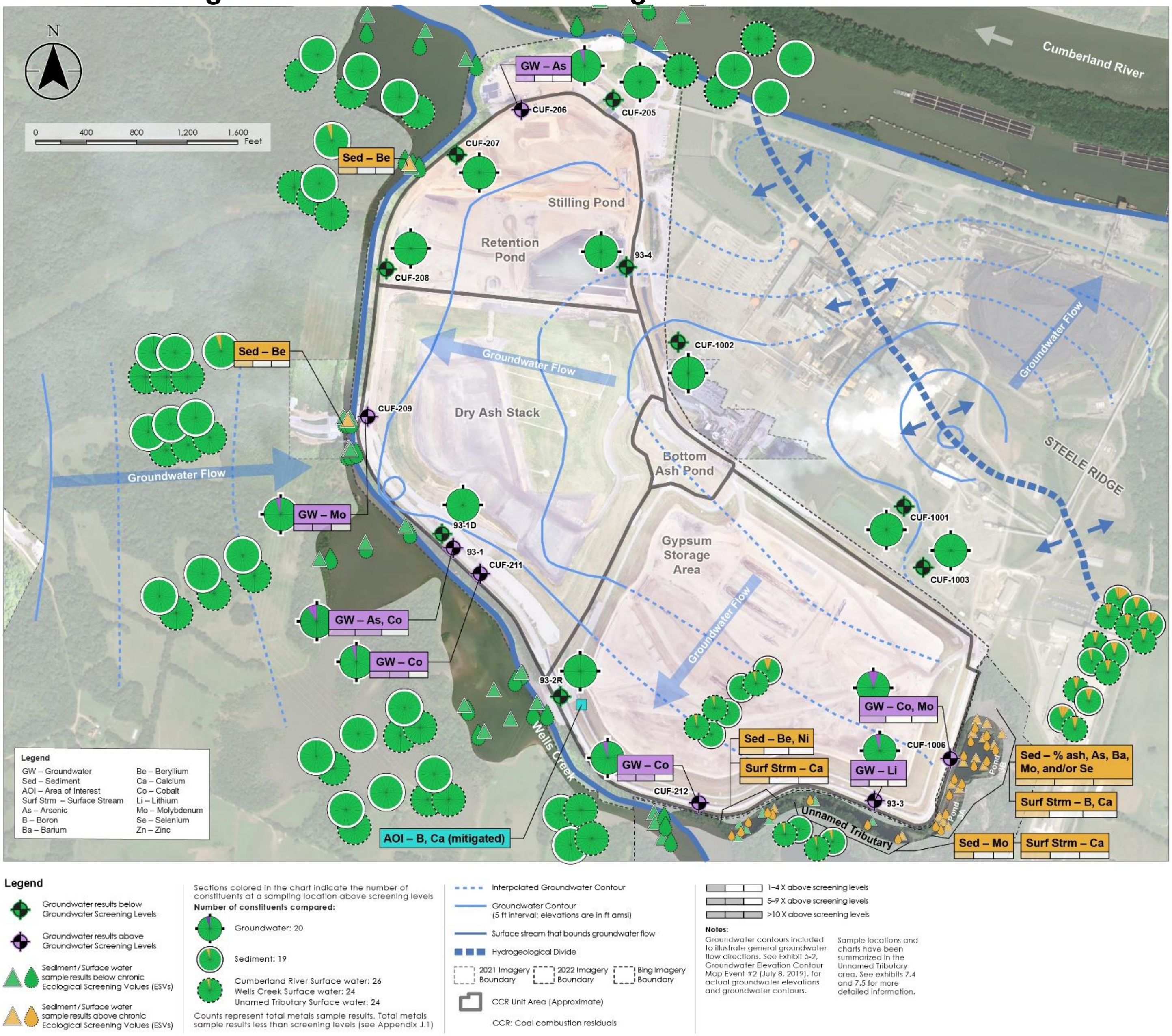
Chapter 8 TDEC Order Investigation Summary and Conceptual Site Models

This section summarizes the assessment of CCR material, structural stability and integrity of the CCR management units, and extent of CCR Parameters within environmental media investigated during the EI at the CUF Plant. CSMs for the CCR management units and overall findings are also presented based on the EI and associated historical and ongoing program results. CSMs describe sources of CCR constituents, pathways by which they can move, and environment media potentially impacted if they are released.

Analytical results were compared to TDEC-approved EAR screening levels to identify areas that require further evaluation. Most screening levels are not regulatory standards and are conservatively based on published health studies. Concentrations above the screening level do not necessarily mean that an adverse health effect is occurring, but rather, that further evaluation is required in the CARA Plan to determine if an unacceptable risk exists, and if corrective action is required. Potential slope stability impacts were defined as those areas having analysis results (i.e., factors of safety) that do not meet TDEC-approved criteria for one or more load cases. This section provides a summary of potential impacts identified during the EI that will be further evaluated in the CARA Plan.

Several EI findings are common among the CCR management units and are discussed in Chapter 8.1. Specific EI findings and CSMs for each CCR management unit are described in Chapters 8.2 through 8.5 and presented in Exhibits 8-1 through 8-4. These exhibits depict findings discussed in this EAR on a representative cross-section of subsurface conditions for each unit. Results of the EI are presented for the overall investigation area in Exhibit 8-5 and near the CCR management units in Exhibit 8-6.

Overall Findings Near CUF Plant CCR Management Units



8.1 Common Findings

The common EI findings for the CUF Plant CCR management units are as follows:

Structural Stability and Integrity: The four CCR management units have adequate structural integrity, and there is no evidence of voids/cavities in bedrock that could lead to loss of structural support and potential release of overlying CCR materials.

Hydrogeology: The alluvial sands and gravels above bedrock beneath the CCR management units have been defined as the uppermost aquifer and are monitored downgradient of the CCR management units. Where the sands and gravels are absent in the eastern part of the CCR management unit area, the underlying bedrock has been defined as the uppermost aquifer. Other observed lithologies (e.g., clays, silts and bedrock) typically have not produced usable amounts of water but are monitored at certain locations for spatial distribution where the sands and gravels are laterally absent. The uppermost aquifer is considered to be under confined conditions and is typically overlain by clays and silts that act as an aquitard. Groundwater in the confined aquifer is not in contact with the CCR material inside the CCR management unit where the aquitard is present because the aquitard physically separates them.

The groundwater flow direction within the uppermost aquifer beneath the CCR management units is generally to the west and southwest towards Wells Creek. In the northwestern part of the CCR management units, groundwater flow is to the northwest toward Wells Creek and north toward the Cumberland River. Groundwater flow in the vicinity of the CCR management units is bounded to the north by the Cumberland River and to the south and west by Wells Creek. There is a groundwater flow divide in the area of the CUF Plant that separates flow to the Cumberland River to the northeast from flow to the southwest toward Wells Creek.

The low permeability of the perimeter dikes limits lateral flow, and the clays and silts at the base of the CCR management units impede vertical flow of pore water. Pore water within the CCR material has specific chemical characteristics that are different from the characteristics of groundwater downgradient of the CCR management units. Certain CCR constituents that have been detected in pore water are affected by geochemical processes during impeded transport by groundwater through geological materials. The effect of these geochemical processes, which can result in the attenuation of CCR constituents and reduced dissolved groundwater concentrations, can explain the observed differences between the characteristics of pore water and groundwater. Additional geochemical evaluation related to CCR constituents in groundwater is ongoing as part of compliance with the CCR Rule, and findings will be incorporated into the CARA Plan.

Surface Streams: Surface stream water quality in the Cumberland River and Wells Creek is within ranges protective of human health and aquatic life. Sampling results were below chronic ESVs and indicate no potential water quality impacts from the CCR management units.

Sediment: Sediment quality is within ranges protective of aquatic life in the Cumberland River adjacent to and downstream of the CCR management units. Within Wells Creek, only beryllium was identified above the chronic ESV at two sediment sample locations.

Bioaccumulation: Mayfly and fish tissue results are similar upstream, adjacent, and downstream of the CCR management units, with some results (mercury in fish tissue and selenium in fish and mayfly tissues) above the ESVs. Mercury and selenium have not been detected in groundwater samples presented in the EAR. This, along with the absence of mercury and selenium above ESVs in surface water and sediment, indicate that potential bioaccumulation of mercury and selenium likely is not related to the CCR management units.

Benthic Communities: The adjacent and downstream benthic communities in the Cumberland River and Wells Creek appear to be similarly healthy, rich, and sensitive as upstream control locations, and collectively, the benthic community data suggest no potential impacts from the CCR management units.

Seeps: Although one seep was identified during the EI, it has been mitigated under the NPDES permit, and no known active seeps are present at the CUF Plant. Monitoring continues to be performed in accordance with the CUF Plant NPDES permit.

Water Use Survey: One spring was identified in the AOI located south/southeast of the CUF Plant and sampled. Based on the overall results of the survey, current and historical CCR management associated with the CUF Plant have not affected water supply wells or springs located downgradient of the CUF Plant.

8.2 Gypsum Storage Area

A summary of EI evaluation findings and a CSM for the Gypsum Storage Area is provided on Exhibit 8-1 in cross-sectional view and on Exhibit 8-6 in plan view. These exhibits also illustrate surrounding units and surface streams for the Gypsum Storage Area.

CCR material in this unit is gypsum above sluiced fly ash and bottom ash, and the estimated total volume of CCR material is about 11.5 million cubic yards. The structural stability evaluation indicates that global and veneer slope stability meet the established factor of safety criteria for the static load cases. For the seismic load cases, the evaluation indicates that veneer slope stability meets the established factor of safety criteria, and that the pseudostatic global and post-earthquake global load cases will meet the criteria as TVA implements targeted regrading as part of its ongoing gypsum harvesting activities. Slope stability for the closed condition will be addressed after closure design is defined.

Most TDEC Appendix I and CCR Rule Appendix IV CCR constituent concentrations in onsite groundwater were below GSLs. The primary constituents of interest in groundwater for the Gypsum Storage Area are cobalt, lithium, and molybdenum. The concentrations of cobalt, lithium, and molybdenum were below the ESVs in sediment and surface water samples in Wells Creek.

The results of the EI and other ongoing ecological monitoring programs indicate operations at this CCR management unit have not impacted downstream surface stream water quality, benthic macroinvertebrate communities, or mayfly and fish tissues and populations in Wells Creek or the Cumberland River.

In the Unnamed Tributary, during the Phase 1 and Phase 2 sampling events, boron and calcium were detected above ESVs in surface water samples, but concentrations decreased farther downstream. Sediment sample concentrations of arsenic, barium, and selenium above ESVs are limited within Ponds 3A and 3B, the farthest upstream impoundments, and are below ESVs further downstream in the Unnamed Tributary. Molybdenum was detected above chronic ESVs in Ponds 2, 3A and 3B, and beryllium and nickel were above their respective chronic ESVs at one location in Pond 1. In conjunction with the PLM results, the sediment results in the Unnamed Tributary suggest that CCR material is present. Potential sources, processes, and pathways will be further evaluated in the CARA Plan.

In summary, potential impacts associated with the Gypsum Storage Area CCR management unit based on EI sampling results are limited to boron and calcium in surface stream water in the Unnamed Tributary; % ash, arsenic, barium, beryllium, molybdenum, nickel, and selenium in sediment in the Unnamed Tributary; and cobalt and lithium in onsite groundwater, each at one monitoring well. These constituents will be further evaluated and addressed in the CARA Plan. In addition, stability analyses will be performed after closure design is defined.

8.3 Dry Ash Stack

A summary of EI evaluation findings and a CSM for the Dry Ash Stack is provided on Exhibit 8-2 in cross-sectional view, and on Exhibit 8-6 in plan view. These exhibits also illustrate surrounding units and surface streams for the Dry Ash Stack.

CCR material is sluiced fly ash and bottom ash overlain by stacked fly ash and bottom ash, with an estimated total volume of about 11.1 million cubic yards. The structural stability evaluation indicates that global and veneer slope stability meet the established factor of safety criteria for the static and seismic load cases. Slope stability for the closed condition will be addressed after closure design is defined.

Most TDEC Appendix I and CCR Rule Appendix IV CCR constituent concentrations in onsite groundwater were below GSLs. The primary constituents of interest in groundwater for the Dry Ash Stack are arsenic, cobalt, and molybdenum. The concentrations of arsenic, cobalt, and molybdenum were below ESVs in sediment and surface water samples in Wells Creek.

Beryllium was detected at only one location in sediment adjacent to this CCR management unit in Wells Creek, at a concentration above the chronic ESV (1.1 times the ESV). Beryllium was not detected above the GSL in groundwater samples from wells at the Dry Ash Stack, and beryllium was not above ESVs in surface stream water and fish tissue samples downstream of this unit. Ash was not detected in sediment samples in Wells Creek above 4%, which is well below the 20% ash threshold trigger level for Phase 2 sampling.

The results of the EI and other ongoing ecological monitoring programs indicate operations at this CCR management unit have not impacted adjacent or downstream surface stream water quality, benthic macroinvertebrate communities, or mayfly and fish tissues and populations in Wells Creek or the Cumberland River.

In summary, potential impacts associated with the Dry Ash Stack CCR management unit appear to be limited to a single detection of beryllium in sediment in Wells Creek, and arsenic, cobalt, and molybdenum in onsite groundwater in certain monitoring wells. These constituents will be further evaluated and addressed in the CARA Plan. In addition, stability analyses will be performed after closure design is defined, if needed.

8.4 Bottom Ash Pond

A summary of EI findings and a CSM for the Bottom Ash Pond is provided on Exhibit 8-4 in cross-sectional view and on Exhibit 8-6 in plan view. These exhibits also illustrate surrounding units and surface streams for the Bottom Ash Pond.

CCR material is sluiced bottom ash and fly ash, with an estimated total volume of CCR of about 390,000 cubic yards. The structural stability evaluation indicates that global and veneer slope stability meet the established factor of safety criteria for the static and seismic load cases.

Groundwater quality for the Bottom Ash Pond is monitored as part of the groundwater monitoring system for the Gypsum Storage Area and Dry Ash Stack summaries presented above.

The Gypsum Storage Area and Dry Ash Stack are located between the Bottom Ash Pond and Wells Creek; therefore, evaluations of potential impacts of this unit on surface streams and sediments are included in the above discussions for the Gypsum Storage Area and Dry Ash Stack.

8.5 Stilling Pond (Including Retention Pond)

A summary of EI findings and a CSM for the Stilling Pond (including Retention Pond) is provided on Exhibit 8-3 in cross-sectional view and on Exhibit 8-6 in plan view. These exhibits also illustrate surrounding units and surface streams for the Stilling Pond (including Retention Pond).

CCR material is sluiced fly ash and bottom ash, with an estimated total volume of about 1.3 million cubic yards prior to TVA initiating ongoing projects to convert these units to process water basins. The structural stability evaluation indicates that global and veneer slope stability meet the established factor of safety criteria for the static and seismic load cases.

Ongoing repurposing construction activities are expected to positively impact conditions by lowering the pore water phreatic surface.

Most TDEC Appendix I and CCR Rule Appendix IV CCR constituent concentrations in onsite groundwater are below GSLs. Arsenic is the only constituent of interest in groundwater for the Stilling Pond (including Retention Pond) at one monitoring well. Ongoing repurposing of this unit may affect groundwater quality including arsenic concentrations. Arsenic was below ESVs in sediment and surface water samples in Wells Creek and the Cumberland River.

Beryllium was detected at one location in sediment adjacent to this CCR management unit in Wells Creek, at a concentration above the chronic ESV (1.3 times the ESV). Beryllium was not detected in groundwater samples above the GSL in wells at the Stilling Pond (including Retention Pond), and beryllium was not above ESVs in surface stream water and fish tissues downstream of this unit in Wells Creek or in the Cumberland River. Ash was not detected in sediment samples in Wells Creek above 4%, which is well below the 20% ash threshold trigger level for Phase 2 sampling.

The results of the EI and other ongoing ecological monitoring programs indicate operations at this CCR management unit have not impacted adjacent or downstream surface stream water quality, benthic macroinvertebrate communities, or mayfly and fish tissues and populations in Wells Creek or the Cumberland River.

Based on the results of the EI and other ongoing monitoring programs, potential impacts associated with the Stilling Pond (including Retention Pond) CCR management unit appear to be limited to a single detection of beryllium in sediment and arsenic in onsite groundwater at one monitoring well. These constituents will be further evaluated and addressed in the CARA Plan.

Chapter 9 Conclusions and Next Steps

9.1 CONCLUSIONS

In accordance with the TDEC Order, TVA prepared an EIP for the CUF Plant CCR management units to obtain and provide information requested by TDEC. As specified in the Order, the objective of the EIP was to "identify the extent of soil, surface water, and ground water contamination by CCR" from onsite management of CCR material in impoundments and landfills. In addition, per TDEC's information requests, the EIP included assessment of CCR management unit structural stability and integrity. Between 2018 and 2021, TVA and Stantec implemented EI activities in accordance with the approved EIP. The EI included characterization of the site hydrogeology and investigations of CCR material, groundwater, background soils, seeps, surface streams, sediments, and ecology, as well as a supplemental Phase 2 investigation within the Unnamed Tributary and the Water Use Survey.

This EAR presents the results of those investigations, describes the extent of surface stream water, sediment, and groundwater contamination from the CUF Plant CCR management units, and provides the information, data, and evaluations used to make those assessments. Geotechnical analysis findings and environmental sampling results above TDEC approved screening levels in specific media will be further evaluated in the CARA Plan to determine whether unacceptable risks exist that require corrective action. As required by the TDEC Order, this EAR will be revised to address TDEC comments until the objective of the EIP is met.

In summary, more than 97% of the environmental sample results from over 1,000 samples were below screening levels. Most screening levels are not regulatory standards and are conservatively based on published health studies. The EI data indicate impacts to limited onsite groundwater areas and that the CCR management units have had minimal, if any, potential impacts to sediment and surface stream water quality, and ecological communities in Wells Creek or the Cumberland River. The EI data will be used to evaluate the basis and methods for CCR management unit closure in the CARA Plan and does not preclude evaluation of closure in place as a viable closure method, nor the continued harvesting of gypsum and fly ash for the manufacture of building materials. The following are overall assessment findings for the investigation based on data as presented in this EAR:

- Surface stream water quality is within ranges protective of human health and aquatic life in the Cumberland River and Wells Creek. Potential risks associated with surface stream water in the Unnamed Tributary will be further evaluated in the CARA Plan to determine if corrective action is needed.
- Sediment quality is within ranges protective of aquatic life in the Cumberland River adjacent to and downstream of the CCR management units. Potential risks associated with sediment at two locations in Wells Creek and sediments in the Unnamed Tributary will be further evaluated in the CARA Plan to determine if corrective actions are needed.
- The EI data indicate that ecological communities are healthy in the Cumberland River and Wells Creek adjacent to and downstream of the CCR management units.
- The CCR management units have adequate structural stability, and slopes are stable under current static and seismic loading conditions (the Gypsum Storage Area will meet seismic global stability criteria as TVA implements targeted regrading as part of its ongoing gypsum harvesting activities). Additional seismic stability

assessments are necessary once closure is defined and will be included in the CARA Plan or in the closure design.

- There are no known active seeps onsite. One seep was identified during the EI and mitigated under the NPDES Permit.
- Most CCR constituent concentrations in groundwater are below GSLs, and groundwater impacts are limited to areas downgradient along the perimeter of the CCR management units. However, additional assessments will be included in the CARA Plan to evaluate methods and design for corrective action for targeted groundwater at well locations with constituents above GSLs.
- Groundwater flow in the unconsolidated materials and bedrock is bounded to the south, west, and north by the Cumberland River and Wells Creek. A northwest-southeast trending groundwater divide to the northeast of the CCR management units separates groundwater flow northeast of the divide to the Cumberland River from groundwater flow to the southwest toward Wells Creek.
- Based on the overall results of the water use survey, current and historical CCR management associated with the CUF Plant have not affected water supply wells or springs located downgradient of the CUF Plant.

The following summary provides the specific findings requiring further evaluation in the CARA Plan. Because the Bottom Ash Pond is not adjacent to a surface water body and is monitored as part of the groundwater monitoring system that includes the Gypsum Storage Area and Dry Ash Stack, the surface stream, sediment, ecological, and groundwater results for the Gypsum Storage Area and Dry Ash Stack presented below are also representative of the Bottom Ash Pond.

Summary of Findings Requiring Further Evaluation in the CARA Plan			
CCR Management Unit	**Stability**	**Groundwater**	**Surface Stream, Sediment, Ecology**
Gypsum Storage Area	Additional analysis for seismic loading after closure design is defined	Lithium (Well 93-3*) Cobalt (Well CUF-212* and CUF-1006) Molybdenum (Well CUF-1006)	Boron and calcium in surface stream water within the Unnamed Tributary, and % ash, arsenic, barium, beryllium, molybdenum, nickel, and selenium in sediment within the Unnamed Tributary
Dry Ash Stack	Additional analysis for seismic loading after closure design is defined	Molybdenum (Well CUF-209) Arsenic (Well CUF-93-1*) Cobalt (Wells CUF-93-1* and CUF-211)	Beryllium in sediment within Wells Creek (one sample)
Bottom Ash Pond	None	Included in Gypsum Storage Area and Dry Ash Stack findings	
Stilling Pond (Including Retention Pond)	None	Arsenic (Well CUF-206)	Beryllium in sediment within Wells Creek (one sample)

* Monitoring wells installed in borings drilled through CCR material.

9.2 Next Steps

This EAR has been revised to include the results and evaluation of the Phase 2 sampling in the Unnamed Tributary, evaluation of groundwater quality east of the Gypsum Storage Area, updated seismic stability analyses, and the results of the Water Use Survey.

Upon approval of the EAR, TVA will prepare and submit a CARA Plan to TDEC in accordance with the TDEC Order. The CARA Plan, which will be subject to a public review and comment process, will evaluate whether unacceptable risks related to management of CCR exist at the CUF Plant. TVA continues to evaluate additional means to beneficially reuse these materials in a manner consistent with regulatory requirements while maximizing value to the Tennessee Valley. The CARA Plan will also specify the actions TVA plans to take at the CCR management units and the basis of those actions. It also will incorporate other operational changes planned or in progress by TVA, including details for continued CCR beneficial use operations, modification of the CCR management units as needed to meet regulatory standards for seismic stability and long-term closure and monitoring.

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TVA. ENV-TI-05.80.05, Field Sampling Equipment Cleaning and Decontamination.

TVA. ENV-TI-05.80.06, Handling and Shipping of Samples.

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TABLES

Table 1-1. Human Health Screening Levels for Groundwater
Environmental Assessment Report

CCR Parameters	Groundwater Screening Levels (µg/L)	Source
CCR Rule Appendix III Constituents :		
Boron	4,000	RSL
Calcium	--	--
Chloride	250,000	SMCL
Fluoride	4,000	MCL
pH	6.5-8.5 S.U.	SMCL
Sulfate	250,000	SMCL
Total Dissolved Solids	500,000	SMCL
CCR Rule Appendix IV Constituents :		
Antimony	6	MCL
Arsenic	10	MCL
Barium	2,000	MCL
Beryllium	4	MCL
Cadmium	5	MCL
Chromium (total)	100	MCL
Cobalt	6	CCR Rule GWPS
Fluoride	4,000	MCL
Lead	15	CCR Rule GWPS
Lithium	40	CCR Rule GWPS
Mercury	2	MCL
Molybdenum	100	CCR Rule GWPS
Radium-226 & 228	5 pCi/L	MCL
Selenium	50	MCL
Thallium	2	MCL
TDEC Appendix I Constituents :		
Copper	1,300	MCLG
Nickel	100	TN MCL
Silver	100	TN SMCL
Vanadium	86	RSL
Zinc	5,000	SMCL

Notes:
MCL: USEPA maximum contaminant level
MCLG: Maximum contaminant level goal
pCi/L: picocuries per liter
SMCL: USEPA secondary maximum contaminant level
S. U.: Standard Unit
RSL: USEPA regional screening level (November 2018)
TN MCL: maximum contaminant level promulgated by State of Tennessee
TN SMCL: secondary maximum contaminant level promulgated by State of Tennessee
ug/L: micrograms per liter

Table 1-2. Human Health and Ecological Site-Specific Screening Levels for Surface Water
Environmental Assessment Report[1]

CCR Parameters	Cumberland Fossil Plant																
	Human Health Surface Water Screening Levels		Ecological Surface Water Screening Levels														
			Cumberland River (Hardness = 100 mg/L)					Wells Creek (Hardness = 140 mg/L)					Unnamed Tributary (Hardness = 750 mg/L)[d]				
	(µg/L)	Source	Total Chronic (µg/L)	Total Acute (µg/L)	Dissolved Chronic (µg/L)	Dissolved Acute (µg/L)		Total Chronic (µg/L)	Total Acute (µg/L)	Dissolved Chronic (µg/L)	Dissolved Acute (µg/L)		Total Chronic (µg/L)	Total Acute (µg/L)	Dissolved Chronic (µg/L)	Dissolved Acute (µg/L)	
CCR Rule Appendix III Constituents :																	
Boron	4,000	RSL	7,200	34,000	NA	NA	a	7,200	34,000	NA	NA	a	7,200	34,000	NA	NA	a
Calcium	--	--	116,000	NA	NA	NA	a	116,000	NA	NA	NA	a	116,000	NA	NA	NA	a
Chloride	250,000	SMCL	230,000	860,000	NA	NA	a	230,000	860,000	NA	NA	a	230,000	860,000	NA	NA	a
Fluoride	4,000	MCL	2,700	9,800	NA	NA	a	2,700	9,800	NA	NA	a	2,700	9,800	NA	NA	a
pH	6 - 9 S.U.	TN DWS	6.5 - 9	NA	NA	NA	b	6.5 - 9	NA	NA	NA	b	6.5 - 9	NA	NA	NA	b
Sulfate	250,000	SMCL	NA	NA	NA	NA		NA	NA	NA	NA		NA	NA	NA	NA	
Total Dissolved Solids	500,000	TN DWS/SMCL	NA	NA	NA	NA		NA	NA	NA	NA		NA	NA	NA	NA	
CCR Rule Appendix IV Constituents :																	
Antimony	6	TN DWS/MCL	190	900			a	190	900			a	190	900			a
Arsenic	10	TN DWS/MCL	150	340	150	340	a	150	340	150	340	a	150	340	150	340	a
Barium	2,000	TN DWS/MCL	220	2,000	NA	NA	a	220	2,000	NA	NA	a	220	2,000	NA	NA	a
Beryllium	4	TN DWS/MCL	11	93	NA	NA	a	11	93	NA	NA	a	11	93	NA	NA	a
Cadmium*	5	TN DWS/MCL	0.790	1.91	0.718	1.80	b	1.03	2.65	0.925	2.47	b	2.39	7.42	2.03	6.58	b
Chromium*	100	TN DWS/MCL	86.2	1803	74.1	570	b	114	2375	97.6	751	b	268	5612	231	1773	b
Cobalt	6	RSL	19	120	NA	NA	a	19	120	NA	NA	a	19	120	NA	NA	a
Fluoride	4,000	MCL	2,700	9,800	NA	NA	a	2,700	9,800	NA	NA	a	2,700	9,800	NA	NA	a
Lead*	5	TN DWS	3.18	81.6	2.52	64.6	b	4.88	125	3.62	93.0	b	18.6	477	10.9	281	b
Lithium	40	RSL	440	910	NA	NA	a	440	910	NA	NA	a	440	910	NA	NA	a
Mercury	2	TN DWS/MCL	0.77	1.4	0.77	1.4	a	0.77	1.4	0.77	1.4	a	0.77	1.4	0.77	1.4	a
Molybdenum	100	RSL	800	7,200	NA	NA	a	800	7,200	NA	NA	a	800	7,200	NA	NA	a
Radium-226 & 228	5 pCi/L	MCL	3 pCi/L	3 pCi/L	NA	NA	c	3 pCi/L	3 pCi/L	NA	NA	c	3 pCi/L	3 pCi/L	NA	NA	c
Selenium	50	TN DWS/MCL	3.1	20	NA	NA	b	3.1	20	NA	NA	b	3.1	20	NA	NA	b
Thallium	2	TN DWS/MCL	6	54	NA	NA	a	6	54	NA	NA	a	6	54	NA	NA	a
TDEC Appendix I Constituents :																	
Copper*	1,300	MCL	9.33	14.0	8.96	13.4	b	12.4	19.2	11.9	18.5	b	30.5	51.7	29.3	49.6	b
Nickel*	100	TN DWS	52.2	469	52.0	468	b	69.3	624	69.1	622	b	169	1516	168	1513	b
Silver*	94	RSL	NA	3.78	NA	3.22	b	NA	6.75	NA	5.74	b	NA	41.1	NA	34.9	b
Vanadium	86	RSL	27	79	NA	NA	a	27	79	NA	NA	a	27	79	NA	NA	a
Zinc*	2,000	HAL	120	120	118	117	b	159	159	157	156	b	388	388	382	379	b

Notes:
[1] The proposed screening level for evaluation of surface water in the EAR is the lowest (most conservative) of the available values for each parameter.
* The freshwater screening values are hardness dependent.
mg/L: milligrams per liter
pCi/L: picocuries per liter
ug/L: micrograms per liter
NA = not applicable
SMCL: USEPA secondary maximum contaminant level
MCL: USEPA maximum contaminant level
MCLG: Maximum contaminant level goal
TN DWS: Tennessee Drinking Water Standards
TN MCL: maximum contaminant level promulgated by State of Tennessee
RSL: USEPA regional screening level (November 2018)
a USEPA Region 4 Surface Water Screening Values for Hazardous Waste Sites (March 2018 Revision).
b Tennessee Department of Environment and Consevation (TDEC), 2019. Chapter 0400-40-03, General Water Quality Criteria.
c U.S. Department of Energy (DOE), 2019. DOE Standard (DOE-STD-1153-2019), A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota.
Biota Concentration Guides for water of 4 pCi/L for Radium-226 and 3 pCi/L for Radium-228.
d The mean hardness of surface water in the Unnamed Tributary is approximately 750 mg/L; however, per TDEC water quality guidelines TDEC, 2019), a hardness value of 400 mg/L was used to calculate hardness-dependent water quality criteria.
Red highlight denotes bioaccumulative constituent (USEPA Region 4 Ecological Risk Assessment Supplemental Guidance (March 2018 Update).

Table 1-3. Ecological Screening Levels for Freshwater Sediment
Environmental Assessment Report

CCR Parameters	Freshwater Sediment Screening Values Chronic (mg/kg-dw)		Freshwater Sediment Screening Values Acute (mg/kg-dw)		Sediment Quality Assessment Guidelines[a] TEC (mg/kg)	Sediment Quality Assessment Guidelines[a] PEC (mg/kg)
CCR Rule Appendix III Constituents :						
Percent Ash	20%	b	40%	c	NA	NA
Boron	NA		NA		NA	NA
Calcium	NA		NA		NA	NA
Chloride	NA		NA		NA	NA
Fluoride	NA		NA		NA	NA
pH	NA		NA		NA	NA
Sulfate	NA		NA		NA	NA
Total Dissolved Solids	NA		NA		NA	NA
CCR Rule Appendix IV Constituents :						
Antimony	2		25	e	NA	NA
Arsenic	9.8		33	e	9.8	33
Barium	240		22925	f	NA	NA
Beryllium	1.2		42	f	NA	NA
Cadmium	1		5	e	1	5
Chromium	43.4		111	e	43	110
Cobalt	50		NA	e	50	NA
Fluoride	NA		NA		NA	NA
Lead	35.8		128	e	36	130
Lithium	NA		NA		NA	NA
Mercury	0.18		1.1	e	0.18	1.1
Molybdenum	38		69760	f	NA	NA
Radium-226 & 228	90 pCi/g		90 pCi/g	d	NA	NA
Selenium	2	g	2.9	e	NA	NA
Thallium	1.2		10	f	NA	NA
TDEC Appendix I Constituents :						
Copper	31.6		149	e	32	150
Nickel	22.7		48.6	e	23	49
Silver	1		2.2	e	NA	NA
Vanadium	66		564	f	NA	NA
Zinc	121		459	e	120	460

NA - Not Available

a MacDonald, et al., 2003. Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for Florida Inland Waters.
TEC - Threshold Effect Concentration, PEC - Probable Effect Concentration.

b Environmental Investigation Plans (EIP) for TVA fossil plants under the TDEC Consent Order.

c Arcadis, 2012. Kingston Ash Recovery Project Non-Time Critical Removal Action River System Baseline Ecological Risk Assessment (BERA).

d U.S. Department of Energy (DOE), 2019. DOE Standard (DOE-STD-1153-2019), A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota.
Biota Concentration Guides for sediment of 100 pCi/g for Radium-226 and 90 pCi/g for Radium-228.

e USEPA Region 4 Sediment Screening Values for Hazardous Waste Sites (March 2018 Revision).

f National Institute for Public Health and the Environment (RIVM), 2005. Environmental Risk Limits for Nine Trace Elements.
The Maximum Permissible Concentration (MPC) is used for the chronic value and the Serious Risk Addition (SRA_{eco}) is used for the acute value.

g Lemly, A.D., 2002. Selenium Assessment in Aquatic Ecosystems

Red highlight denotes bioaccumulative constituent (USEPA Region 4 Ecological Risk Assessment Supplemental Guidance (March 2018 Update).

Table 1-4. Screening Levels for Mayfly Tissue Critical Body Residues
Environmental Assessment Report

CCR Parameters	Mayfly Tissue Critical Body Residue NOAEL (mg/kg-ww)	Mayfly Tissue Critical Body Residue LOAEL (mg/kg-ww)	
CCR Rule Appendix III Constituents :			
Boron	NA	NA	
Calcium	NA	NA	
Chloride	NA	NA	
Fluoride	NA	NA	
pH	NA	NA	
Sulfate	NA	NA	
Total Dissolved Solids	NA	NA	
CCR Rule Appendix IV Constituents :			
Antimony	NA	NA	
Arsenic	0.0249	0.249	a
Barium	NA	NA	
Beryllium	NA	NA	
Cadmium	15.6	156	a
Chromium (total)	0.144	1.44	a
Cobalt	0.1061	1.061	
Fluoride	NA	NA	
Lead	269	2690	a
Lithium	NA	NA	
Mercury	2.7	27	a
Molybdenum	NA	NA	
Radium-226 & 228	NA	NA	
Selenium	0.051	0.51	a
Thallium	1.206	12.06	a
TDEC Appendix I Constituents :			
Copper	26	260	a
Nickel	0.115	1.15	a
Silver	0.23	2.3	a
Vanadium	0.604	6.04	a
Zinc	382	3820	a

Notes:

a Arcadis, 2012. Kingston Ash Recovery Project Non-Time Critical Removal Action River System Baseline Ecological Risk Assessment (BERA).

Toxicity values were selected from the U.S. Army Corps of Engineers/ USEPA Environmental Residue-Effects Database (ERED).

LOAEL - Lowest Observed Adverse Effect Level

NOAEL - No Observed Adverse Effect Level

mg/kg-dw - milligrams per kilogram, dry weight

mg/kg-ww - milligrams per kilogram, wet weight

Red highlight denotes bioaccumulative constituent (USEPA Region 4 Ecological Risk Assessment Supplemental Guidance (March 2018 Update).

Table 1-5. Screening Levels for Fish Tissue Critical Body Residues
Environmental Assessment Report

CCR Parameters	Whole Body Fish Tissue Critical Body Residue NOAEL (mg/kg-ww)	Whole Body Fish Tissue Critical Body Residue LOAEL (mg/kg-ww)		Liver Tissue Critical Body Residue NOAEL (mg/kg-ww)	Liver Tissue Critical Body Residue LOAEL (mg/kg-ww)		Muscle Tissue Critical Body Residue NOAEL (mg/kg-ww)	Muscle Tissue Critical Body Residue LOAEL (mg/kg-ww)		Ovary Tissue Critical Body Residue NOAEL (mg/kg-ww)	Ovary Tissue Critical Body Residue LOAEL (mg/kg-ww)	
CCR Rule Appendix III Constituents :												
Boron	NA	NA		NA	NA		NA	NA		NA	NA	
Calcium	NA	NA		NA	NA		NA	NA		NA	NA	
Chloride	NA	NA		NA	NA		NA	NA		NA	NA	
Fluoride	NA	NA		NA	NA		NA	NA		NA	NA	
pH	NA	NA		NA	NA		NA	NA		NA	NA	
Sulfate	NA	NA		NA	NA		NA	NA		NA	NA	
Total Dissolved Solids	NA	NA		NA	NA		NA	NA		NA	NA	
CCR Rule Appendix IV Constituents :												
Antimony	NA	NA		NA	NA		NA	NA		NA	NA	
Arsenic	0.04	0.4	a	0.569	5.69	a	0.076	0.76	a	8.4	84	a
Barium	NA	NA		NA	NA		NA	NA		NA	NA	
Beryllium	5.13	51.3	a	NA	NA		NA	NA		NA	NA	
Cadmium	0.0019	0.019	a	0.0000137	0.000137	a	0.03	0.12	a	NA	NA	
Chromium (total)	0.128	1.28	a	0.042	0.42	a	NA	NA		NA	NA	
Cobalt	NA	NA		NA	NA		NA	NA		NA	NA	
Fluoride	NA	NA		NA	NA		NA	NA		NA	NA	
Lead	0.0278	0.278	a	0.0393	0.393	a	2.3	23	a	NA	NA	
Lithium	NA	NA		NA	NA		NA	NA		NA	NA	
Mercury	0.006	0.06	a	0.0009	0.009	a	0.08	0.8	a	NA	NA	
Molybdenum	NA	NA		NA	NA		NA	NA		NA	NA	
Radium-226 & 228	NA	NA		NA	NA		NA	NA		NA	NA	
Selenium	8.5	8.5	b	0.524	5.24	a	11.3	11.3	b	15.1	15.1	b
Thallium	0.027	0.27	a	NA	NA		NA	NA		NA	NA	
TDEC Appendix I Constituents :												
Copper	0.196	1.96	a	6.52	65.2	a	3.4	34	a	NA	NA	
Nickel	11.81	118.1	a	8.22	82.2	a	11.81	118.1	a	NA	NA	
Silver	0.0114	0.114	a	19	190	a	NA	NA		NA	NA	
Vanadium	0.68	2.7	a	0.03	0.3	a	NA	NA		NA	NA	
Zinc	0.45	4.5	a	3.4	34	a	NA	NA		NA	NA	

Notes:

a Arcadis, 2012. Kingston Ash Recovery Project Non-Time Critical Removal Action River System Baseline Ecological Risk Assessment (BERA).
Toxicity values were selected from the U.S. Army Corps of Engineers/USEPA Environmental Residue-Effects Database (ERED).

b USEPA, 2016. Chronic Ambient Water Quality Criterion for Selenium. Fish tissue concentrations expressed as mg/kg-dry weight.

LOAEL – Lowest Observed Adverse Effect Level

NOAEL - No Observed Adverse Effect Level

mg/kg-dw - milligrams per kilogram, dry weight

mg/kg-ww - milligrams per kilogram, wet weight

Red highlight denotes bioaccumulative constituent (USEPA Region 4 Ecological Risk Assessment Supplemental Guidance (March 2018 Update).

Table 3-1 - Lithologic Summary
Cumberland Fossil Plant
August 2018 - April 2019

Geologic Unit	Boring IDs	Depth Range	Soil Type and Particle-Size Range	Color Range	Additional Observations
Alluvial deposits	CUF-BG02, CUF-BG04, CUF-BG08, CUF-BG15, CUF-BG17, CUF-201, CUF-202	Ground surface to between 7.6 and 16.9 feet bgs	Silty lean clay and silty fat clay, occasional limestone, shale, and chert gravel throughout, gravel content generally increases with depth.	Reddish brown to greyish or yellowish brown.	Generally low to medium plasticity.
Residuum of the Mississippian St. Louis Limestone	CUF-BG11, CUF-BG12	Ground surface to between 13.8 and 14.1 feet bgs	Silty fat clay with gravel and sand to silty clayey gravel with sand, sandstone gravel and cobbles throughout to a depth of 5.0 feet bgs. From 5.0 feet bgs to refusal lean clay with gravel. Gravel consists of limestone, chert, and sandstone.	Red to brown to a depth of 5.0 feet bgs. From 5.0 feet bgs to refusal yellowish red.	Generally non-plastic to medium plasticity to a depth of 5.0 feet bgs. 5.0 feet bgs to refusal low to medium plasticity.
Residuum of the Devonian Camden, Harriman, and Ross Formations	CUF-BG01, CUF-BG16	Ground surface to between 6.8 and 25.0 feet bgs	CUF-BG01 - Silty lean clay, with siltstone fine gravel. CUF-BG16 - Silty fat clay with sand and gravel. Sand and gravel content increasing with depth from 5.0 feet bgs to refusal.	CUF-BG01 - Strong brown mottled with gray. Reddish gray mottled with orange-red and tan, from 10.0 to 13.0 feet bgs and 17.5 to 20.0 feet bgs, respectively. CUF-BG16 - Yellowish red.	CUF-BG01 - generally non-plastic to low plasticity, contained iron-stained siltstone fine gravel. CUF-BG16 - medium plasticity.
Residuum of the Silurian age Lego Limestone and Waldron Shale, Laurel Limestone, and Brassfield Limestone (3 combined units)	CUF-BG10, CUF-BG14, CUF-BG06	Ground surface to between 7.6 and 12.6 feet bgs	Silty lean clay, generally with sand or trace sand and fine chert gravel throughout. Despite these three borings being in separate units, the profile is essentially uniformly described as silty lean clay except in boring CUF-BG10, where it was classified as silty fat clay from the surface to a depth of 5.0 feet bgs.	Brown to strong brown or yellowish red.	Variable plasticity, from non-plastic to medium and high plasticity.
Residuum of the Ordovician Stones River Group	CUF-BG07, CUF-1001ALT2; (a distance of approximately 1.13 miles separates these two locations)	Ground surface to between 18.0 and 18.1 feet bgs	CUF-BG07 - Silty lean clay with chert gravel throughout to a depth of 5.0 feet bgs. From 5.0 feet bgs to refusal, lean clay with chert fragments throughout. Weathered limestone cobbles from 17.5 to 18.0 feet bgs. CUF-1001ALT2 - Fill material from ground surface to 6.0 feet bgs then silty fat clay, with trace sand and gravel from 6.0 to 12.0 feet bgs. Fat clay from 12.0 to 16.2 feet bgs. Clayey well graded gravel with some sand from 16.2 feet bgs to refusal, medium to coarse, gravel with very little to no weathering.	CUF-BG07 - Dark yellowish brown to yellowish red, becomes strong brown at 15.0 feet bgs. CUF-1001ALT2 - Reddish-brown from 6.0 to 12.0 feet bgs, yellowish red from 12.0 to 18.1 feet bgs.	CUF-BG07 - Low to medium plasticity. CUF-1001ALT2 - Medium plasticity to 12.0 feet bgs then loose.
Residuum of the Ordovician Hermitage Formation	CUF-BG13, CUF-1000ALT, CUF-1000ALTA	Ground surface to between 9.9 and 22.4 feet bgs.	Silty to sandy lean clay generally with sandstone and chert gravel to a depth of between 3.0 to 10.1 feet bgs, then fat clay to sandy fat clay with chert and sandstone gravel to 13.5 feet bgs. Clayey sand, fine to coarse grained with sandstone gravel and sandy lean clay with sandstone gravel from 13.5 to 16.5 feet bgs. Fat clay with sand from 16.5 feet bgs to refusal.	CUF-BG13 - Dark reddish brown to dark red. CUF-1000ALT - Reddish brown to yellowish red to 3.0 feet bgs then strong brown and yellowish red. CUF-1000ALTA - Strong brown to yellowish brown.	Generally low to medium plasticity.
Residuum of the Ordovician/Cambrian Knox Dolomite	CUF-BG03, CUF-BG05, CUF-BG09, CUF-1004ALT, CUF-1004ALT2, CUF-1004ALT2A	Ground surface to between 7.4 and 20.8 feet bgs.	Lean clay with silt or sand with chert gravel and cobbles throughout. Profile uniformly described as lean clay except in borings CUF-BG05, logged as fat clay from ground surface to 5.0 feet bgs, and CUF-1004ALT2A, which included a layer of fat clay from 13.5 to 15.0 feet bgs.	Red to brown or yellowish red.	Generally non-plastic to medium plasticity.

Notes:

bgs - below ground surface

ID - identification

Stantec

TABLE 4-1 – Pore Water Level Measurements
Cumberland Fossil Plant
June-November 2019

Temporary Well / Piezometer ID	Top of Casing Elevation	Piezometer Sensor Elevation	Pore Water Elevation (ft msl)					
	ft msl	ft bgs	6/3/2019	7/8/2019	8/13/2019	9/9/2019	10/28/2019	11/18/2019
Temporary Wells								
CUF-TW01	430.99	n/a	390.95	390.54	390.12	389.64	389.65	389.87
CUF-TW03	429.53	n/a	400.70	400.49	400.34	400.29	399.83	399.96
CUF-TW05	426.80	n/a	395.99	395.86	395.86	395.78	395.30	395.36
CUF-TW07	443.69	n/a	384.88	385.05	385.15	385.03	384.89	384.78
CUF-TW08	443.36	n/a	391.06	390.75	390.37	389.90	389.30	389.11
CUF-TW09	446.44	n/a	389.62	389.45	389.30	388.93	388.66	387.73
Piezometers								
CUF-B14A	n/a	360.8	NM	NM	383.9	383.8	383.8	NM
CUF-B15A	n/a	353.3	NM	387.3	387.2	387.1	386.8	NM
CUF-B16A	n/a	383.4	NM	388.7	388.6	388.5	388.3	NM
CUF-B17A	n/a	363.9	NM	388.3	388.3	388.1	387.9	NM
CUF_DAS_A_1_VWPZ2	n/a	335.0	NM	374.8	NM	374.8	374.6	NM
CUF_DAS_A_2_VWPZ2	n/a	353.4	NM	374.6	NM	373.6	372.5	NM
CUF_DAS_D_2_VWPZ1	n/a	376.6	NM	382.3	NM	382.0	382.0	NM
CUF_DAS_D_3_VWPZ3	n/a	371.9	NM	382.5	NM	382.2	382.2	NM
CUF_DAS_G_1_VWPZ1	n/a	379.6	NM	390.1	NM	390.2	389.9	NM
CUF_DAS_G_2_VWPZ2	n/a	396.1	NM	403.1	NM	402.4	404.0	NM
CUF_DAS_INT_1_VWPZ3	n/a	379.1	NM	388.6	NM	388.6	388.2	NM
CUF_DAS_INT_2_VWPZ2	n/a	388.5	NM	391.7	NM	391.2	390.7	NM
CUF_F_2A_VWPZ2	n/a	353.6	NM	385.4	NM	385.1	384.9	NM
CUF_F_2B_VWPZ4	n/a	377.1	NM	386.0	NM	385.9	386.1	NM
CUF_GSA_G_1_VWPZ1	n/a	384.6	NM	393.5	NM	393.3	393.0	NM
CUF_GSA_G_2_VWPZ1	n/a	388.2	NM	396.6	NM	395.9	396.1	NM
CUF_GSA_INT_1_VWPZ5	n/a	393.1	NM	399.5	NM	399.4	399.1	NM
CUF_GSA_INT_2_VWPZ2	n/a	380.3	NM	390.4	NM	389.9	389.7	NM
CUF_GSA_L_1_VWPZ4	n/a	369.3	NM	394.5	NM	394.0	393.5	NM
CUF_GSA_M_1_VWPZ2	n/a	382.0	NM	386.5	NM	385.2	384.5	NM
CUF_GSA_M_2_VWPZ3	n/a	380.3	NM	385.3	NM	384.3	383.9	NM
CUF_H_2A_VWPZ4	n/a	389.8	NM	396.1	NM	395.9	395.5	NM
CUF_H_2B_VWPZ3	n/a	353.7	NM	388.3	NM	388.1	387.7	NM
CUF_H_2C_VWPZ4	n/a	374.0	NM	389.1	NM	389.1	388.9	NM
CUF_PZ21	n/a	356.0	NM	389.5	NM	389.3	389.0	NM
CUF_PZ36	n/a	363.2	NM	386.7	NM	NM	NM	NM
CUF_PZ37	n/a	367.2	NM	376.2	NM	375.8	376.2	NM
CUF_PZ43	n/a	374.3	NM	391.6	NM	391.6	391.2	NM

See notes on last page.

Notes:

bgs	below ground surface
ft	feet
ID	identification
msl	mean sea level
n/a	not applicable
NM	not measured

1. Top of casing elevations were obtained boring logs, well details, and well survey data.
2. For piezometers, pore water elevations and piezometer data were obtained from geotechnical instrumentation database. Data from vibrating wire piezometers were averaged for the measurement date. For consistency in reporting for the TDEC Order, historical piezometer IDs were modified (if necessary) to include ‘VWPZ’ to indicate a vibrating wire piezometer.
3. Depth to pore water in piezometers and pore water elevations at all locations are calculated values. Accuracy of piezometer data is to 0.1 ft.
4. Pore water levels were not measured in select piezometers as noted above because the sensors were not recording data.

Table 4-2 - Estimated CCR Material Areas, Depths, and Volumes
Cumberland Fossil Plant

CCR Unit	CCR Material Above Phreatic Surface (CY)	CCR Material Below Phreatic Surface (CY)	Total (CY)	Minimum CCR Depth (FT)	Maximum CCR Depth (FT)	CCR Unit Area (AC)
Gypsum Storage Area	5,949,580	5,786,750	11,736,330	0	75	145
Dry Ash Stack	6,919,110	4,755,910	11,675,020	0	108	113
Bottom Ash Pond	201,400	201,640	403,040	0	47	9
Stilling Pond (including Retention Pond)	1,417,240	47,210	1,464,450	0	54	59
Study Area Units Total	**14,487,330**	**10,791,510**	**25,278,840**	**Not Applicable**	**Not Applicable**	**326**

Notes:

1. CCR – coal combustion residuals
2. CY – cubic yards
3. The volumes reported herein do not correspond to a closed condition or reflect recent dewatering activities, and the phreatic surface would be expected to decrease after capping of CCR management units (if the units were to be closed with CCR in place).
4. For details regarding the development of the three-dimensional models of the CCR management units, refer to the MQA SAR . (Appendix G.5).
5. For details regarding water level measurements used to estimate the phreatic surface elevation, refer to Chapter 4.3.3.3.

EXHIBITS

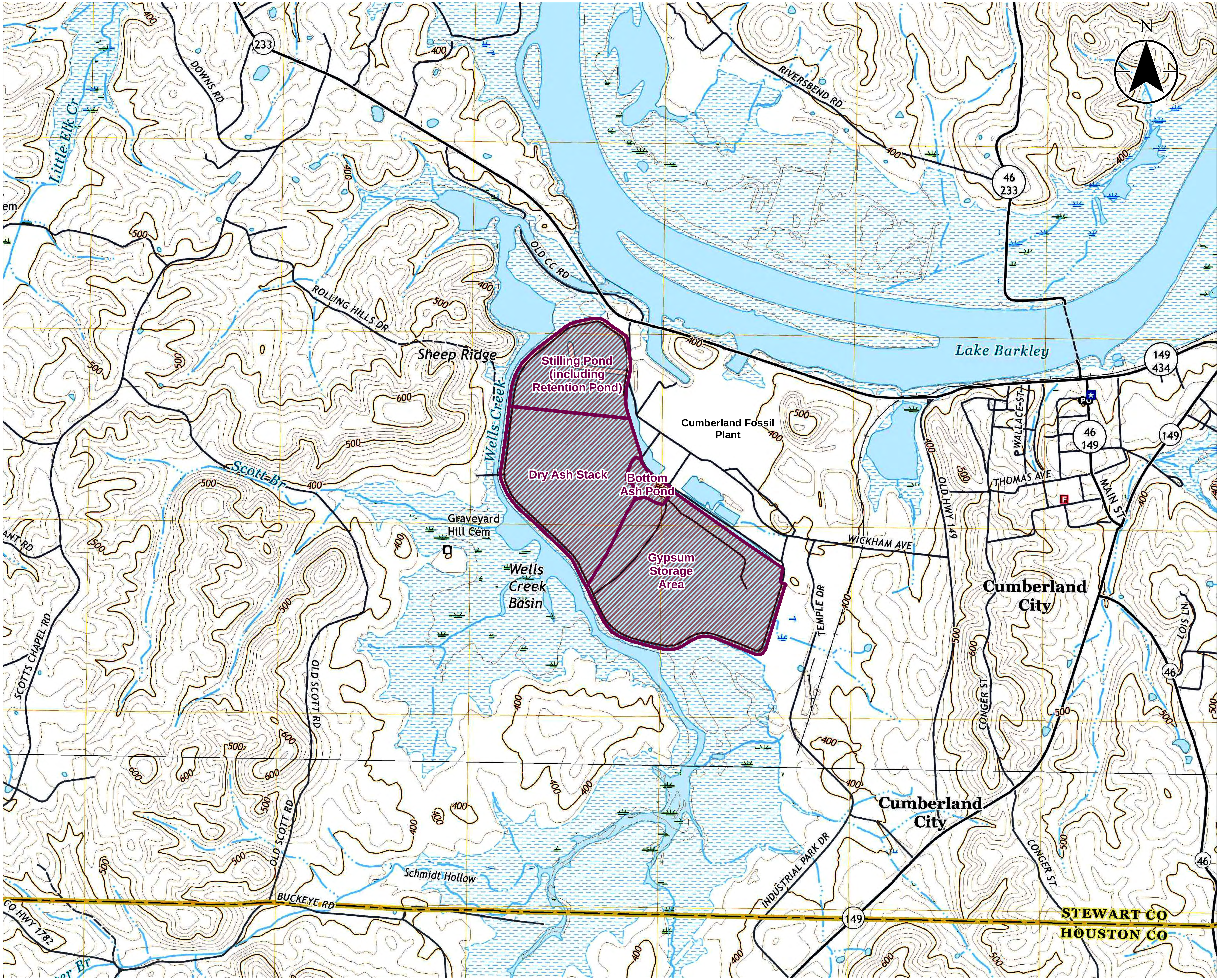


Exhibit No.

1-1

Title

Location Plan and Topographic Map

Client/Project

Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location

Stewart County, Tennessee

175568209
Prepared by MB on 2021-12-13
Technical Review by VS on 2021-12-13

0 800 1,600 2,400 3,200 Feet

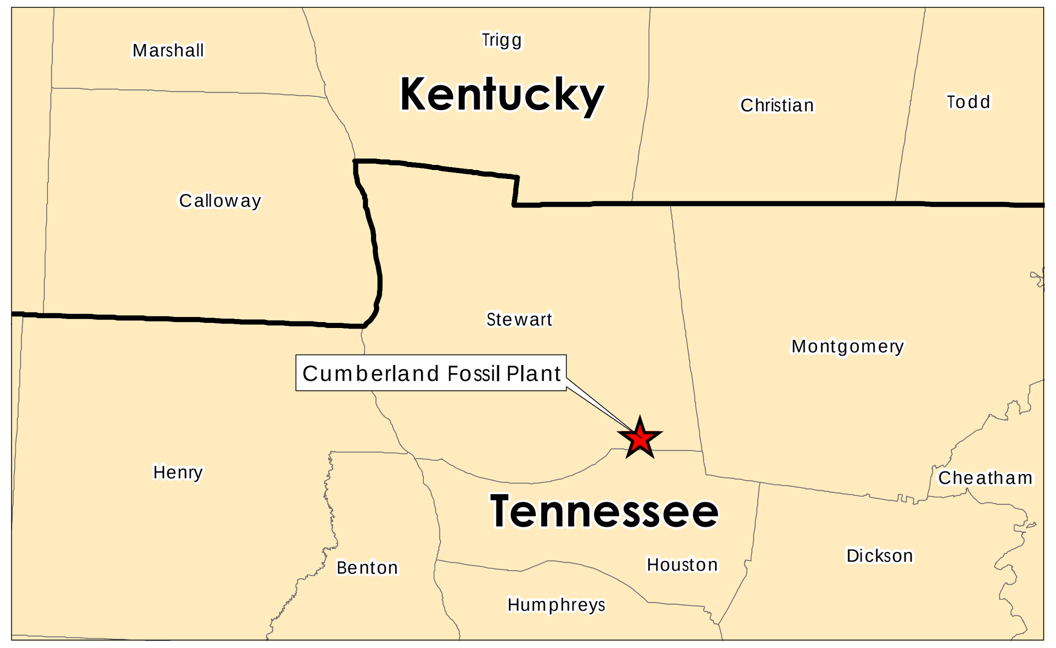
1:9,600 (At original document size of 22x34)

Legend

CCR Unit Area (Approximate)

Notes

1. Coordinate System: NAD 1927 StatePlane Tennessee FIPS 4100
2. Topographic mapping corresponds to the Cumberland City Quadrangle (Edition of 2019, Scale 1:24,000) and the Erin Quadrangle (Edition of 2019, Scale 1:24,000)



Stantec TVA

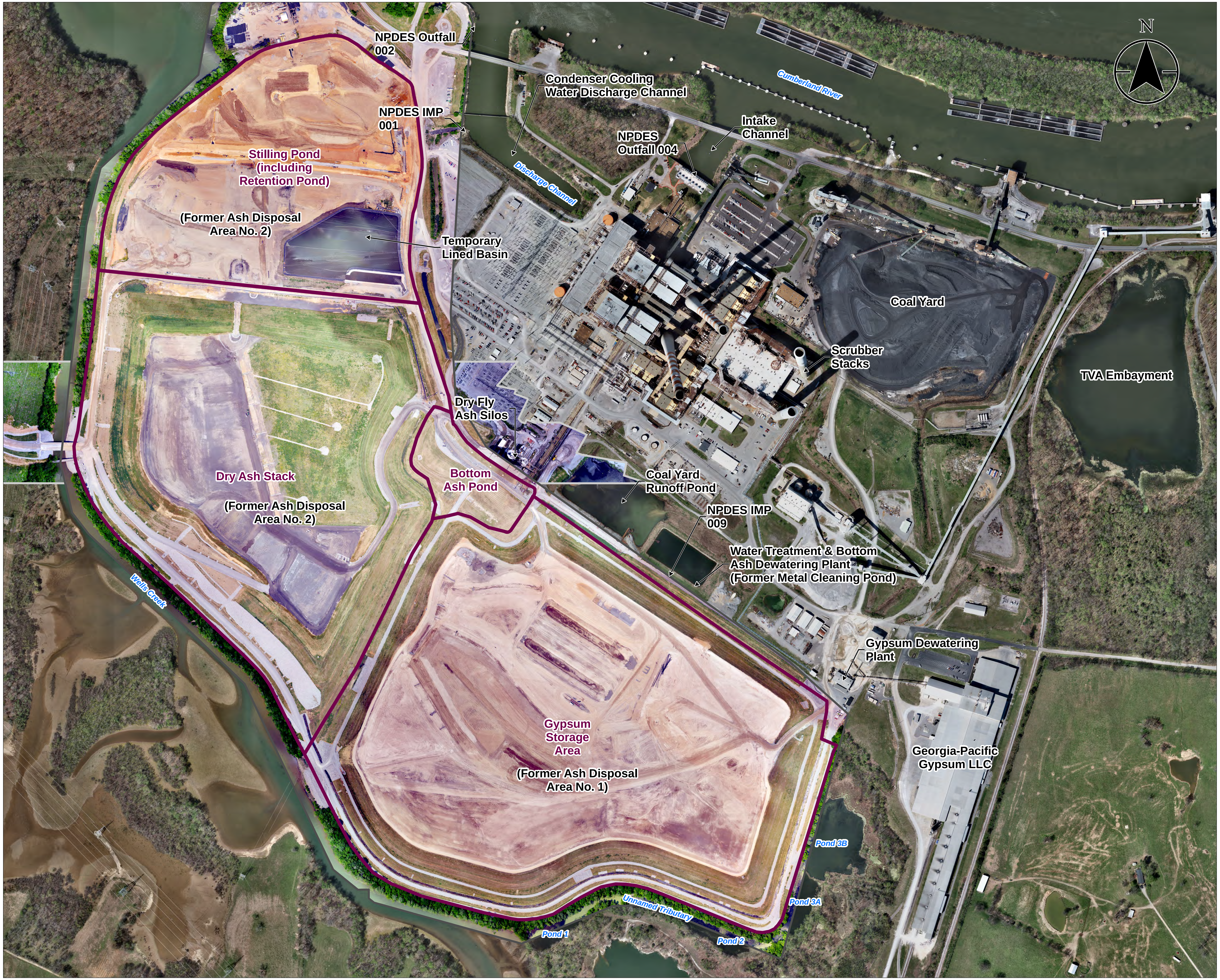


Exhibit No.

2-1

Title

CUF Plant Overview

Client/Project

Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location

Stewart County, Tennessee

175568209

Prepared by MB on 2022-10-20
Technical Review by EM on 2022-10-20

0 300 600 900 1,200 Feet

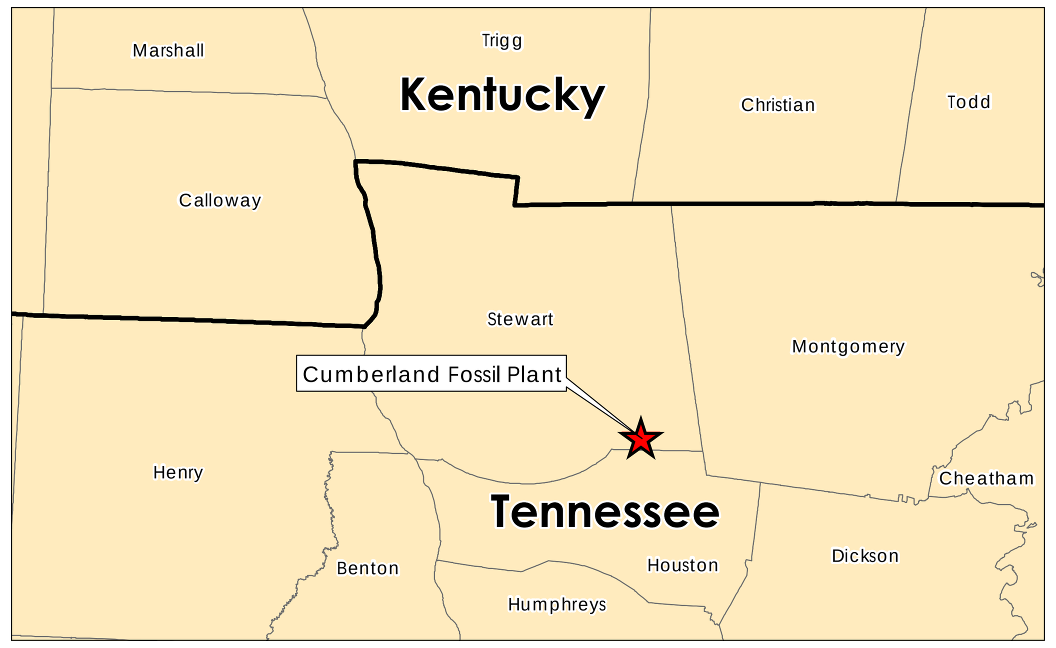
1:3,600 (At original document size of 22x34)

Legend

- 2021 Imagery Boundary
- 2022 Imagery Boundary
- CCR Unit Area (Approximate)

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by Tuck Mapping (c. 2017) and TVA (5/21/2021 and 5/12/2022)
3. NPDES IMP - National Pollutant Discharge Elimination System Internal Monitoring Point.



Stantec TVA

U:\TVA-EIP\175568209_CUF_Phase2\gis\mxd\EAR\2-1_CUF_Plant_Overview.mxd Revised: 2022-10-20 By: mbough

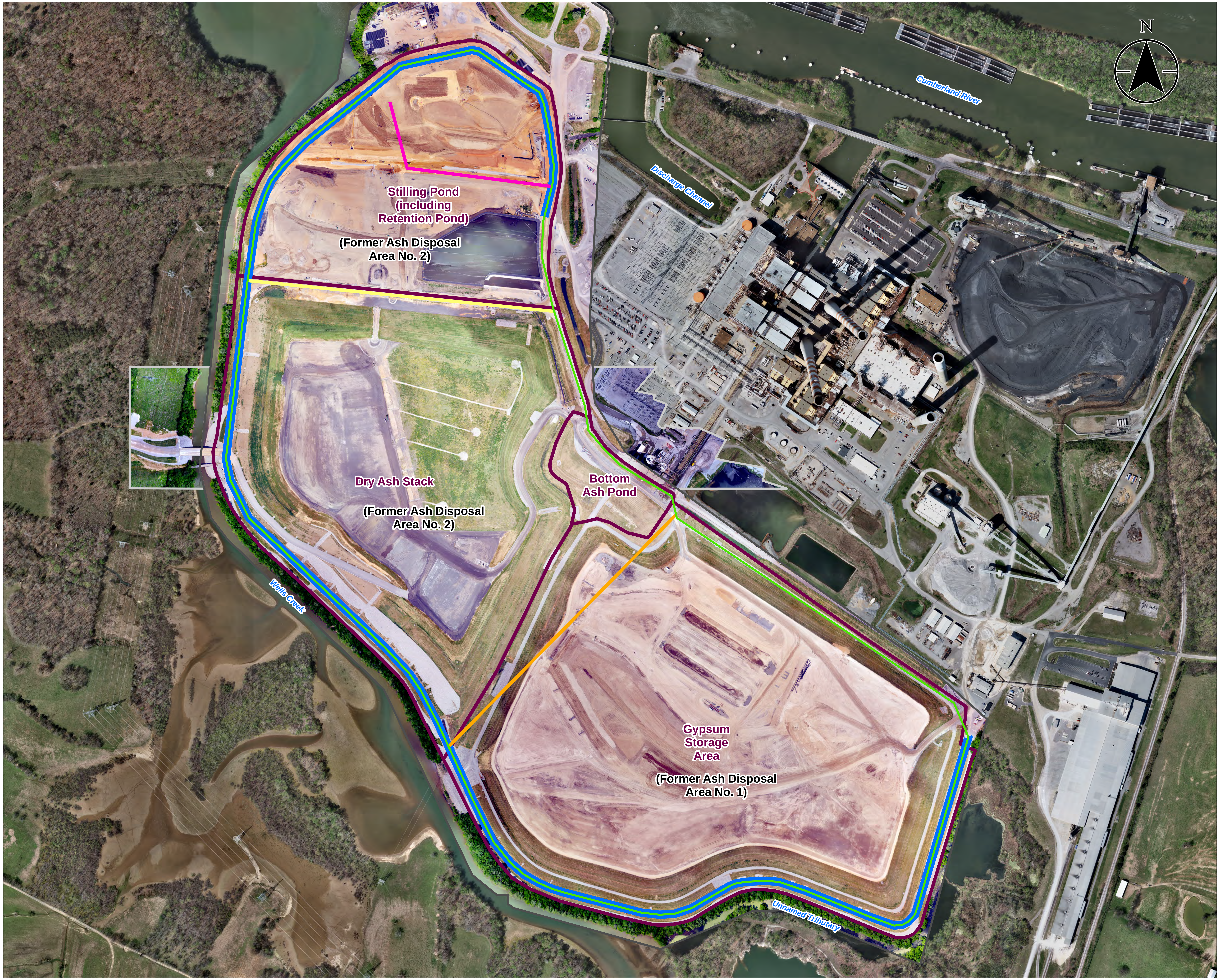


Exhibit No.

2-2

Title

Dike Construction History

Client/Project

Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location

Stewart County, Tennessee

175568209
Prepared by MB on 2022-10-20
Technical Review by EM on 2022-10-20

0 300 600 900 1,200 Feet

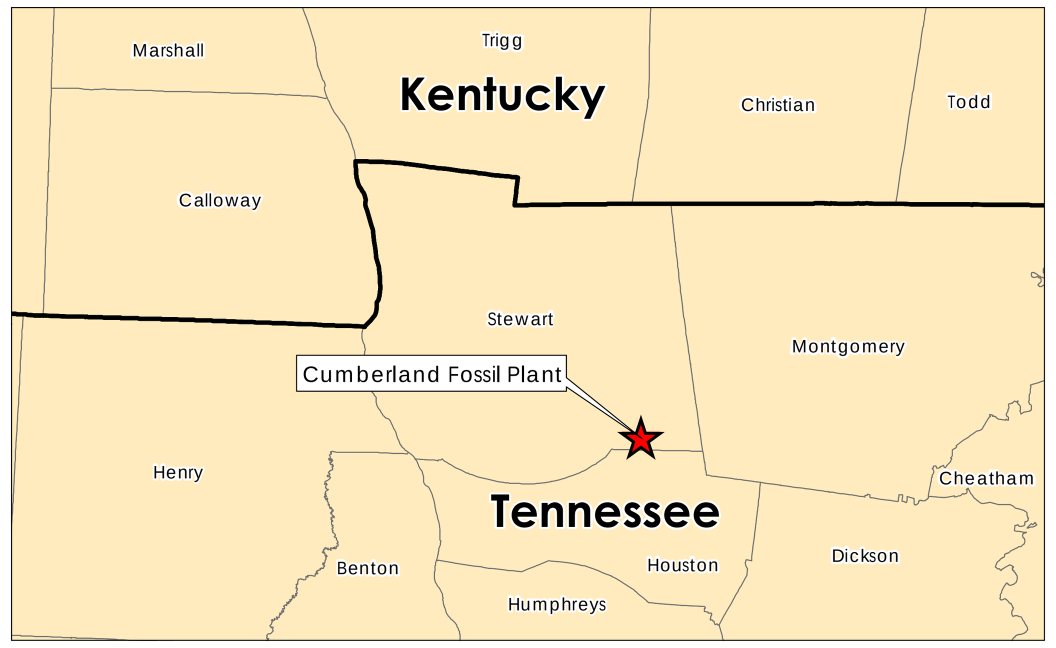
1:3,600 (At original document size of 22x34)

Legend

- 1969: Initial Dike (Approximate)
- 1976: Divider Dike (Approximate)
- 1977: Divider Dike (Approximate)
- 1979: Perimeter Dike Raise (Approximate)
- 1996: Divider Dike (Approximate)
- 2021 Imagery Boundary
- 2022 Imagery Boundary
- CCR Unit Area (Approximate)

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by Tuck Mapping (c. 2017) and TVA (5/21/2021 and 5/12/2022)



Stantec TVA

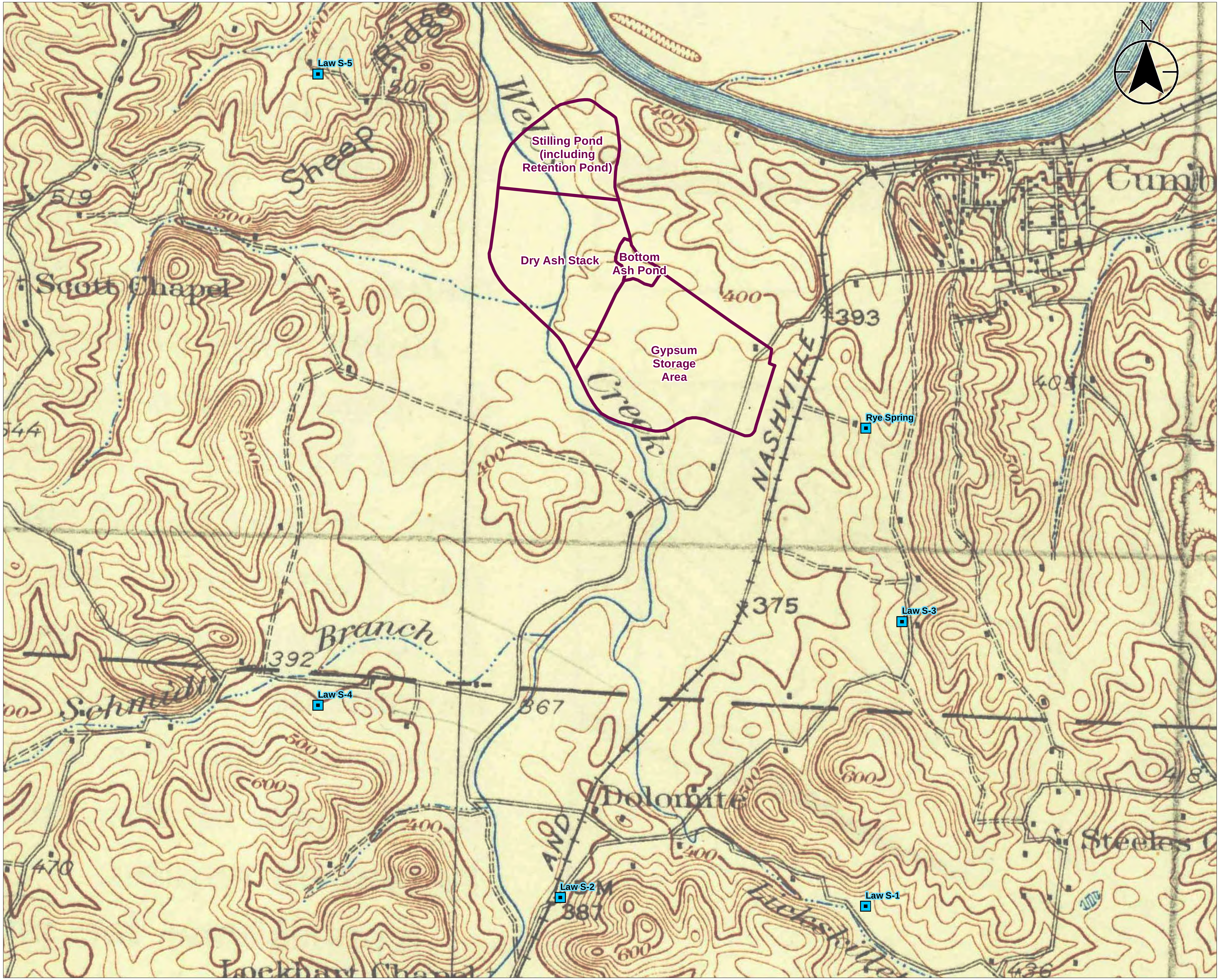


Exhibit No.

2-3

Title

Topographic Map - USGS (1931)

Client/Project

Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location

Stewart County, Tennessee

175568209

Prepared by TR on 2021-12-02
Technical Review by EM on 2021-12-02

0 | 800 | 1,600 | 2,400 | 3,200 Feet

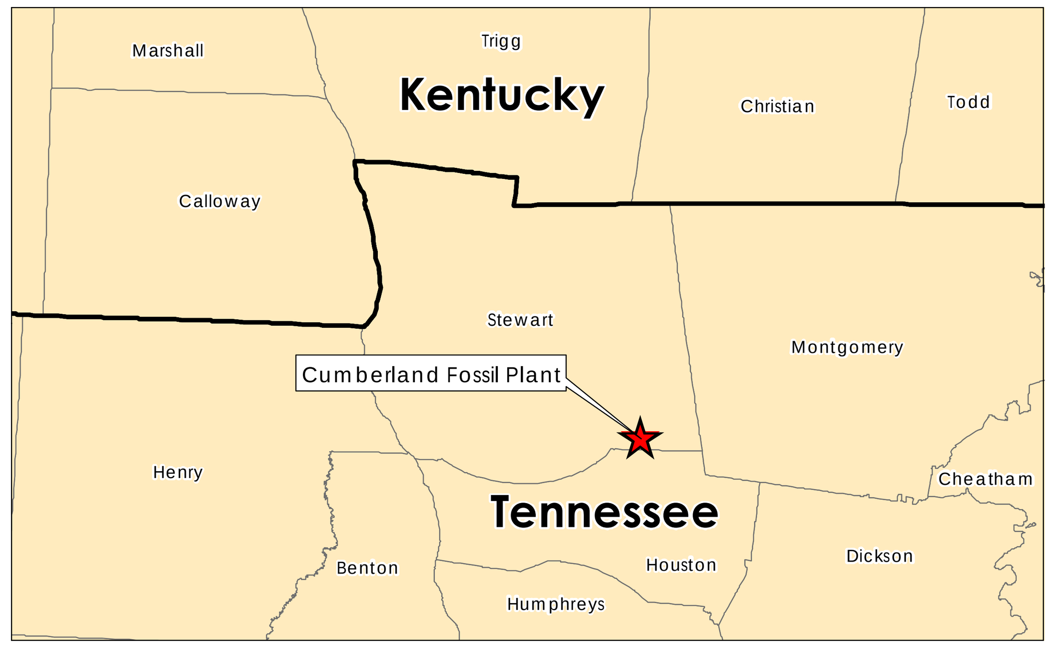
1:9,600 (At original document size of 22x34)

Legend

- Reported Spring
- CCR Unit Area (Approximate)

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Topographic mapping corresponds to the Erin Quadrangle (Edition of 1931, Scale 1:62,500)
3. Spring locations are approximate and referenced from Law (1992b)



Stantec TVA

Exhibit No.
2-4

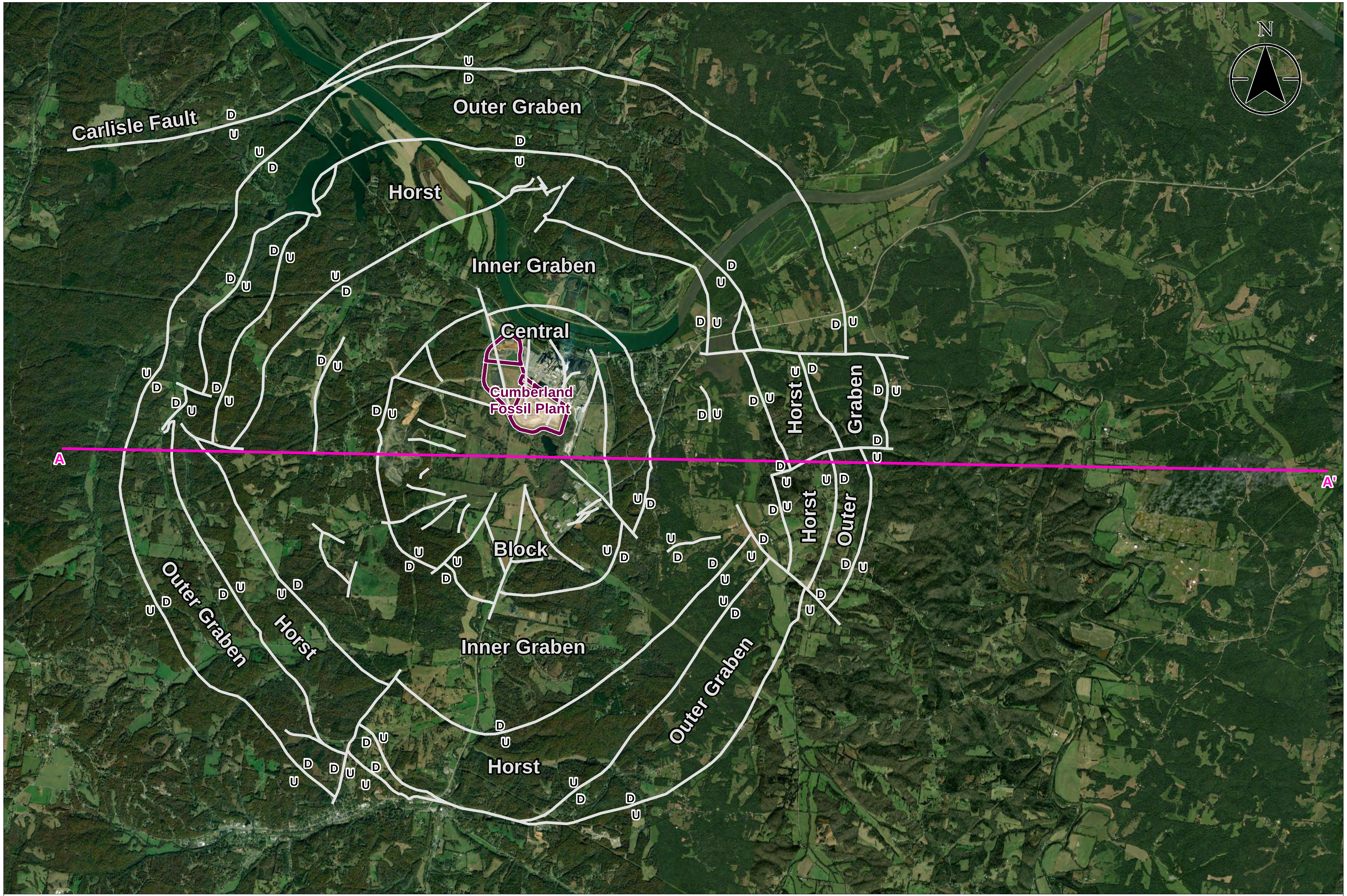
Title
Geologic Map

Client/Project
Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

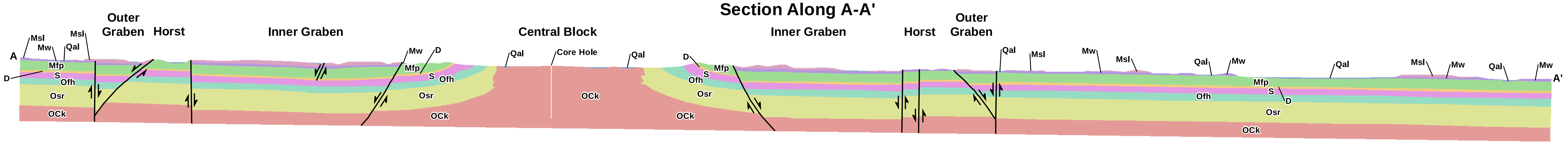
Project Location
Stewart County, Tennessee

175568209
Prepared by MB on 2023-01-19
Technical Review by VS on 2023-01-19

0 3,000 6,000 9,000 12,000 Feet
1:36,000 (At original document size of 22x34)



Section Along A-A'



Legend

- CCR Unit Area (Approximate)
- Cross Section A-A'
- Fault Line
- Fault (Cross Section View)

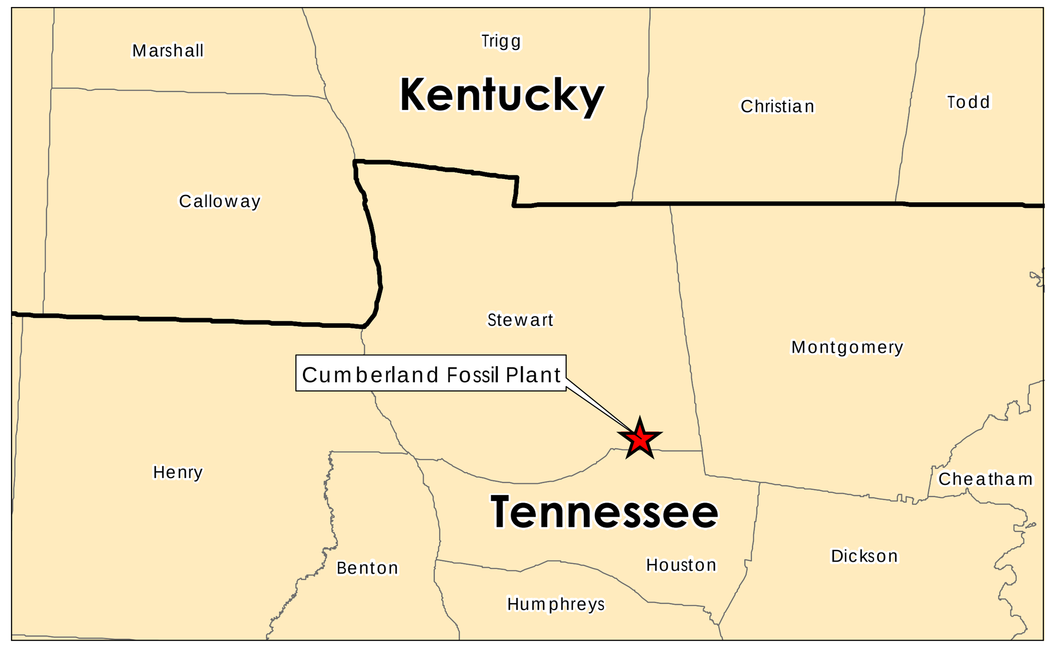
Geology (Cross Section View)

- Core Hole
- Qal - Alluvial Deposits
- Msl - St. Louis Limestone
- Mw - Warsaw Limestone
- Mfp - Fort Payne Formation, New Providence Shale, and Chattanooga Shale
- D - Devonian, Undifferentiated
- S - Silurian, Undifferentiated
- Ofh - Fernvale Limestone and Hermitage Formation
- Osr - Stones River Group
- OCk - Knox Dolomite

U upthrown side, D downthrown side

Notes

1. Coordinate System: NAD 1927 StatePlane Tennessee FIPS 4100
2. Imagery Provided by Esri World Imagery
3. Geologic map corresponds to *The Geologic Map of Wells Creek Area, Tennessee (Tennessee Division of Geology Bulletin 68, Plate 1)* (Stearns, Tiedemann, and Wilson, 1968).



Stantec TVA

Exhibit No.
2-5

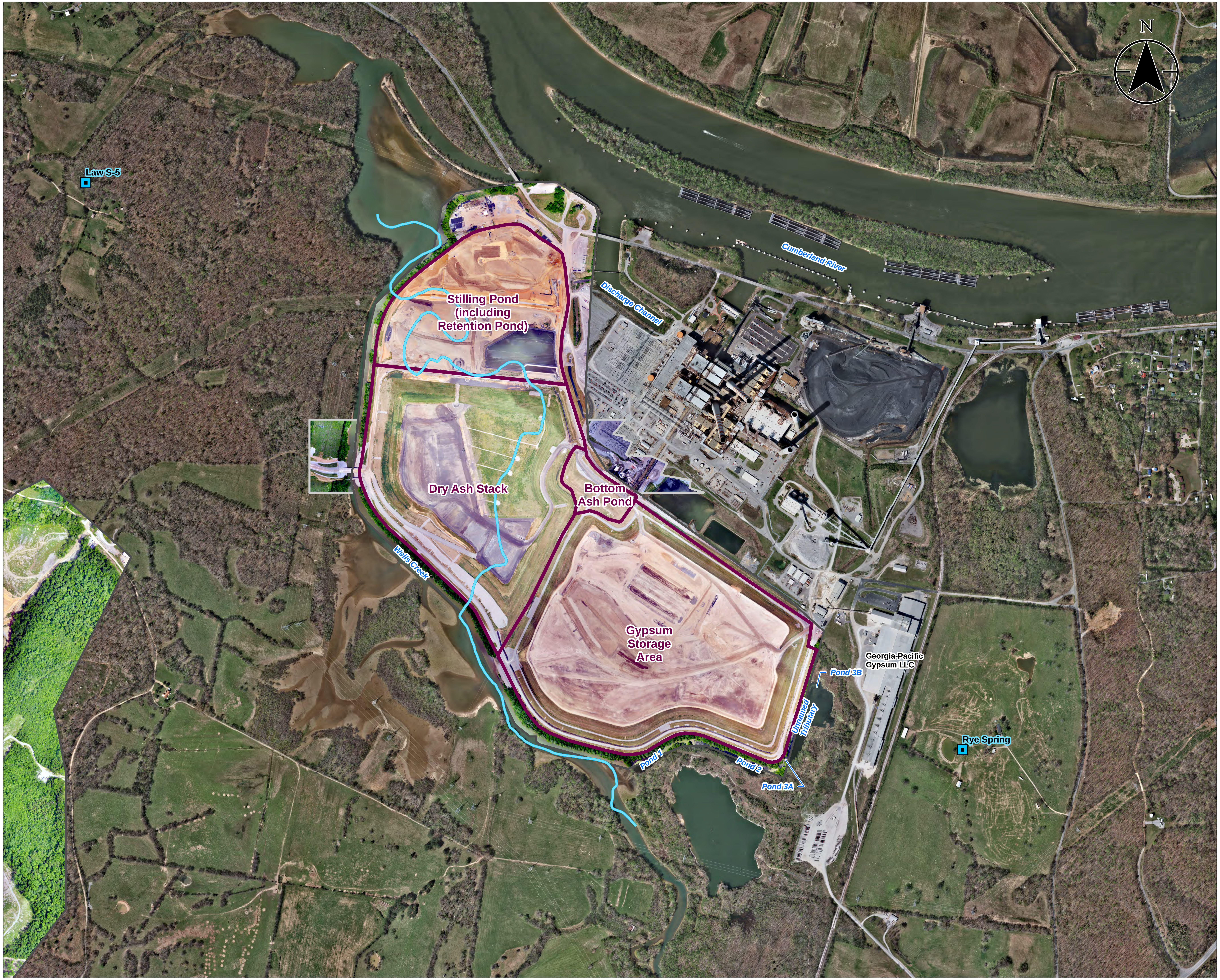
Title
Reported Springs and Historic Wells Creek Alignment

Client/Project
Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location
Stewart County, Tennessee

175568209
Prepared by MB on 2022-10-25
Technical Review by HW on 2022-10-25

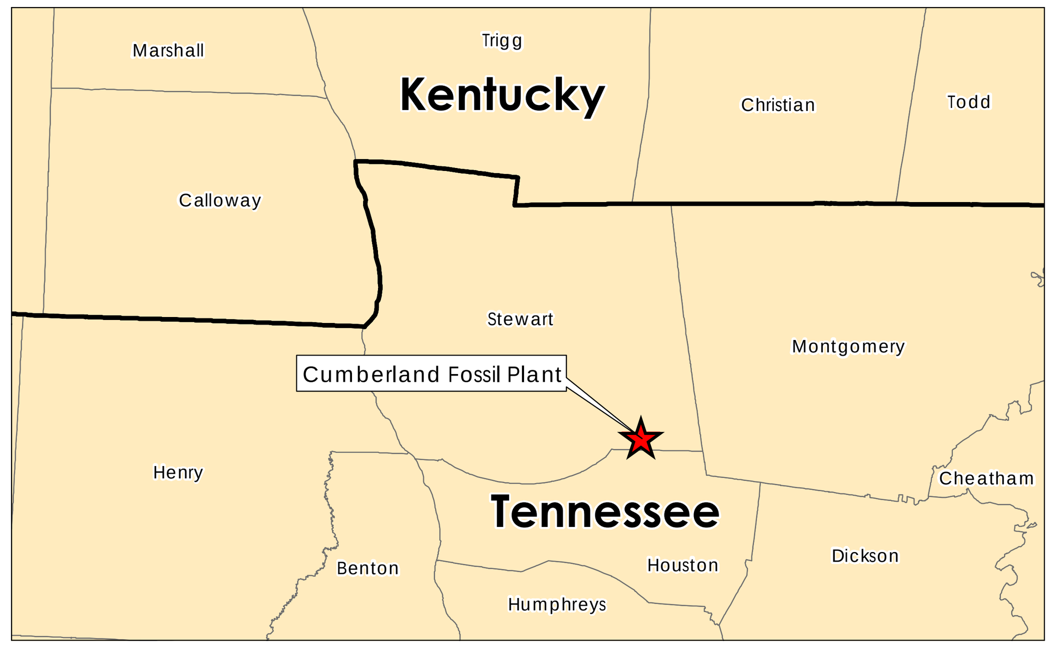
0 500 1,000 1,500 2,000 Feet
1:6,000 (At original document size of 22x34)



Legend

- Reported Spring
- Historical Wells Creek Alignment (Approximate)
- 2021 Imagery Boundary
- 2022 Imagery Boundary
- CCR Unit Area (Approximate)

Notes
1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by Tuck Mapping (c. 2017) and TVA (5/21/2021 and 5/12/2022)



U:\TVA-EIP\175568209_CUF_Phase2\gis\mxd\EAR\2-5_CUF_Reported_Springs_Historic_Wells_Creek.mxd Revised: 2022-10-25 By: mbough

Exhibit No.

2-6

Title

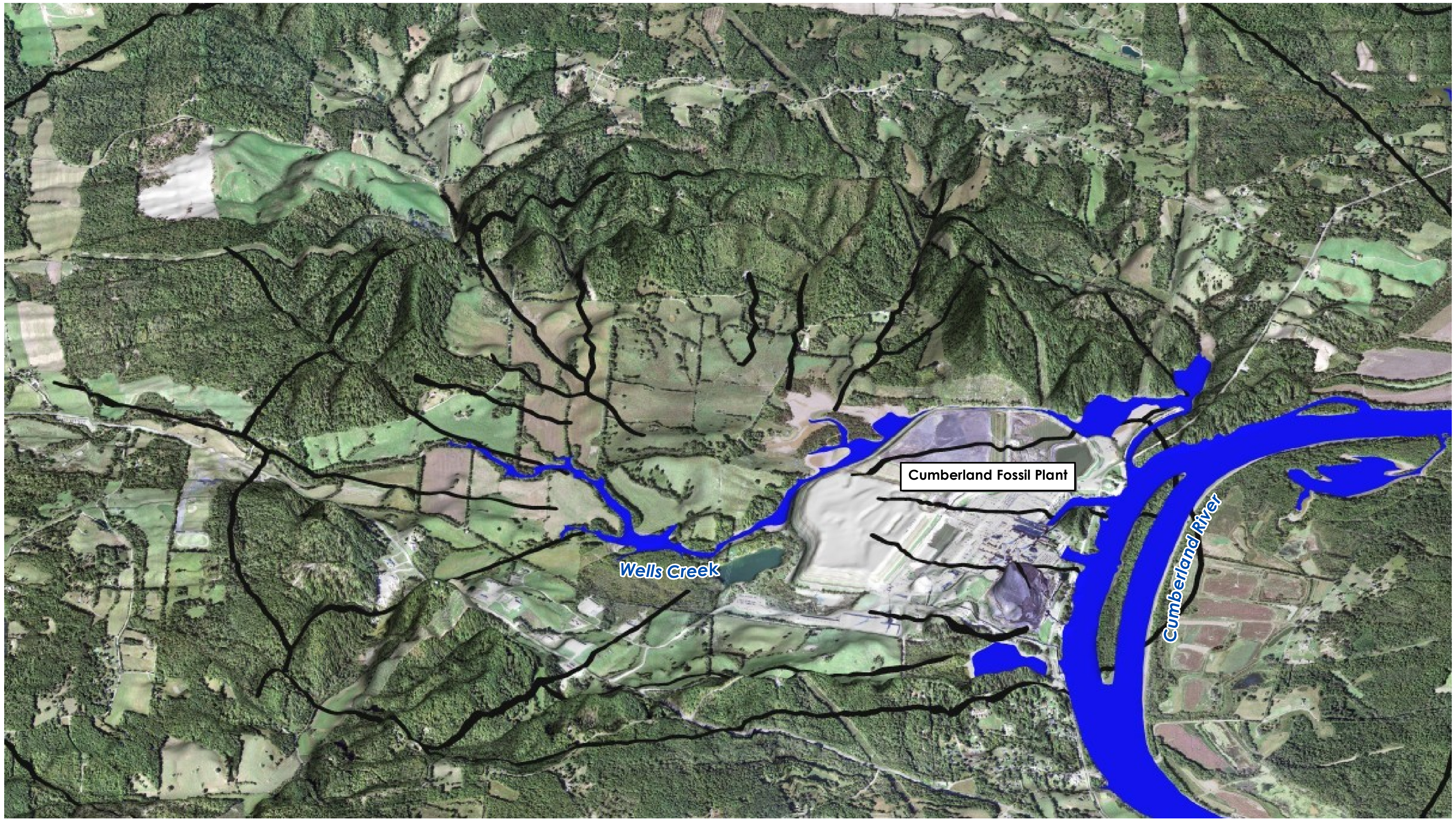
Wells Creek Basin Faults, Fractures, and Topographic Relief

Client/Project 175568209

Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Clinton, Tennessee
Stewart County, Tennessee

Prepared by TH on 2021-10-12
TR by CH on 2021-01-27
IR Review by SG on 2021-01-27



Oblique View

Legend

- Water Bodies
- Faults and Fractures Mapped by Wilson & Sterns, 1968

Notes:
Imagery is an oblique view of a 3-dimensional representation of a digital elevation model with 4X vertical exaggeration. The horizontal scale below is referenced to the location of the Cumberland Fossil Plant. Areas in the fore- and background of the image will have different horizontal scales.

N
0 2,000 4,000 Feet
Approximate Scale

Stantec

TVA

C:\Users\theller\Desktop\CUF\CUF_exhibit_2-5_TopographicRelief.mxd Revised: 2021-10-13 By: theller

Exhibit No.

3-1

Title

Background Soil Boring Location Map

Client/Project

Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location

Stewart County, Tennessee

175568209
Prepared by DMB on 2022-10-26
Technical Review by ES on 2022-10-26

0 600 1,200 1,800 2,400 Feet

1:7,200 (At original document size of 22x34)

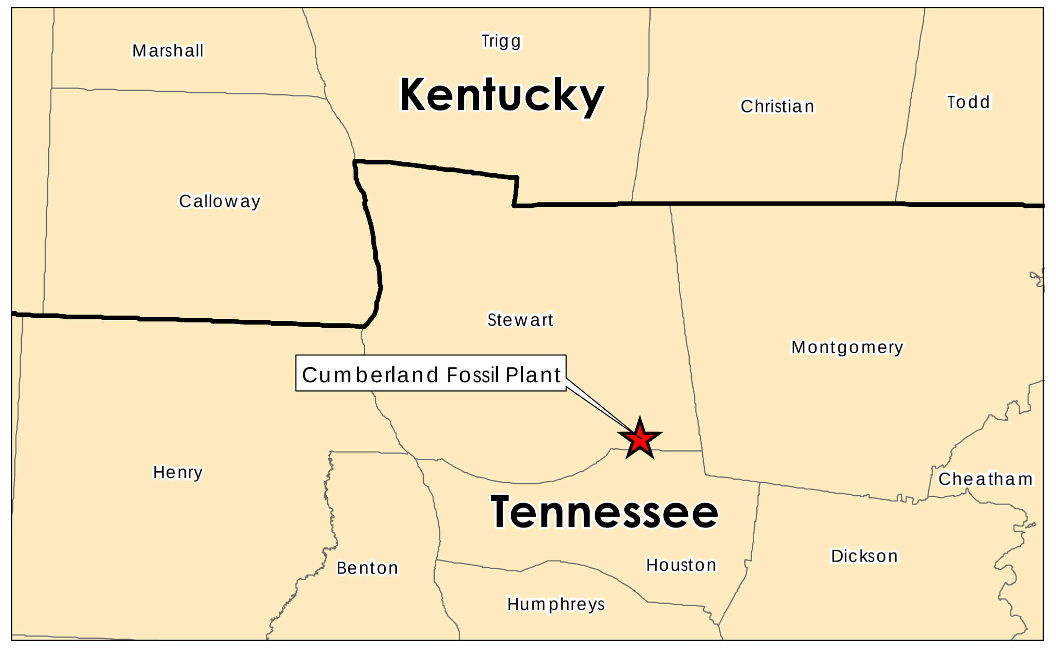
Legend

- Background Soil Boring — BGS Id
- Drilled and Abandoned Borehole — Boring Name
- Background Monitoring Well — Well Name / Boring Name
- 2021 Imagery Boundary
- 2022 Imagery Boundary
- CCR Unit Area (Approximate)

N

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by Tuck Mapping (c. 2017) and TVA (5/21/2021 and 5/12/2022)
3. Each inset outline color correlates with the same color extent shown in the main figure.
4. CUF-1001ALT had soil samples that were collected and submitted for analysis prior to the subsequent abandonment of the location.
5. Sample collected from boring CUF-1001ALT2 was labeled CUF-BS-CUF1001-12.0/16.5-20190410.



Stantec TVA

Exhibit No.
4-1

Title

Boring Location Map

Client/Project

Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location: Stewart County, Tennessee

175568209
Prepared by LMB on 2022-10-25
Technical Review by ND on 2022-10-25

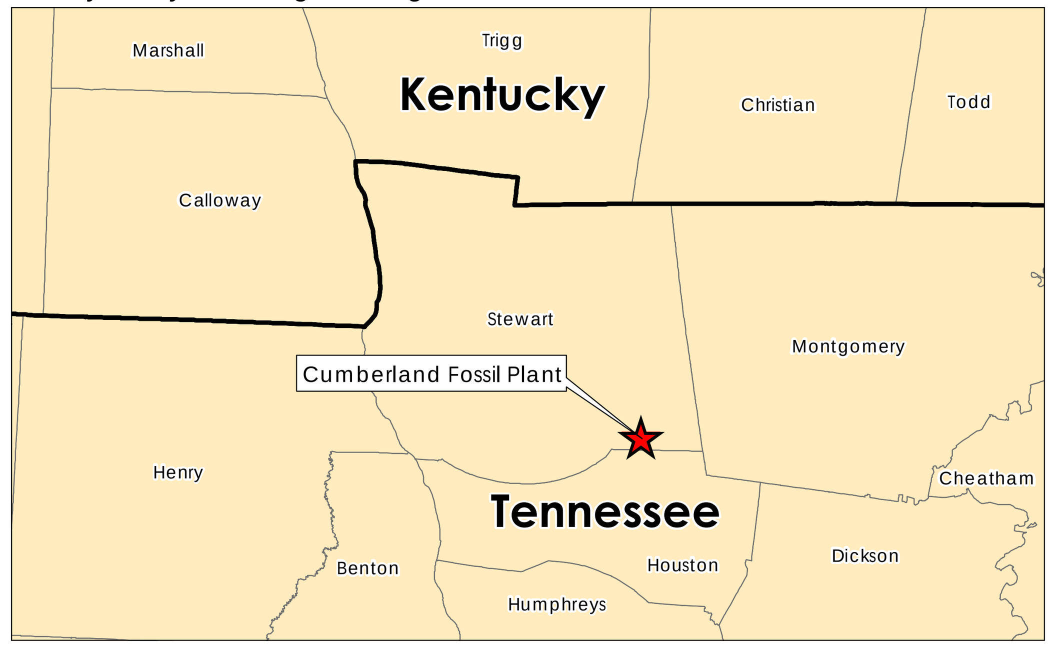
0 300 600 900 1,200 Feet
1:3,600 (At original document size of 22x34)

Legend

- Geotechnical Boring
- Geotechnical Boring with Vibrating Wire Piezometer
- Temporary Well (Screened Interval)
- Historical Wells Creek Alignment (Approximate)
- 1990's Perimeter Dike and Foundation Soil Grouting Alignment (Approximate)
- 1980's Interior Bottom Ash Dike (Approximate)
- 2021 Imagery Boundary
- 2022 Imagery Boundary
- CCR Unit Area (Approximate)

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by Tuck Mapping (c. 2017) and TVA (5/21/2021 and 5/12/2022)
3. Temporary wells TW02, TW04, and TW06 were not installed because the borings had insufficient depth of water within gypsum to warrant installation.
4. The locations of geotechnical borings CUF-B11 through CUF-B19 and temporary well locations were surveyed by the R.L.S. Group on 04/24/2019 and 05/15/2019. The geotechnical borings CUF-B20 through CUF-B25 were surveyed by DDS Engineering on 09/22/2020 and 12/01/2020.



Stantec TVA

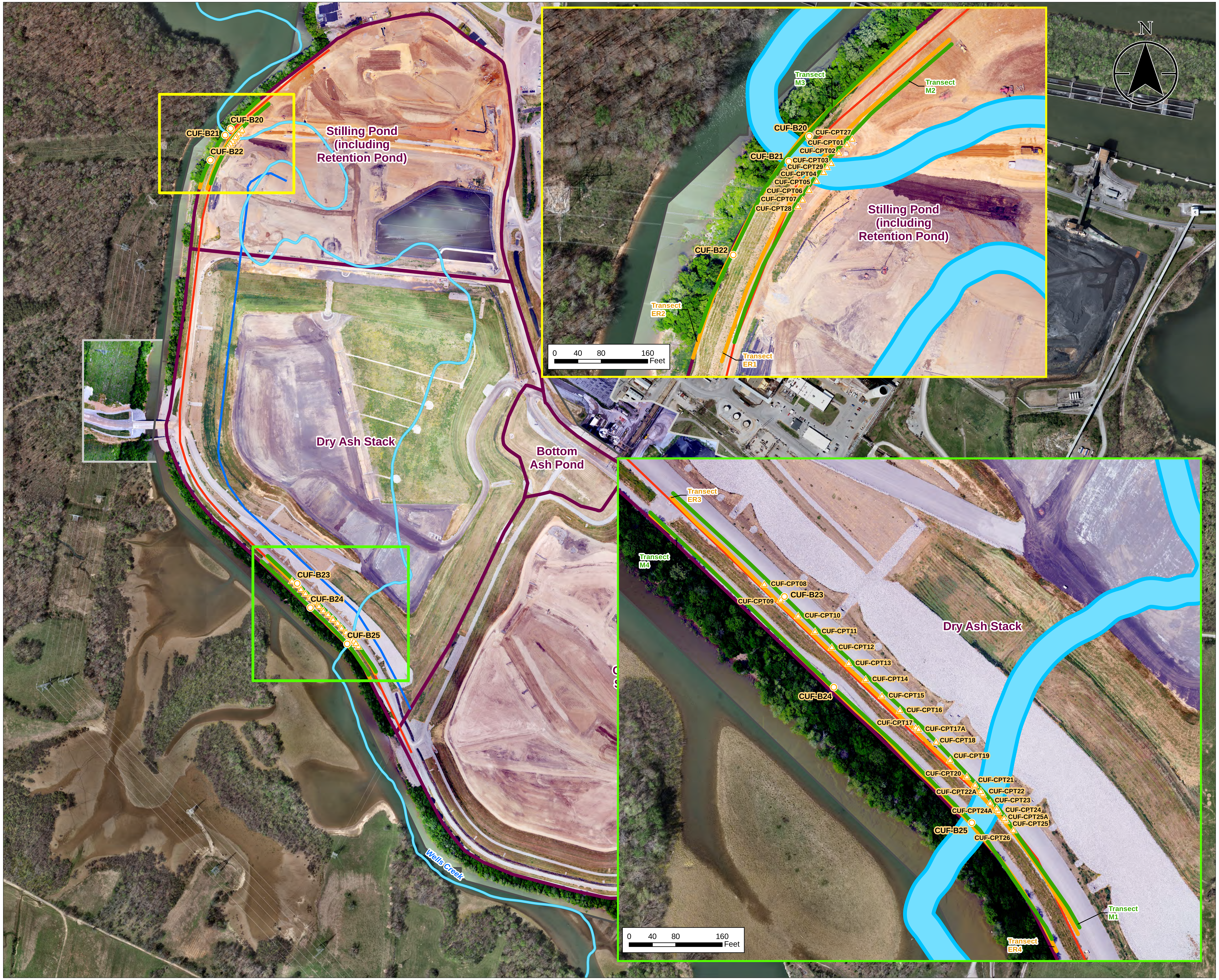


Exhibit No.
4-2

Title
Cone Penetration Testing, Surface Geophysical Surveys, and Supplemental Geotechnical Borings

Client/Project
Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location
Stewart County, Tennessee

175566329
Prepared by LMB on 2022-10-25
Technical Review by JD on 2022-10-25

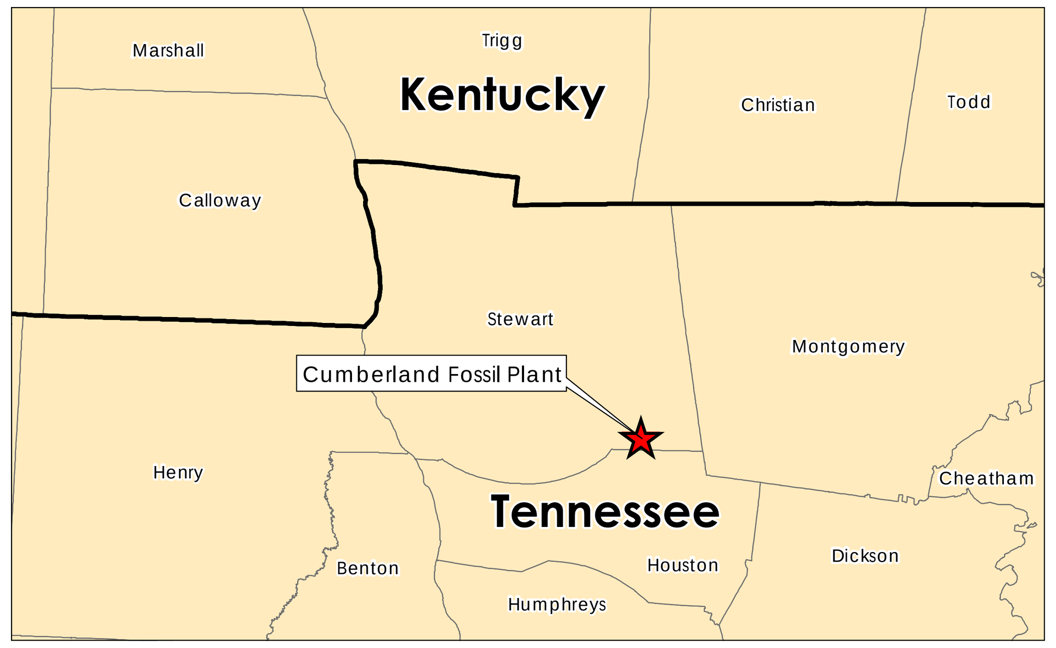
0 300 600 900 1,200
Feet
1:3,600 (At original document size of 22x34)

Legend

- Geotechnical Boring
- Cone Penetration Test
- Performed Geophysical Survey (Electrical Resistivity Imaging (ERI))
- Performed Geophysical Survey (Multichannel Analysis of Surface Waves (MASW))
- Historical Wells Creek Alignment (Approximate)
- 1990's Perimeter Dike and Foundation Soil Grouting Alignment (Approximate)
- 1980's Interior Bottom Ash Dike (Approximate)
- 2021 Imagery Boundary
- 2022 Imagery Boundary
- CCR Unit Area (Approximate)

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by Tuck Mapping (c. 2017) and TVA (5/21/2021 and 5/12/2022)
3. Location of performed CPTs were surveyed by the RLS Group on 04/29/2019. The location of the geotechnical borings were surveyed by DDS Engineering on 09/22/2020 and 12/01/2020.
4. Electrical Resistivity Imaging (ERI) and Multichannel Analysis of Surface Waves (MASW) surveys were conducted by ARM Geophysics at the transect locations along the raised dike crest and the remnant starter dike crest. Transect locations were based on handheld GPS coordinates by ARM Geophysics at the time of the surveys.



Stantec TVA

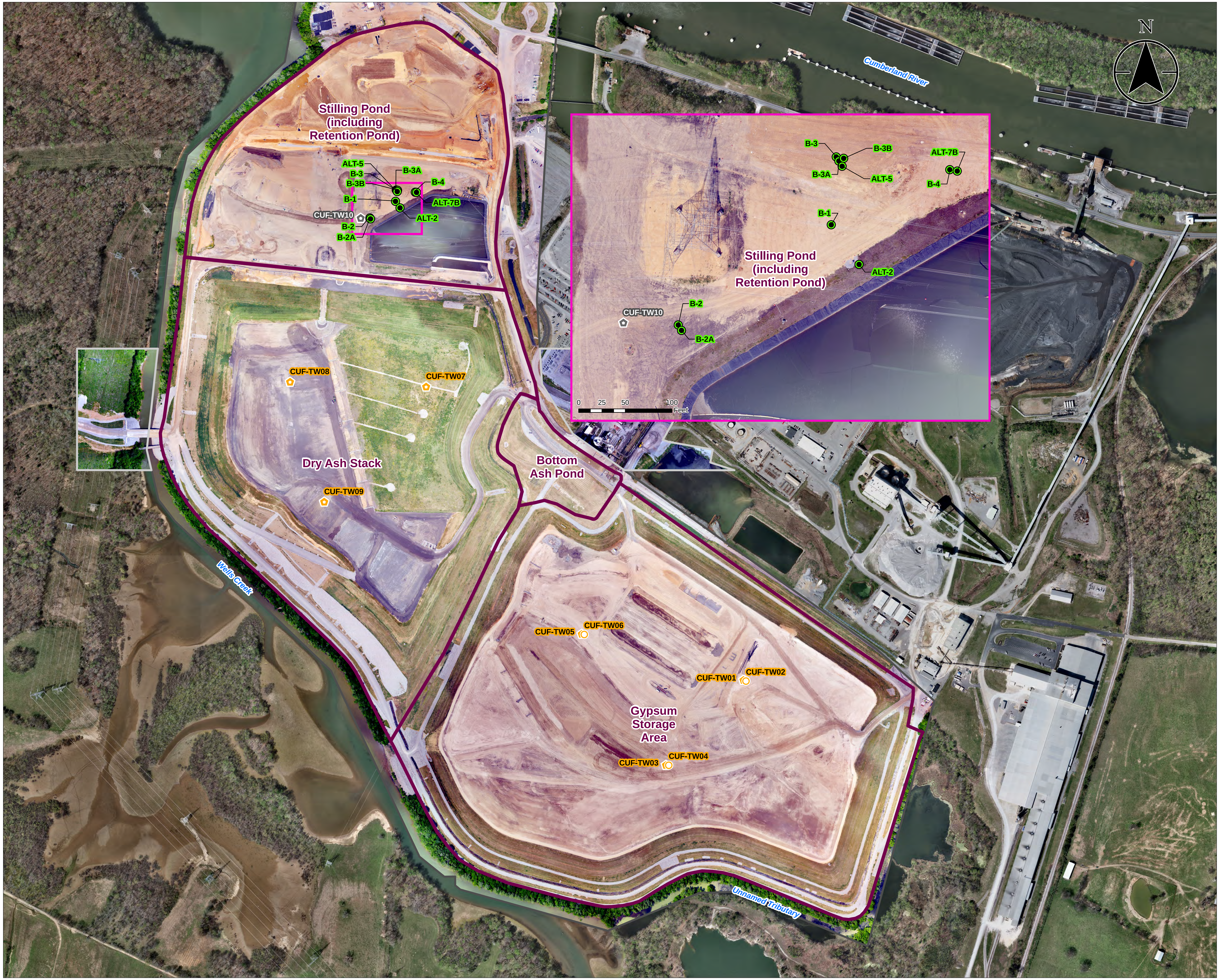


Exhibit No.

4-3

Title

Boring and Temporary Well Location Map

Client/Project

Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location

Stewart County, Tennessee

175568209

Prepared by DMB on 2022-10-13
Technical Review by RH on 2022-10-13

0 300 600 900 1,200 Feet

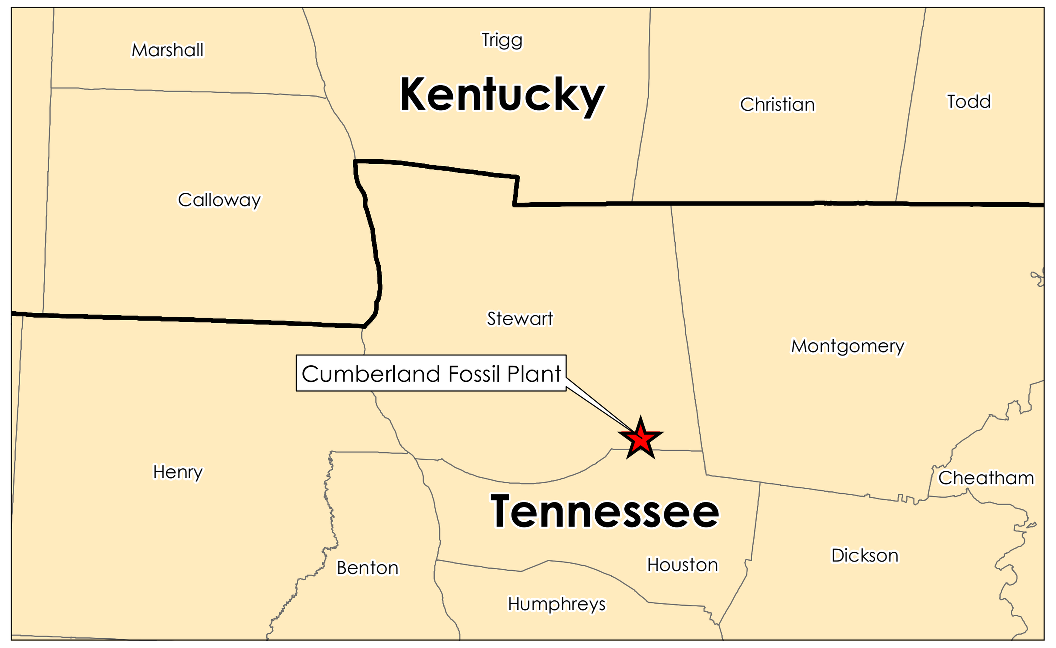
1:3,600 (At original document size of 22x34)

Legend

- Boring
- Non-TDEC Order Geotechnical Boring (used for supplemental CCR material sampling)
- Temporary Well
- Proposed Temporary Well (Not Completed)
- 2021 Imagery Boundary
- 2022 Imagery Boundary
- CCR Unit Area (Approximate)

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by Tuck Mapping (c. 2017) and TVA (5/21/2021 and 5/12/2022)
3. Geotechnical data includes CCR thickness, clay foundation soil thickness, top of rock elevation, and rock coring (RQD).
4. The geotechnical boring IDs do not include the "MAP (Main Ash Pond)" nomenclature.



Stantec

TVA

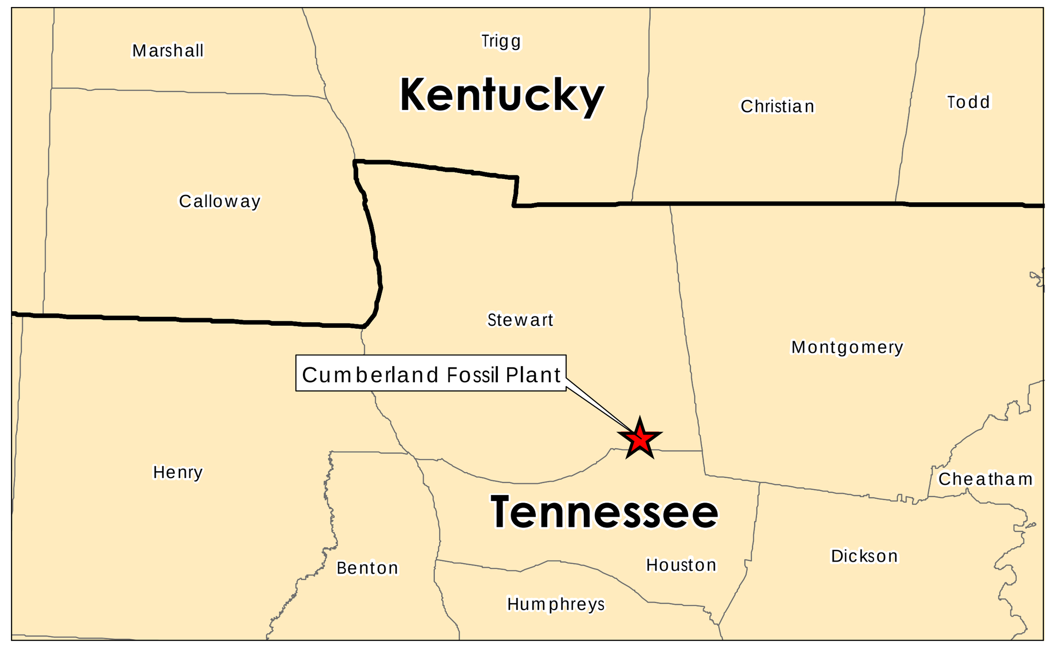


Exhibit No.

4-4

Title

Pore Water Elevation Contour Map, Event #2 (July 8, 2019)

Client/Project

Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location: Stewart County, Tennessee

175568209
Prepared by MB on 2022-12-05
Technical Review by MD on 2022-12-05

0 | 400 | 800 | 1,200 | 1,600 Feet

1:4,800 (At original document size of 22x34)

Legend

- Groundwater Investigation Monitoring Well — groundwater elevation in feet above mean sea level (ft amsl); value not used for contouring
- Other Monitoring Well — groundwater elevation in ft amsl; value not used for contouring
- Piezometer — groundwater elevation in ft amsl; value not used for contouring
- Piezometer in CCR — pore water elevation in ft amsl
- Temporary well in CCR — pore water elevation in ft amsl
- Cumberland River Gauging Station — surface water elevation in ft amsl
- Interpolated Pore water Contour (5 ft interval; elevations are in ft amsl)
- Pore water Contour (5 ft interval; elevations are in ft amsl)
- Surface Stream Flow
- 2021 Imagery Boundary
- 2022 Imagery Boundary
- CCR Unit Area (Approximate)

CCR: Coal combustion residuals

< Groundwater elevations are rounded to nearest foot to constrain potential elevation when depth to groundwater could not be measured.

*Groundwater elevation displayed but not used as input for contouring due to factors such as well construction or being screened in a different hydrogeologic unit.

**Piezometer was not collecting groundwater measurements during this monitoring event.

***Nested VWPZ sensors monitoring pore water and groundwater elevations in the same borehole, and the location is shown by a single symbol.

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by Tuck Mapping (c. 2017) and TVA (5/21/2021 and 5/12/2022)
3. Pore water contours were created with manual adjustment using Surfer Version 16 (December 13, 2018)
4. For PZ's with multiple instruments in CCR material, the reading with the highest pore water elevation is displayed, unless that reading is suspected of being erroneous.

Stantec TVA

U:\TVA-EIP\175568209_CUF_Phase2\gis\mxd\EAR\4-4_CUF_PoreWaterElevationContourMapEvent2.mxd Revised: 2022-12-05 By: mbough

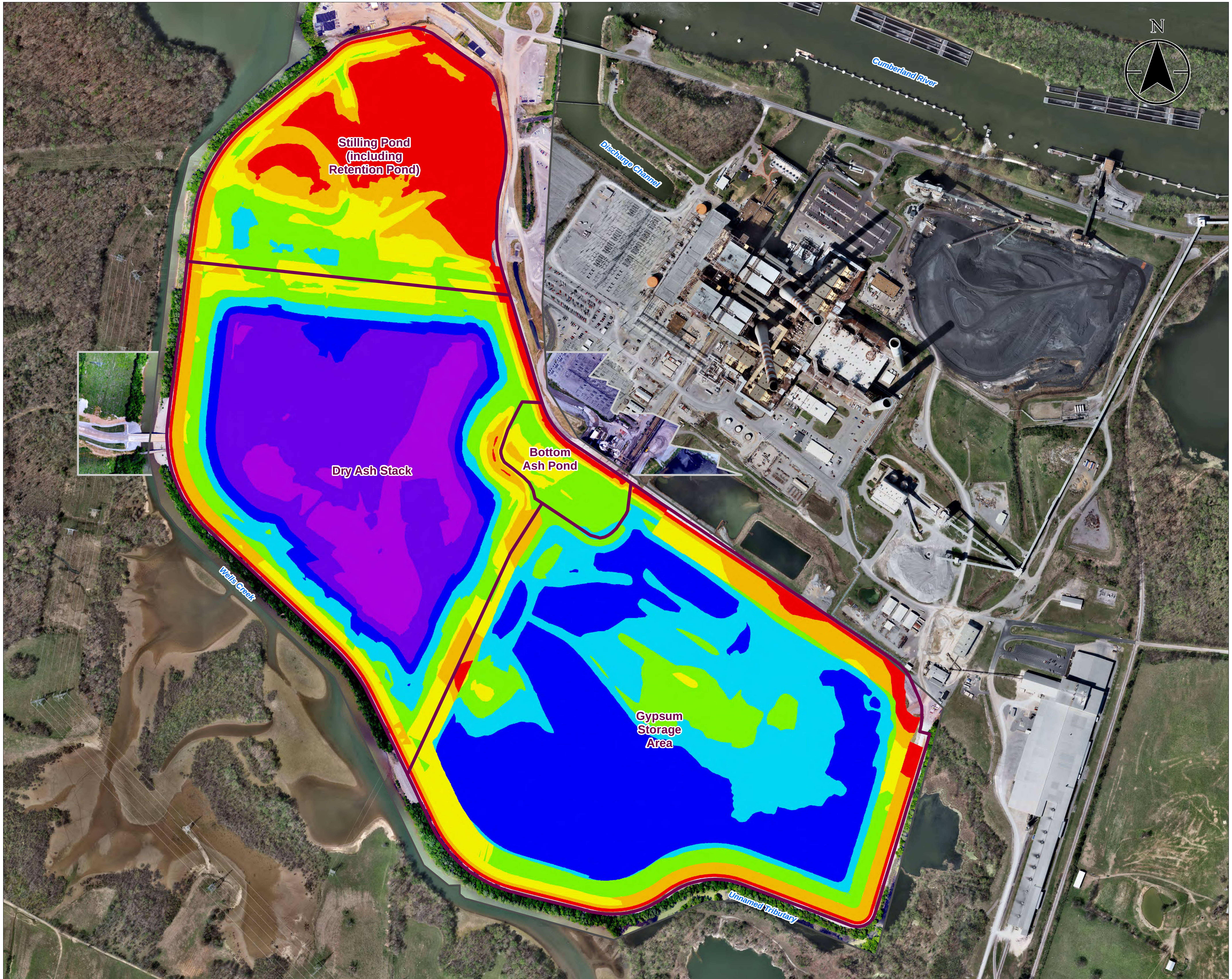


Exhibit No.
4-5

Title

Estimated Limits and Thickness of CCR Material

Client/Project

Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location
Stewart County, Tennessee

175568209
Prepared by MB on 2022-12-07
Technical Review by VS on 2022-12-07

0 300 600 900 1,200 Feet
1:3,600 (At original document size of 22x34)

Legend

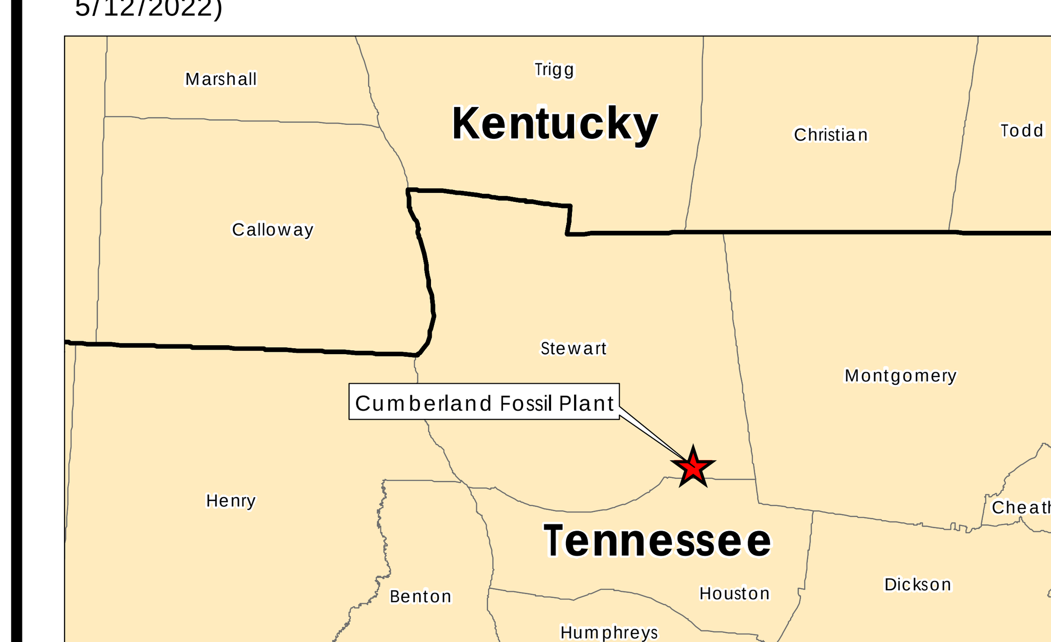
- CCR Unit Area (Approximate)
- 2021 Imagery Boundary
- 2022 Imagery Boundary

SUMMARY TABLE

NUMBER	MIN. DEPTH (FT)	MAX. DEPTH (FT)	AREA (AC)	COLOR
1	0	10	35	
2	10	20	28	
3	20	30	30	
4	30	45	47	
5	45	60	51	
6	60	75	70	
7	75	90	38	
8	90	108	19	

Notes

1. The information presented herein is based on data as of May 21, 2021.
2. The information presented herein applies only to the CCR management unit areas within the scope of the TDEC Order (i.e. Material Quantity Assessment Study Area).
3. Coordinate System: NAD 1927 StatePlane Tennessee FIPS 4100
4. Imagery Provided by Tuck Mapping (c. 2017) and TVA (5/21/2021 and 5/12/2022)



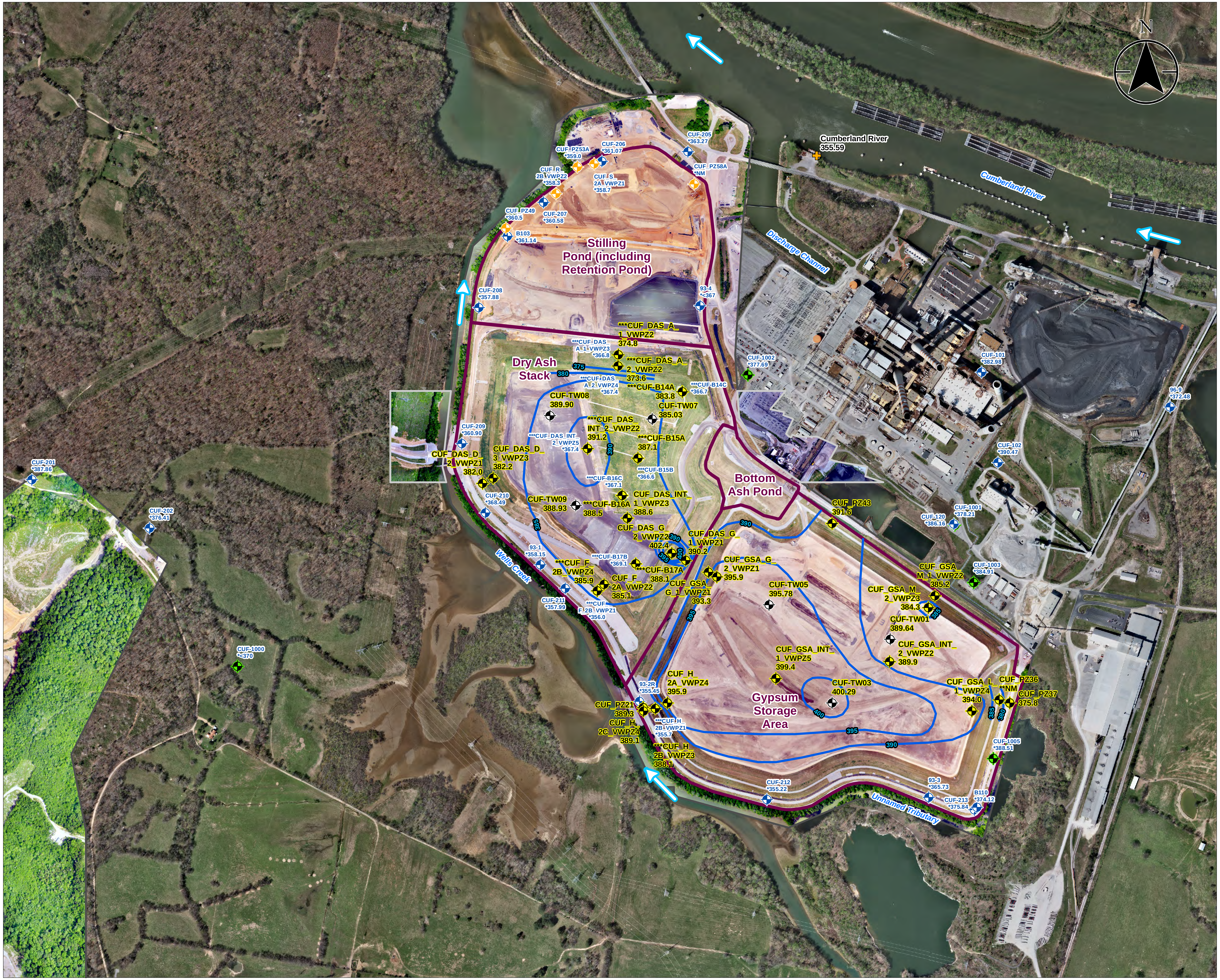


Exhibit No.

4-6

Title

Pore Water Elevation Contour Map, Event #3 (September 9, 2019)

Client/Project

Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location
Stewart County, Tennessee

175568209
Prepared by MB on 2022-12-05
Technical Review by MW on 2022-12-05

0 400 800 1,200 1,600 Feet

1:4,800 (At original document size of 22x34)

Legend

- Groundwater Investigation Monitoring Well: groundwater elevation in feet above mean sea level (ft amsl); value not used for contouring
- Other Monitoring Well: groundwater elevation in ft amsl; value not used for contouring
- Piezometer: groundwater elevation in ft amsl; value not used for contouring
- Piezometer in CCR: pore water elevation in ft amsl
- Temporary well in CCR: pore water elevation in ft amsl
- Cumberland River Gauging Station: surface water elevation in ft amsl
- Pore Water Contour (5 ft interval; elevations are in ft amsl)
- Surface Stream Flow
- 2021 Imagery Boundary
- 2022 Imagery Boundary
- CCR Unit Area (Approximate)

CCR: Coal combustion residuals

< Groundwater elevations are rounded to nearest foot to constrain potential elevation when depth to groundwater could not be measured.

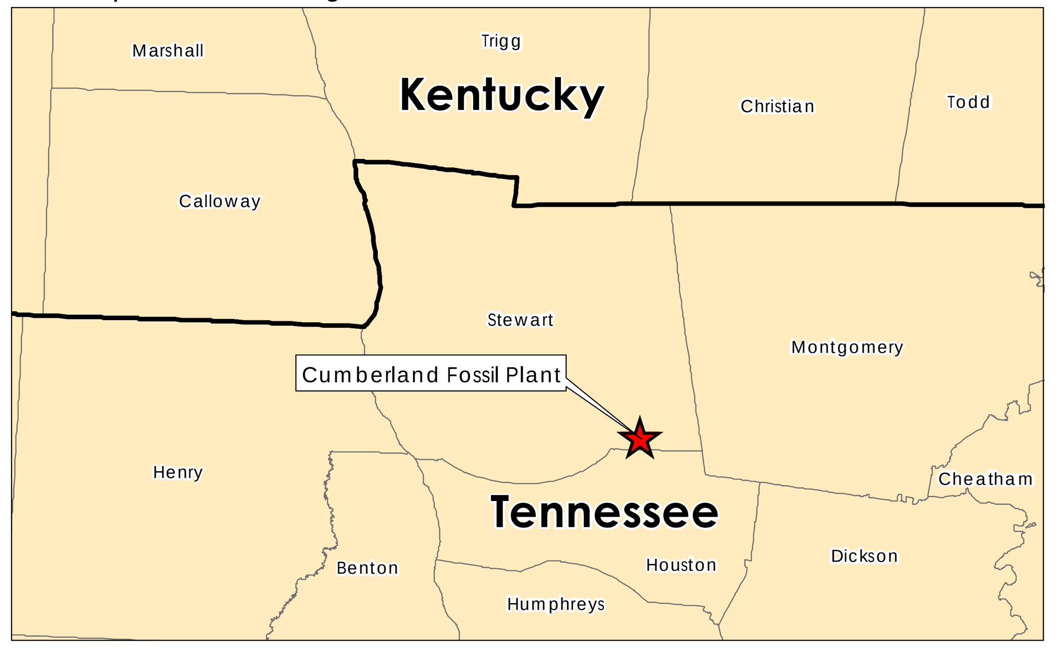
*Groundwater elevation displayed but not used as input for contouring due to factors such as well construction or being screened in a different hydrogeologic unit.

**Piezometer was not collecting groundwater measurements during this monitoring event.

***Nested Vibrating Wire Piezometer sensors monitoring pore water and groundwater elevations in the same borehole, and the location is shown by a single symbol.

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by Tuck Mapping (c. 2017) and TVA (5/21/2021 and 5/12/2022)
3. Pore water contours were created with manual adjustment using Surfer Version 16 (December 13, 2018)
4. For Piezometers with multiple instruments in CCR material, the reading with the highest pore water elevation is displayed, unless that reading is suspected of being erroneous.



Stantec TVA

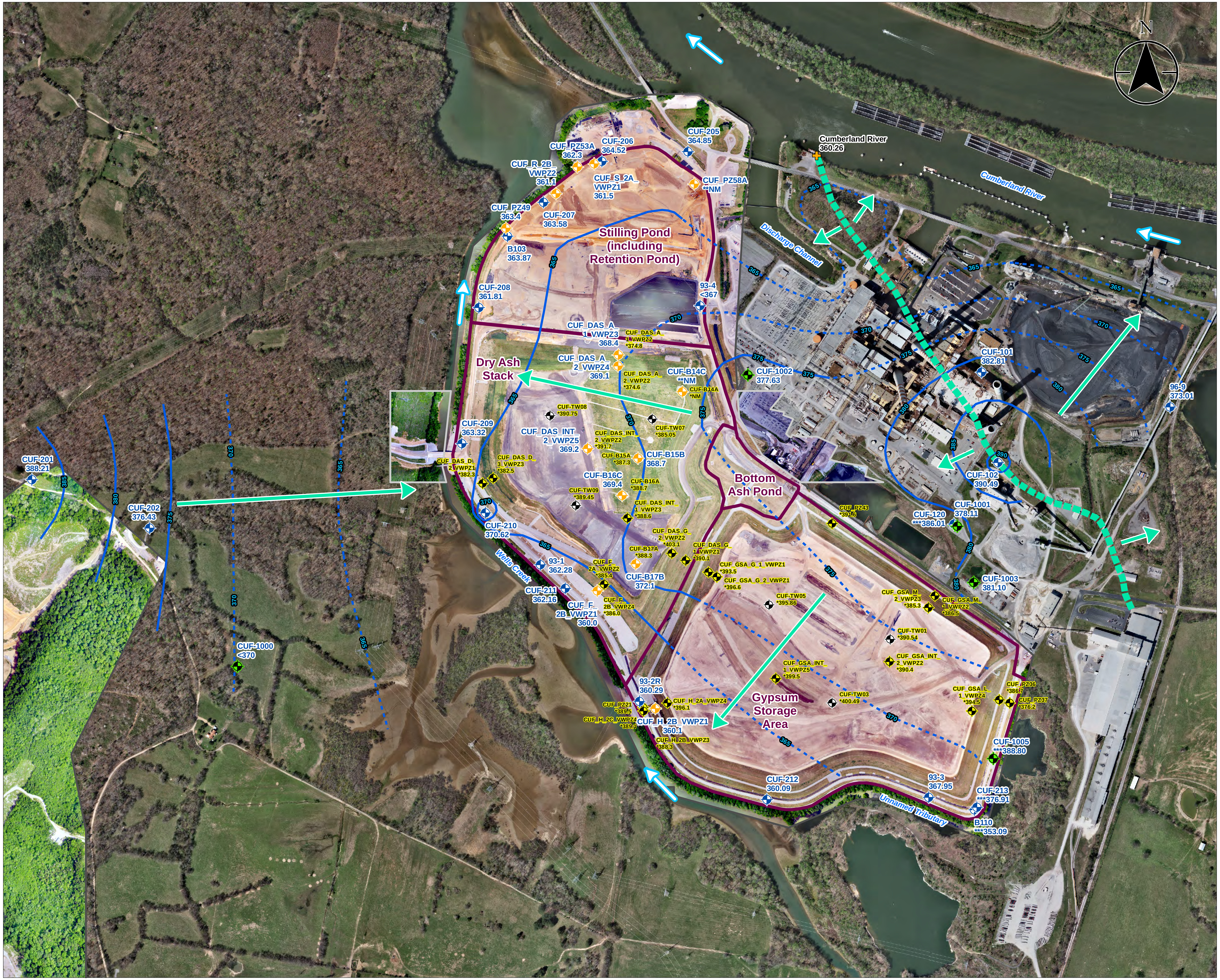


Exhibit No.

5-1

Title

Groundwater Elevation Contour Map, Event #2 (July 8, 2019)

Client/Project

Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location

Stewart County, Tennessee

175568209
Prepared by MB on 2022-12-15
Technical Review by MD on 2022-12-15

0 400 800 1,200 1,600 Feet

1:4,800 (At original document size of 22x34)

Legend

- Groundwater Investigation Monitoring Well
  groundwater elevation in feet above mean sea level (ft amsl)
- Other Monitoring Well
  groundwater elevation in ft amsl
- Piezometer
  groundwater elevation in ft amsl
- Piezometer in CCR
  pore water elevation in ft amsl; value not used for contouring
- Temporary well in CCR
  pore water elevation in ft amsl; value not used for contouring
- Cumberland River Gauging Station
  surface water elevation in ft amsl
- Inferred Groundwater Flow
- Interpolated Groundwater Contour (5 ft interval; elevations are in ft amsl)
- Groundwater Contour (5 ft interval; elevations are in ft amsl)
- Groundwater Divide
- Surface Stream Flow
- 2021 Imagery Boundary
- 2022 Imagery Boundary
- CCR Unit Area (Approximate)

CCR: Coal combustion residuals

The groundwater elevations and flow are focused on data from wells that monitor the uppermost aquifer, but also rely on data collected from wells or piezometers installed in the CCR management units or other hydrogeological units to support the evaluations.

< Groundwater elevations are rounded to nearest foot to constrain potential elevation when depth to groundwater could not be measured.

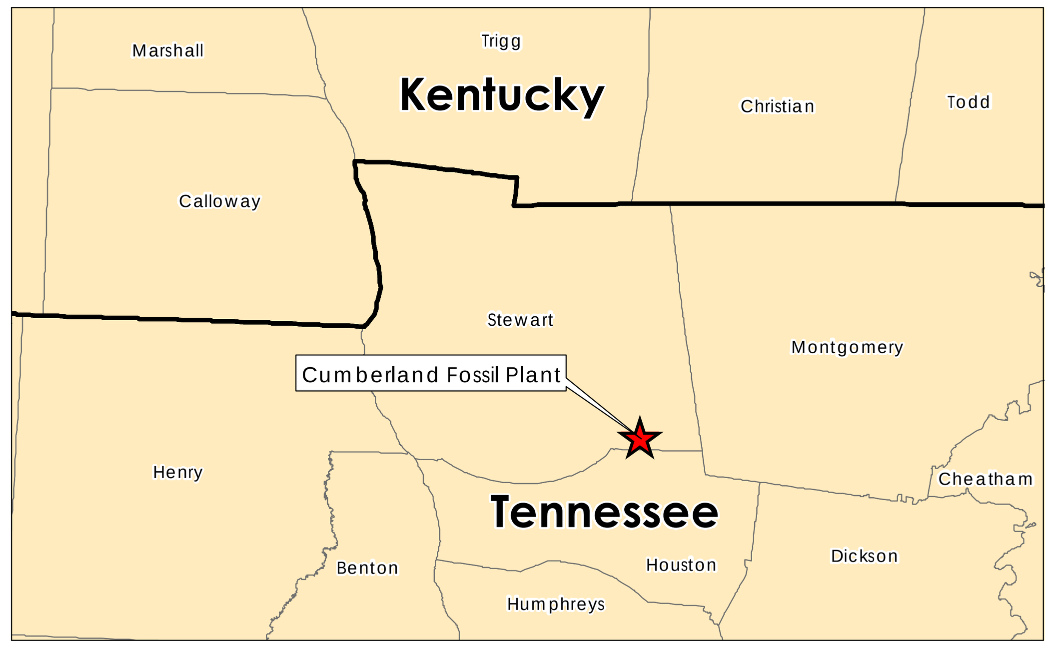
*Location monitoring pore water and is not used to develop groundwater contours.

**Piezometers were not collecting groundwater measurements during this monitoring event.

***Groundwater elevation displayed but not used as input for contouring due to factors such as well construction or being screened in a different hydrogeologic unit.

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by Tuck Mapping (c. 2017) and TVA (5/21/2021 and 5/12/2022)
3. Groundwater contours were created using Surfer Version 16.1.350 (December 13, 2018) and manual adjustment
4. For PZ's with multiple instruments in CCR material, the reading with the highest pore water elevation is displayed, unless that reading is suspected of being erroneous.
5. Groundwater contours for the Gypsum Storage Area are inferred from perimeter monitoring wells.



Stantec TVA

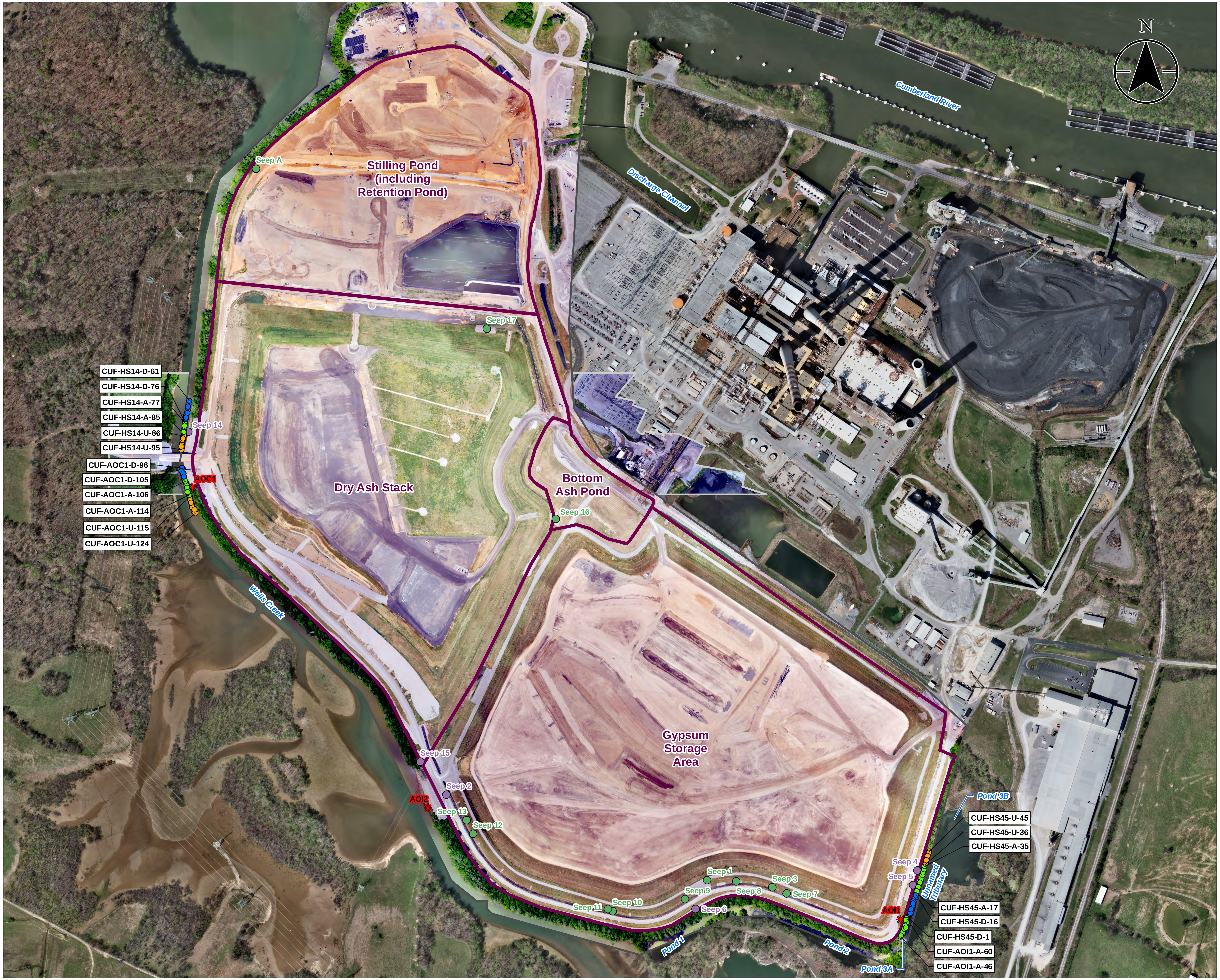


Exhibit No.
6-1

Title
Seep Investigation Areas of Interest and Water Quality Parameter Measurement Locations

Client/Project
Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location
Stewart County, Tennessee

175568209
Prepared by MB on 2022-10-26
Technical Review by HW on 2022-10-26

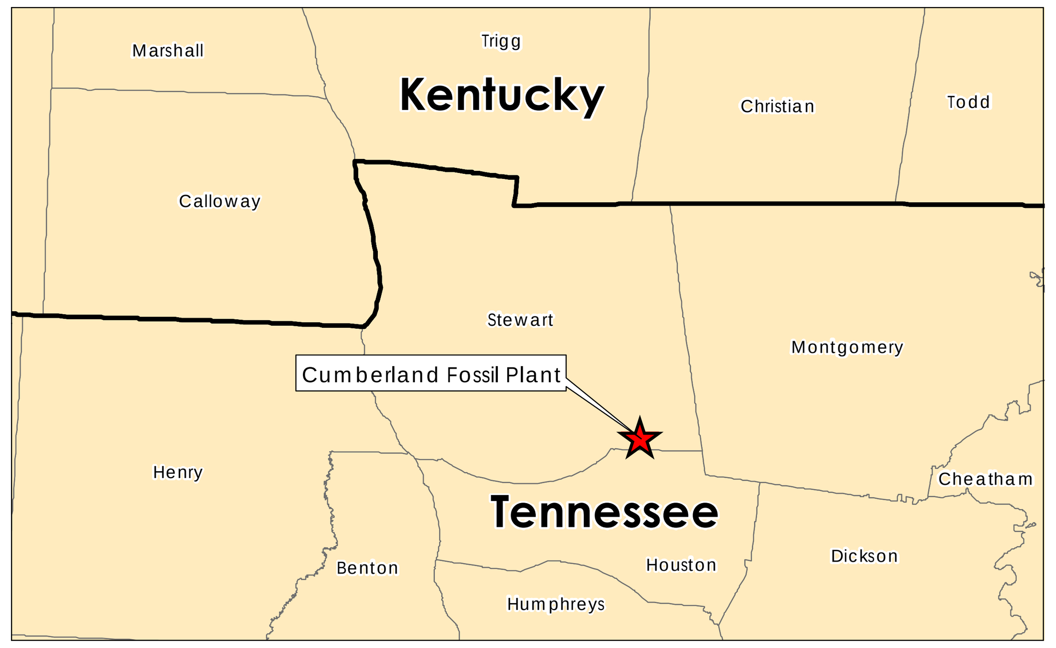
0 300 600 900 1,200 Feet
1:3,600 (At original document size of 22x34)

Legend

Measurement Locations

- Adjacent (A)
- Downstream (D)
- Upstream (U)
- Area of Interest (AOI)/Area of Concern (AOC) Location
- Historical Seep Above Perimeter Ditch
- Historical Seep Below Perimeter Ditch
- 2021 Imagery Boundary
- 2022 Imagery Boundary
- CCR Unit Area (Approximate)

Notes
1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by Tuck Mapping (c. 2017) and TVA (5/21/2021 and 5/12/2022)



Stantec TVA

Exhibit No.

7-1

Title

Surface Stream Sampling Results above Ecological Screening Values

Client/Project

Tennessee Valley Authority
Cumberland Fossil Plant (CUF) TDEC Order

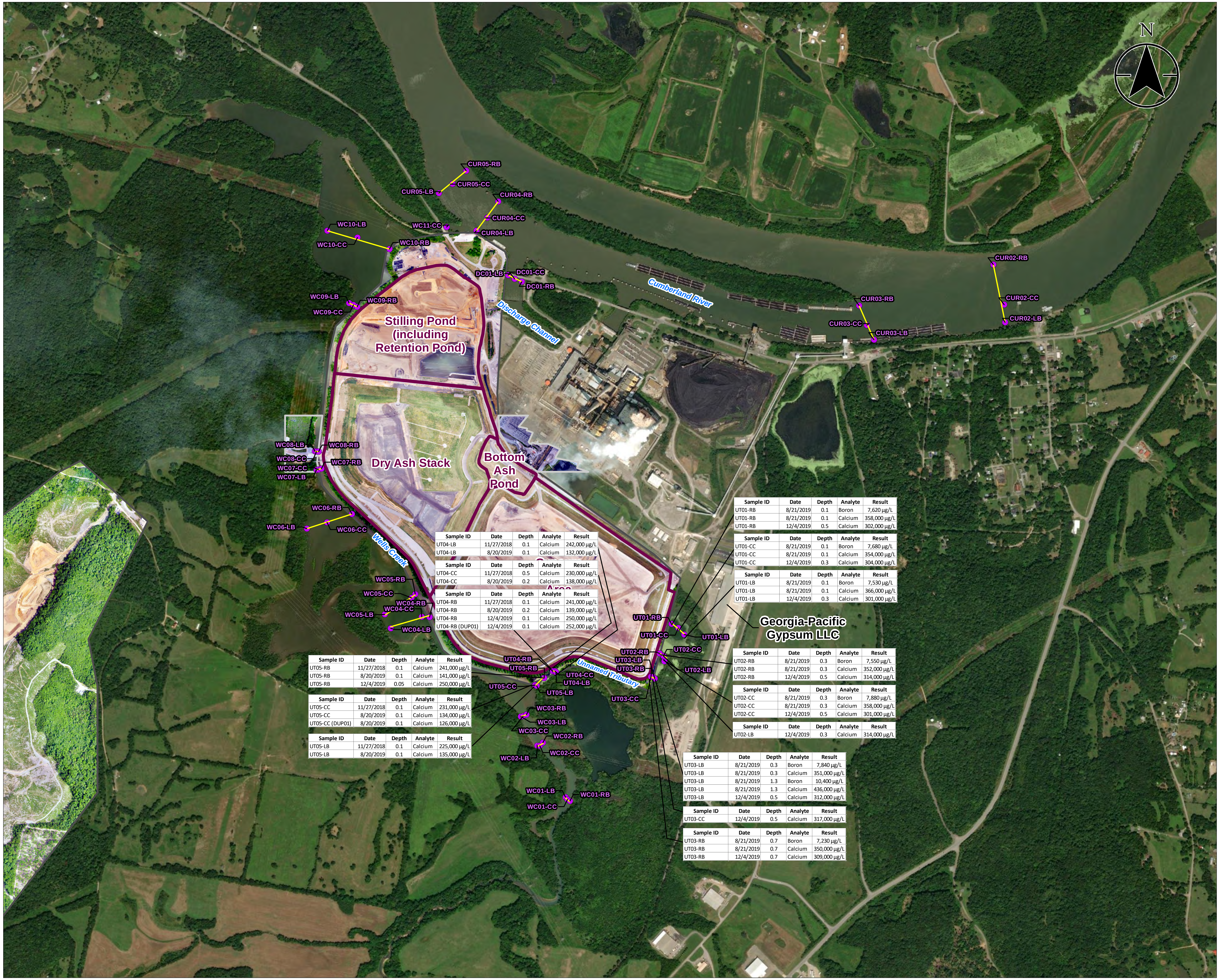
Project Location

Stewart County, Tennessee

175568209
Prepared by DMB on 2022-12-12
Technical Review by ME on 2022-12-12

0 650 1,300 1,950 2,600 Feet

1:7,800 (At original document size of 22x34)



Sample ID	Date	Depth	Analyte	Result
UT04-LB	11/27/2018	0.1	Calcium	242,000 µg/L
UT04-LB	8/20/2019	0.1	Calcium	132,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT04-CC	11/27/2018	0.5	Calcium	230,000 µg/L
UT04-CC	8/20/2019	0.2	Calcium	138,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT04-RB	11/27/2018	0.1	Calcium	241,000 µg/L
UT04-RB	8/20/2019	0.2	Calcium	139,000 µg/L
UT04-RB	12/4/2019	0.1	Calcium	250,000 µg/L
UT04-RB (DUP01)	12/4/2019	0.1	Calcium	252,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT05-RB	11/27/2018	0.1	Calcium	241,000 µg/L
UT05-RB	8/20/2019	0.1	Calcium	141,000 µg/L
UT05-RB	12/4/2019	0.05	Calcium	250,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT05-CC	11/27/2018	0.1	Calcium	231,000 µg/L
UT05-CC	8/20/2019	0.1	Calcium	134,000 µg/L
UT05-CC (DUP01)	8/20/2019	0.1	Calcium	126,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT05-LB	11/27/2018	0.1	Calcium	225,000 µg/L
UT05-LB	8/20/2019	0.1	Calcium	135,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT01-RB	8/21/2019	0.1	Boron	7,620 µg/L
UT01-RB	8/21/2019	0.1	Calcium	358,000 µg/L
UT01-RB	12/4/2019	0.5	Calcium	302,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT01-CC	8/21/2019	0.1	Boron	7,680 µg/L
UT01-CC	8/21/2019	0.1	Calcium	354,000 µg/L
UT01-CC	12/4/2019	0.3	Calcium	304,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT01-LB	8/21/2019	0.1	Boron	7,530 µg/L
UT01-LB	8/21/2019	0.1	Calcium	366,000 µg/L
UT01-LB	12/4/2019	0.3	Calcium	301,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT02-RB	8/21/2019	0.3	Boron	7,550 µg/L
UT02-RB	8/21/2019	0.3	Calcium	352,000 µg/L
UT02-RB	12/4/2019	0.5	Calcium	314,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT02-CC	8/21/2019	0.3	Boron	7,880 µg/L
UT02-CC	8/21/2019	0.3	Calcium	358,000 µg/L
UT02-CC	12/4/2019	0.5	Calcium	301,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT02-LB	12/4/2019	0.3	Calcium	314,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT03-LB	8/21/2019	0.3	Boron	7,840 µg/L
UT03-LB	8/21/2019	0.3	Calcium	351,000 µg/L
UT03-LB	8/21/2019	1.3	Boron	10,400 µg/L
UT03-LB	8/21/2019	1.3	Calcium	436,000 µg/L
UT03-LB	12/4/2019	0.5	Calcium	312,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT03-CC	12/4/2019	0.5	Calcium	317,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT03-RB	8/21/2019	0.7	Boron	7,230 µg/L
UT03-RB	8/21/2019	0.7	Calcium	350,000 µg/L
UT03-RB	12/4/2019	0.7	Calcium	309,000 µg/L

Legend

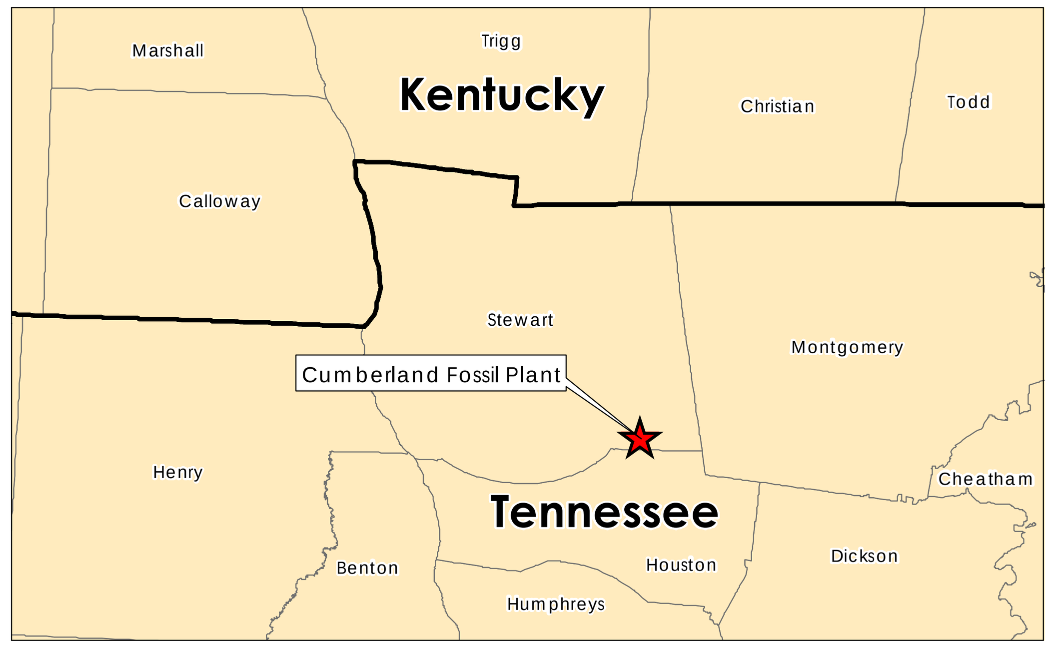
- Surface Stream Sampling Locations
- Surface Stream Sampling Locations - Transect
- 2021 Imagery Boundary
- 2022 Imagery Boundary
- CCR Unit Area (Approximate)

ESV - Ecological Screening Value
CC - Center Channel
RB- Right Bank
LB- Left Bank
µg/L - micrograms per Liter

Boron Acute ESV	34,000 µg/L
Boron Chronic ESV	7,200 µg/L
Calcium Chronic ESV	116,000 µg/L

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (5/21/2021 and 5/12/2022) and Esri World Imagery
3. Note: Due to the dredging operations, surface water sampling in the Cumberland River was delayed until September. This sampling event is presented on Exhibits A.6 and A.6.1.



Stantec TVA

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Exhibit No.
7-2

Title

Sediment Sampling Results above Ecological Screening Values

Client/Project

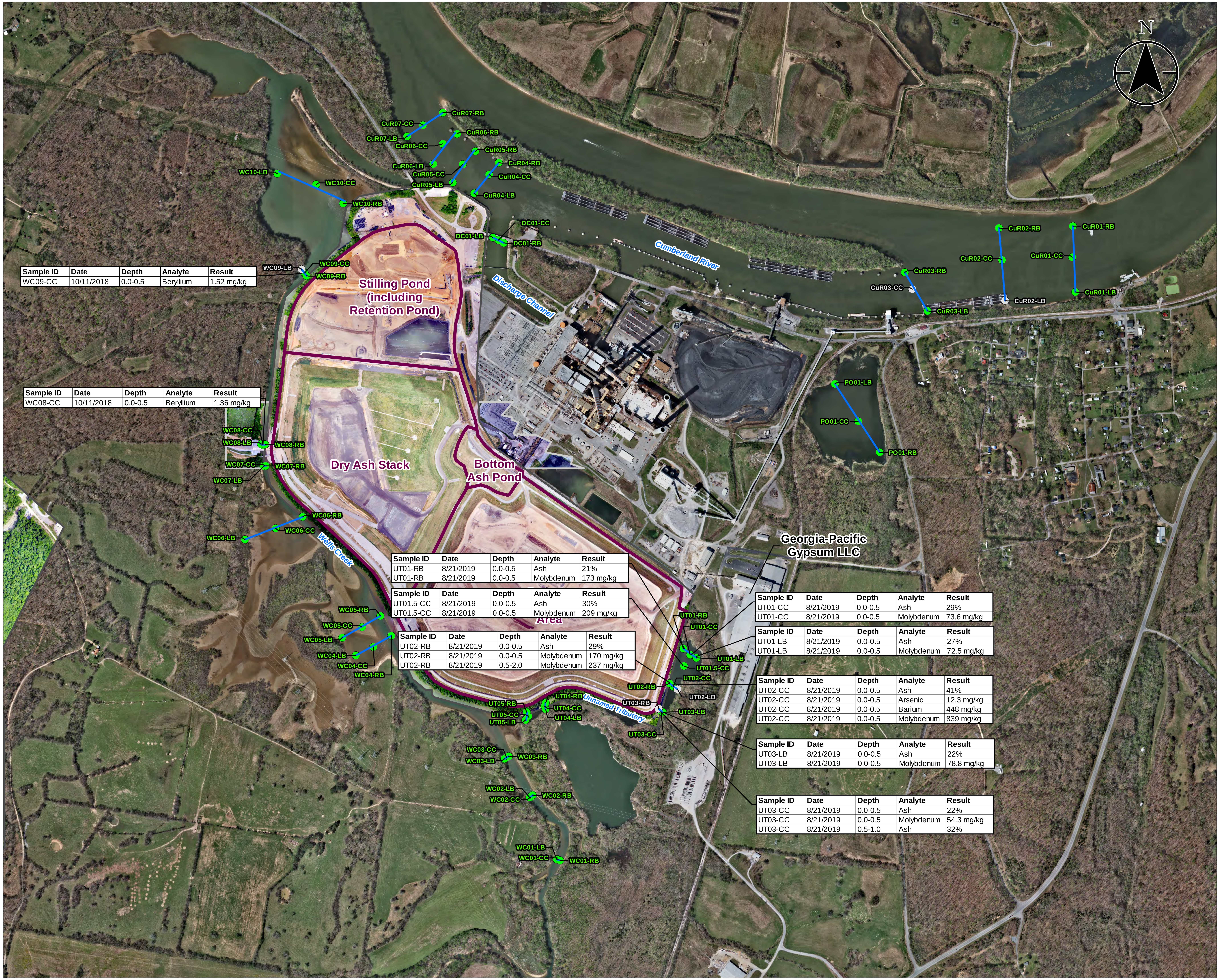
Tennessee Valley Authority
Cumberland Fossil Plant (CUF) TDEC Order

Project Location: Stewart County, Tennessee

175568209
Prepared by LMB on 2022-10-27
Technical Review by AT on 2022-10-27

0 550 1,100 1,650 2,200 Feet

1:6,600 (At original document size of 22x34)



Sample ID	Date	Depth	Analyte	Result
WC09-CC	10/11/2018	0.0-0.5	Beryllium	1.52 mg/kg

Sample ID	Date	Depth	Analyte	Result
WC08-CC	10/11/2018	0.0-0.5	Beryllium	1.36 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT01-RB	8/21/2019	0.0-0.5	Ash	21%
UT01-RB	8/21/2019	0.0-0.5	Molybdenum	173 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT01.5-CC	8/21/2019	0.0-0.5	Ash	30%
UT01.5-CC	8/21/2019	0.0-0.5	Molybdenum	209 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT02-RB	8/21/2019	0.0-0.5	Ash	29%
UT02-RB	8/21/2019	0.0-0.5	Molybdenum	170 mg/kg
UT02-RB	8/21/2019	0.5-2.0	Molybdenum	237 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT01-CC	8/21/2019	0.0-0.5	Ash	29%
UT01-CC	8/21/2019	0.0-0.5	Molybdenum	73.6 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT01-LB	8/21/2019	0.0-0.5	Ash	27%
UT01-LB	8/21/2019	0.0-0.5	Molybdenum	72.5 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT02-CC	8/21/2019	0.0-0.5	Ash	41%
UT02-CC	8/21/2019	0.0-0.5	Arsenic	12.3 mg/kg
UT02-CC	8/21/2019	0.0-0.5	Barium	448 mg/kg
UT02-CC	8/21/2019	0.0-0.5	Molybdenum	839 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT03-LB	8/21/2019	0.0-0.5	Ash	22%
UT03-LB	8/21/2019	0.0-0.5	Molybdenum	78.8 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT03-CC	8/21/2019	0.0-0.5	Ash	22%
UT03-CC	8/21/2019	0.0-0.5	Molybdenum	54.3 mg/kg
UT03-CC	8/21/2019	0.5-1.0	Ash	32%

Legend

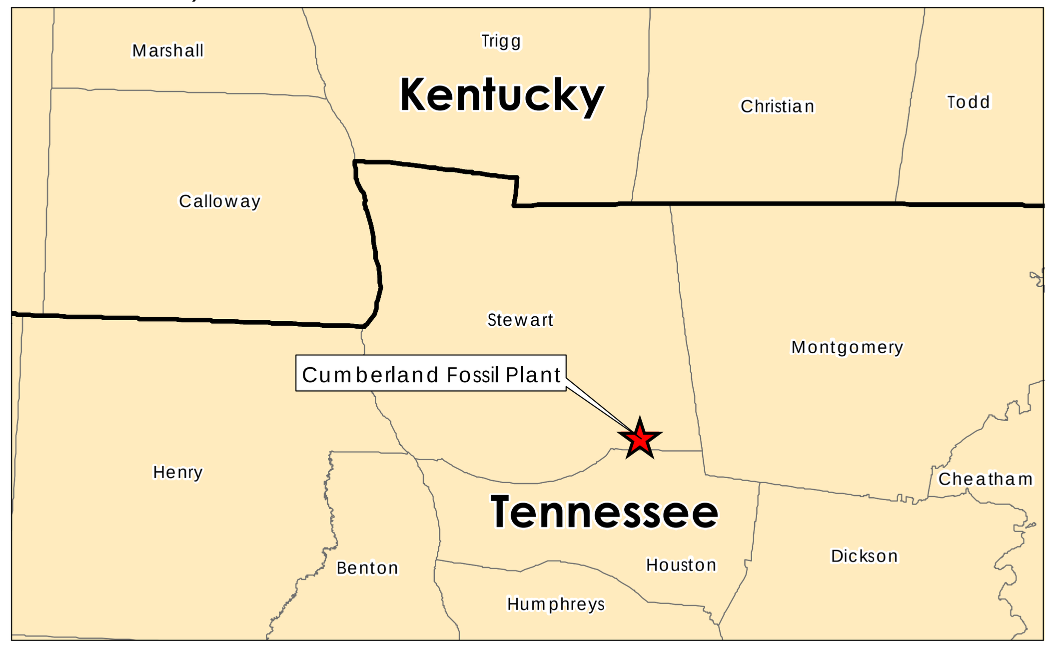
- Sediment Sampling Locations - Collected
- Sediment Sampling Locations - Attempted: Insufficient Sediment for Sampling
- Sediment Sampling Locations - Transect
- 2021 Imagery Boundary
- 2022 Imagery Boundary
- CCR Unit Area (Approximate)

Abbreviations:
CC - Center Channel
RB- Right Bank
LB- Left Bank
mg/kg - milligrams per kilogram

Chronic Ecological Screening Values	
% Ash	20%
Arsenic	9.8 mg/kg
Barium	240 mg/kg
Beryllium	1.2 mg/kg
Molybdenum	38 mg/kg

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by Tuck Mapping (c. 2017) and TVA (5/21/2021 and 5/12/2022)



Stantec TVA

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Exhibit No.

7-3

Title

Mayfly Sampling Results above Critical Body Residue Values

Client/Project

Tennessee Valley Authority
Cumberland Fossil Plant (CUF) TDEC Order

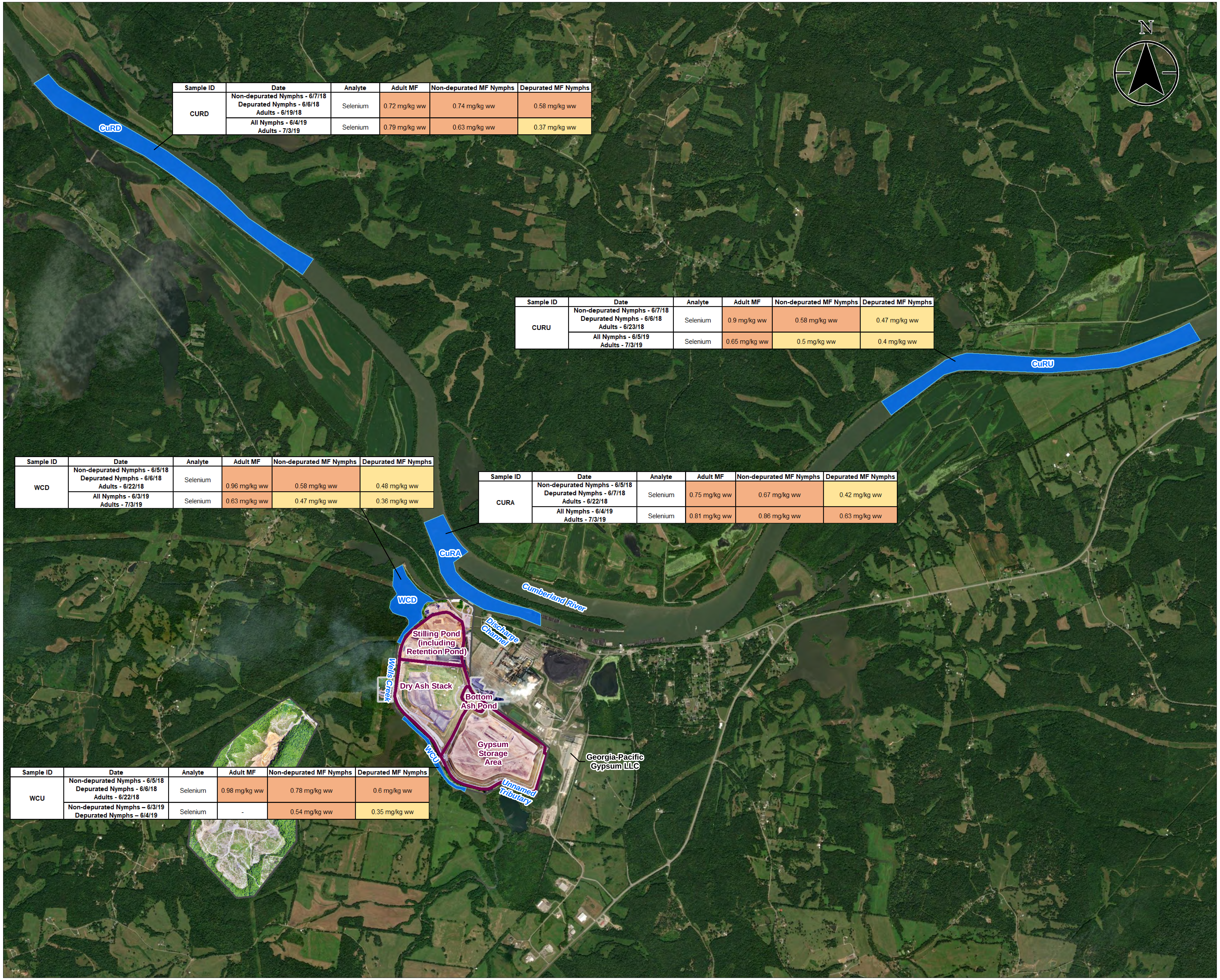
Project Location 175568209

Stewart County, Tennessee

Prepared by DMB on 2022-10-26
Technical Review by JC on 2022-10-26

0 1,500 3,000 4,500 6,000 Feet

1:18,000 (At original document size of 22x34)



Sample ID	Date	Analyte	Adult MF	Non-depurated MF Nymphs	Depurated MF Nymphs
CURD	Non-depurated Nymphs - 6/7/18 Depurated Nymphs - 6/6/18 Adults - 6/19/18	Selenium	0.72 mg/kg ww	0.74 mg/kg ww	0.58 mg/kg ww
	All Nymphs - 6/4/19 Adults - 7/3/19	Selenium	0.79 mg/kg ww	0.63 mg/kg ww	0.37 mg/kg ww

Sample ID	Date	Analyte	Adult MF	Non-depurated MF Nymphs	Depurated MF Nymphs
CURU	Non-depurated Nymphs - 6/7/18 Depurated Nymphs - 6/6/18 Adults - 6/23/18	Selenium	0.9 mg/kg ww	0.58 mg/kg ww	0.47 mg/kg ww
	All Nymphs - 6/5/19 Adults - 7/3/19	Selenium	0.65 mg/kg ww	0.5 mg/kg ww	0.4 mg/kg ww

Sample ID	Date	Analyte	Adult MF	Non-depurated MF Nymphs	Depurated MF Nymphs
WCD	Non-depurated Nymphs - 6/5/18 Depurated Nymphs - 6/6/18 Adults - 6/22/18	Selenium	0.96 mg/kg ww	0.58 mg/kg ww	0.48 mg/kg ww
	All Nymphs - 6/3/19 Adults - 7/3/19	Selenium	0.63 mg/kg ww	0.47 mg/kg ww	0.36 mg/kg ww

Sample ID	Date	Analyte	Adult MF	Non-depurated MF Nymphs	Depurated MF Nymphs
CURA	Non-depurated Nymphs - 6/5/18 Depurated Nymphs - 6/7/18 Adults - 6/22/18	Selenium	0.75 mg/kg ww	0.67 mg/kg ww	0.42 mg/kg ww
	All Nymphs - 6/4/19 Adults - 7/3/19	Selenium	0.81 mg/kg ww	0.86 mg/kg ww	0.63 mg/kg ww

Sample ID	Date	Analyte	Adult MF	Non-depurated MF Nymphs	Depurated MF Nymphs
WCU	Non-depurated Nymphs - 6/5/18 Depurated Nymphs - 6/6/18 Adults - 6/22/18	Selenium	0.98 mg/kg ww	0.78 mg/kg ww	0.6 mg/kg ww
	Non-depurated Nymphs – 6/3/19 Depurated Nymphs – 6/4/19	Selenium	-	0.54 mg/kg ww	0.35 mg/kg ww

Legend

Mayfly Sampling Reaches

CuRU – Cumberland River Upstream
CuRA – Cumberland River Adjacent
CuRD – Cumberland River Downstream
WCU – Wells Creek Upstream
WCD – Wells Creek Downstream

2021 Imagery Boundary

2022 Imagery Boundary

CCR Unit Area (Approximate)

Concentration > CBR NOAEL

Concentration > CBR LOAEL

Abbreviations:

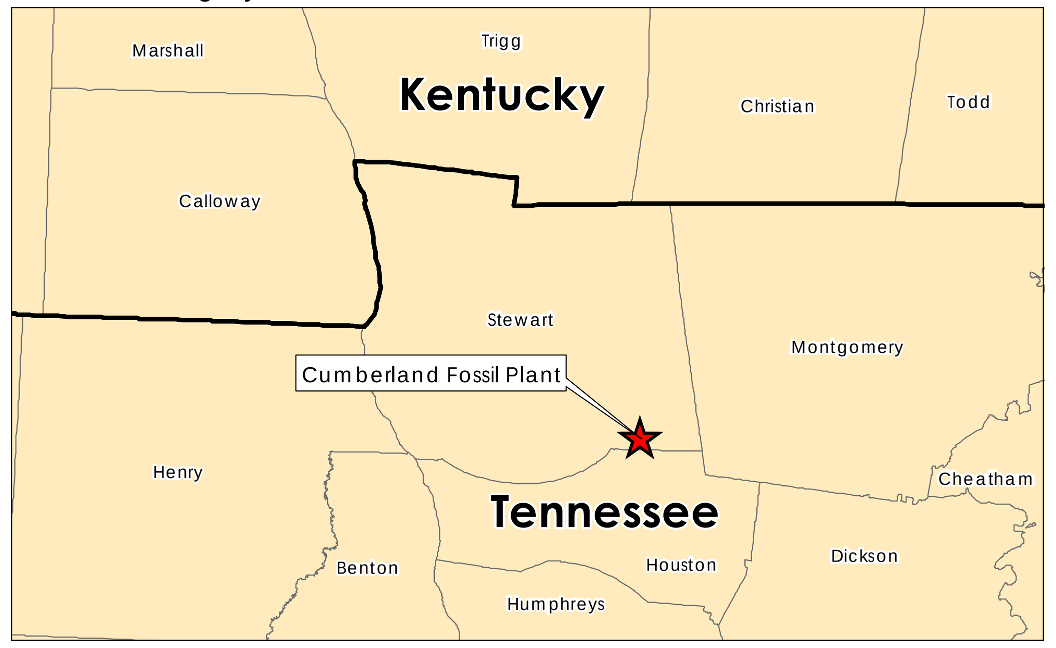
mg/kg ww	Milligrams per kilogram wet weight
CBR	Critical body residue
NOAEL	No observed adverse effect level
LOAEL	Lowest observed adverse effect level
MF	Mayflies

	Mayfly Tissue Critical Body Residue	
	NOAEL	LOAEL
Selenium	0.051	0.51

CBR NOAEL and LOAEL values are provided in Table 1-4 and Appendix A.2

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (5/21/2021 and 5/12/2022) and Esri World Imagery



Stantec

TVA

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Exhibit No.
7-4

Title
Phase 1 and Phase 2 Surface Stream Sampling Results above Ecological Screening Levels

Client/Project
Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location
Stewart County, Tennessee

175568209
Prepared by MB on 2022-12-12
Technical Review by JC on 2022-12-12

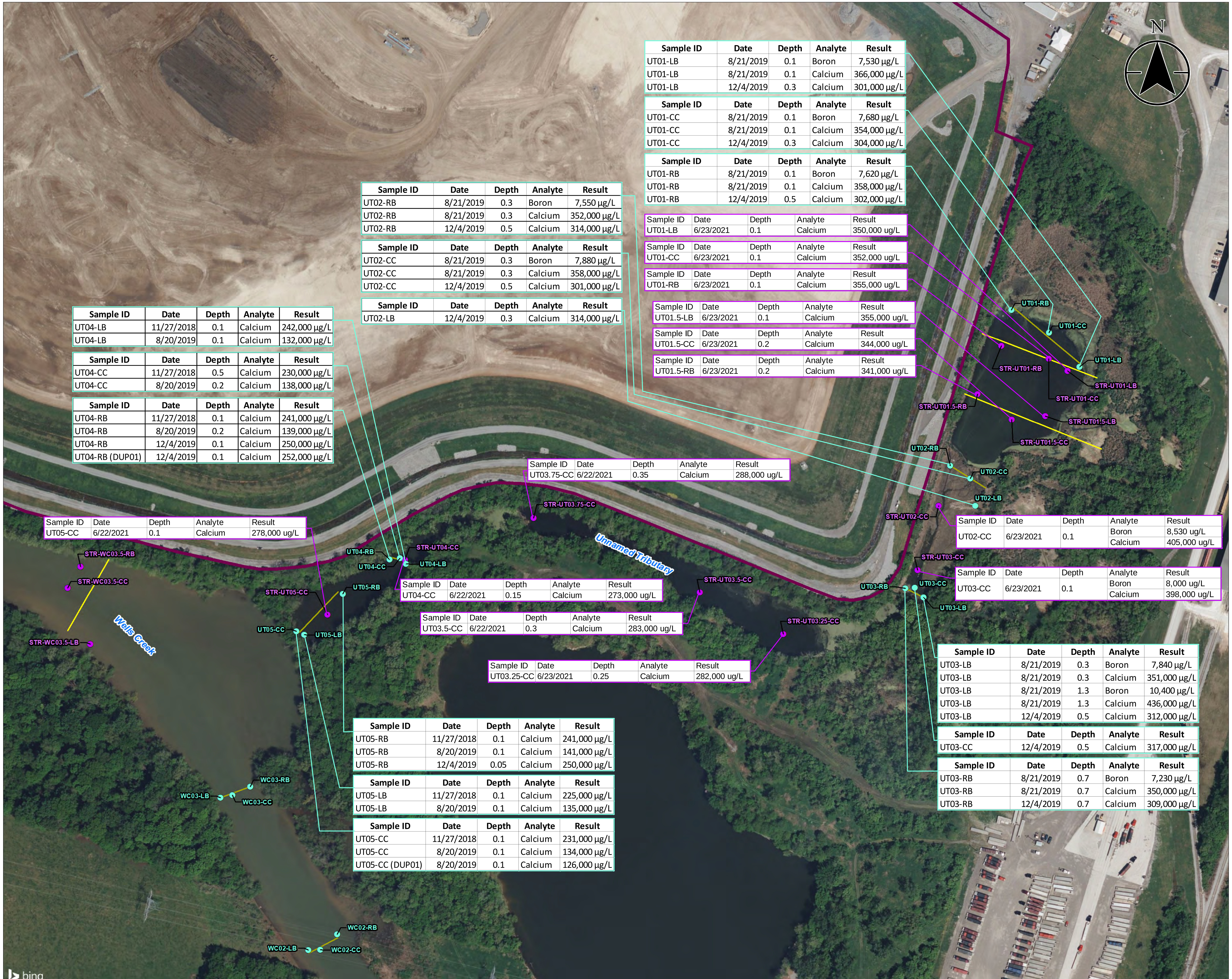
0 125 250 375 500 Feet
1:1,500 (At original document size of 22x34)

Legend

- Surface Stream Sampling Locations (Phase 1)
- Surface Stream Sampling Locations (Phase 2)
- Surface Stream Sampling Locations - Transect (Phase 1)
- Surface Stream Sampling Locations – Transect (Phase 2)
- CCR Unit Area (Approximate)

ESV - Ecological Screening Value
CC - Center Channel
RB- Right Bank
LB- Left Bank
µg/L - micrograms per Liter

Boron Acute ESV	34,000 µg/L
Boron Chronic ESV	7,200 µg/L
Calcium Chronic ESV	116,000 µg/L



Sample ID	Date	Depth	Analyte	Result
UT01-LB	8/21/2019	0.1	Boron	7,530 µg/L
UT01-LB	8/21/2019	0.1	Calcium	366,000 µg/L
UT01-LB	12/4/2019	0.3	Calcium	301,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT01-CC	8/21/2019	0.1	Boron	7,680 µg/L
UT01-CC	8/21/2019	0.1	Calcium	354,000 µg/L
UT01-CC	12/4/2019	0.3	Calcium	304,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT01-RB	8/21/2019	0.1	Boron	7,620 µg/L
UT01-RB	8/21/2019	0.1	Calcium	358,000 µg/L
UT01-RB	12/4/2019	0.5	Calcium	302,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT01-LB	6/23/2021	0.1	Calcium	350,000 ug/L

Sample ID	Date	Depth	Analyte	Result
UT01-CC	6/23/2021	0.1	Calcium	352,000 ug/L

Sample ID	Date	Depth	Analyte	Result
UT01-RB	6/23/2021	0.1	Calcium	355,000 ug/L

Sample ID	Date	Depth	Analyte	Result
UT01.5-LB	6/23/2021	0.1	Calcium	355,000 ug/L

Sample ID	Date	Depth	Analyte	Result
UT01.5-CC	6/23/2021	0.2	Calcium	344,000 ug/L

Sample ID	Date	Depth	Analyte	Result
UT01.5-RB	6/23/2021	0.2	Calcium	341,000 ug/L

Sample ID	Date	Depth	Analyte	Result
UT02-RB	8/21/2019	0.3	Boron	7,550 µg/L
UT02-RB	8/21/2019	0.3	Calcium	352,000 µg/L
UT02-RB	12/4/2019	0.5	Calcium	314,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT02-CC	8/21/2019	0.3	Boron	7,880 µg/L
UT02-CC	8/21/2019	0.3	Calcium	358,000 µg/L
UT02-CC	12/4/2019	0.5	Calcium	301,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT02-LB	12/4/2019	0.3	Calcium	314,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT04-LB	11/27/2018	0.1	Calcium	242,000 µg/L
UT04-LB	8/20/2019	0.1	Calcium	132,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT04-CC	11/27/2018	0.5	Calcium	230,000 µg/L
UT04-CC	8/20/2019	0.2	Calcium	138,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT04-RB	11/27/2018	0.1	Calcium	241,000 µg/L
UT04-RB	8/20/2019	0.2	Calcium	139,000 µg/L
UT04-RB	12/4/2019	0.1	Calcium	250,000 µg/L
UT04-RB (DUP01)	12/4/2019	0.1	Calcium	252,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT03.75-CC	6/22/2021	0.35	Calcium	288,000 ug/L

Sample ID	Date	Depth	Analyte	Result
UT05-CC	6/22/2021	0.1	Calcium	278,000 ug/L

Sample ID	Date	Depth	Analyte	Result
UT02-CC	6/23/2021	0.1	Boron	8,530 ug/L
			Calcium	405,000 ug/L

Sample ID	Date	Depth	Analyte	Result
UT03-CC	6/23/2021	0.1	Boron	8,000 ug/L
			Calcium	398,000 ug/L

Sample ID	Date	Depth	Analyte	Result
UT04-CC	6/22/2021	0.15	Calcium	273,000 ug/L

Sample ID	Date	Depth	Analyte	Result
UT03.5-CC	6/22/2021	0.3	Calcium	283,000 ug/L

Sample ID	Date	Depth	Analyte	Result
UT03.25-CC	6/23/2021	0.25	Calcium	282,000 ug/L

Sample ID	Date	Depth	Analyte	Result
UT03-LB	8/21/2019	0.3	Boron	7,840 µg/L
UT03-LB	8/21/2019	0.3	Calcium	351,000 µg/L
UT03-LB	8/21/2019	1.3	Boron	10,400 µg/L
UT03-LB	8/21/2019	1.3	Calcium	436,000 µg/L
UT03-LB	12/4/2019	0.5	Calcium	312,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT03-CC	12/4/2019	0.5	Calcium	317,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT03-RB	8/21/2019	0.7	Boron	7,230 µg/L
UT03-RB	8/21/2019	0.7	Calcium	350,000 µg/L
UT03-RB	12/4/2019	0.7	Calcium	309,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT05-RB	11/27/2018	0.1	Calcium	241,000 µg/L
UT05-RB	8/20/2019	0.1	Calcium	141,000 µg/L
UT05-RB	12/4/2019	0.05	Calcium	250,000 µg/L

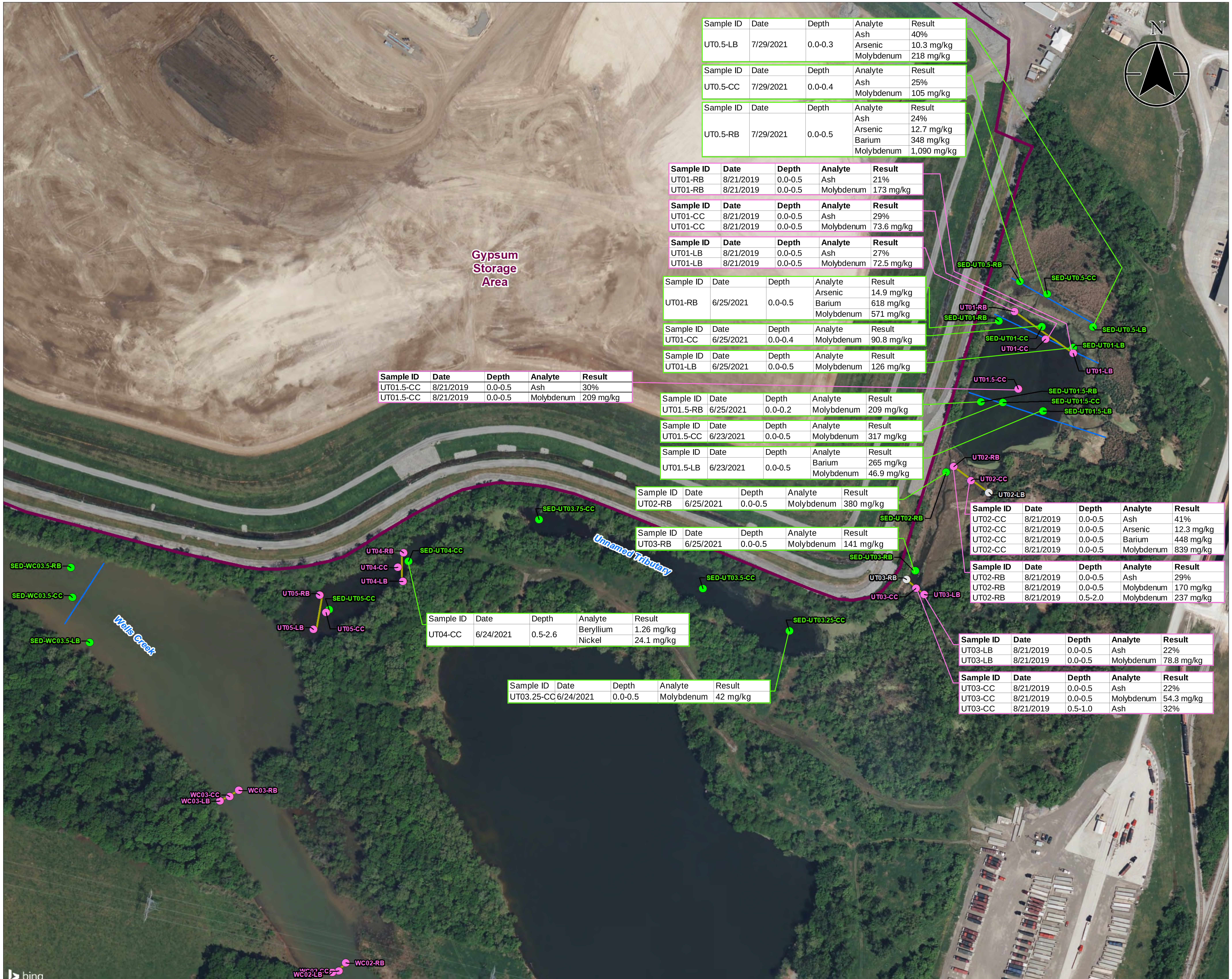
Sample ID	Date	Depth	Analyte	Result
UT05-LB	11/27/2018	0.1	Calcium	225,000 µg/L
UT05-LB	8/20/2019	0.1	Calcium	135,000 µg/L

Sample ID	Date	Depth	Analyte	Result
UT05-CC	11/27/2018	0.1	Calcium	231,000 µg/L
UT05-CC	8/20/2019	0.1	Calcium	134,000 µg/L
UT05-CC (DUP01)	8/20/2019	0.1	Calcium	126,000 µg/L

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by Bing Imagery

Stantec TVA



Sample ID	Date	Depth	Analyte	Result
UT0.5-LB	7/29/2021	0.0-0.3	Ash	40%
			Arsenic	10.3 mg/kg
			Molybdenum	218 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT0.5-CC	7/29/2021	0.0-0.4	Ash	25%
			Molybdenum	105 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT0.5-RB	7/29/2021	0.0-0.5	Ash	24%
			Arsenic	12.7 mg/kg
			Barium	348 mg/kg
			Molybdenum	1,090 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT01-RB	8/21/2019	0.0-0.5	Ash	21%
UT01-RB	8/21/2019	0.0-0.5	Molybdenum	173 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT01-CC	8/21/2019	0.0-0.5	Ash	29%
UT01-CC	8/21/2019	0.0-0.5	Molybdenum	73.6 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT01-LB	8/21/2019	0.0-0.5	Ash	27%
UT01-LB	8/21/2019	0.0-0.5	Molybdenum	72.5 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT01-RB	6/25/2021	0.0-0.5	Arsenic	14.9 mg/kg
			Barium	618 mg/kg
			Molybdenum	571 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT01-CC	6/25/2021	0.0-0.4	Molybdenum	90.8 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT01-LB	6/25/2021	0.0-0.5	Molybdenum	126 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT01.5-CC	8/21/2019	0.0-0.5	Ash	30%
UT01.5-CC	8/21/2019	0.0-0.5	Molybdenum	209 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT01.5-RB	6/25/2021	0.0-0.2	Molybdenum	209 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT01.5-CC	6/23/2021	0.0-0.5	Molybdenum	317 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT01.5-LB	6/23/2021	0.0-0.5	Barium	265 mg/kg
			Molybdenum	46.9 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT02-RB	6/25/2021	0.0-0.5	Molybdenum	380 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT03-RB	6/25/2021	0.0-0.5	Molybdenum	141 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT02-CC	8/21/2019	0.0-0.5	Ash	41%
UT02-CC	8/21/2019	0.0-0.5	Arsenic	12.3 mg/kg
UT02-CC	8/21/2019	0.0-0.5	Barium	448 mg/kg
UT02-CC	8/21/2019	0.0-0.5	Molybdenum	839 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT02-RB	8/21/2019	0.0-0.5	Ash	29%
UT02-RB	8/21/2019	0.0-0.5	Molybdenum	170 mg/kg
UT02-RB	8/21/2019	0.5-2.0	Molybdenum	237 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT04-CC	6/24/2021	0.5-2.6	Beryllium	1.26 mg/kg
			Nickel	24.1 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT03-LB	8/21/2019	0.0-0.5	Ash	22%
UT03-LB	8/21/2019	0.0-0.5	Molybdenum	78.8 mg/kg

Sample ID	Date	Depth	Analyte	Result
UT03-CC	8/21/2019	0.0-0.5	Ash	22%
UT03-CC	8/21/2019	0.0-0.5	Molybdenum	54.3 mg/kg
UT03-CC	8/21/2019	0.5-1.0	Ash	32%

Sample ID	Date	Depth	Analyte	Result
UT03.25-CC	6/24/2021	0.0-0.5	Molybdenum	42 mg/kg

Exhibit No.
7-5

Title

Phase 1 and Phase 2 Sediment Sampling Results above Ecological Screening Levels

Client/Project

Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location 175568209

Stewart County, Tennessee

Prepared by MB on 2022-12-12
Technical Review by JC on 2022-12-12

0 125 250 375 500 Feet

1:1,500 (At original document size of 22x34)

Legend

- Sediment Sampling Locations - Collected (Phase 1)
- Sediment Sampling Locations - Attempted: Insufficient Sediment for Sampling (Phase 1)
- Sediment Sampling Locations (Phase 2)
- Sediment Sampling Locations - Transect (Phase 1)
- Sediment Sampling Locations - Transects (Phase 2)
- CCR Unit Area (Approximate)

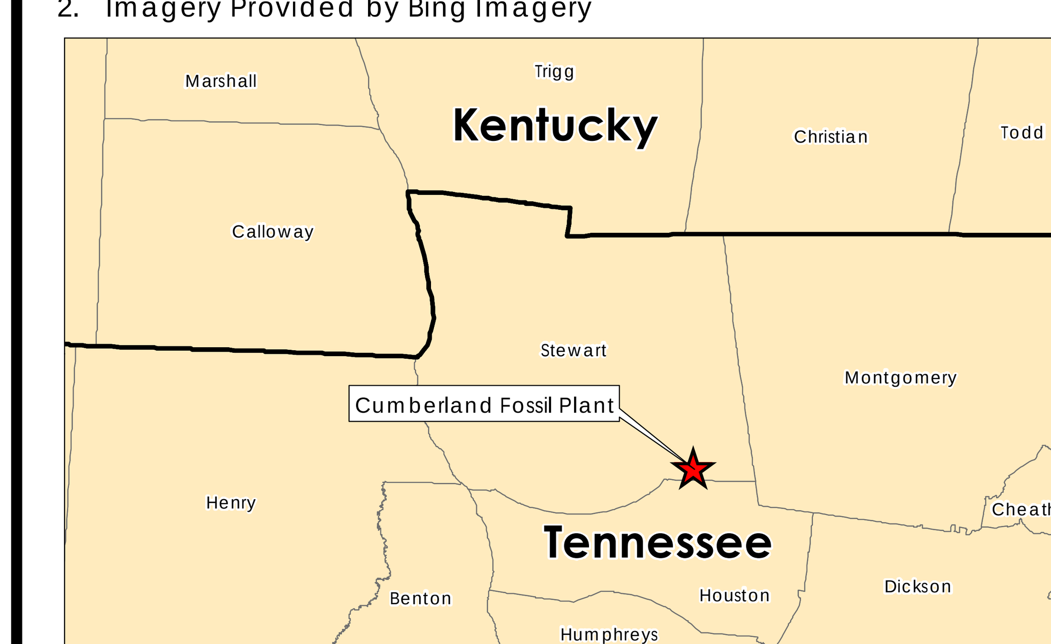
Abbreviations:

CC - Center Channel
RB- Right Bank
LB- Left Bank
mg/kg - milligrams per kilogram

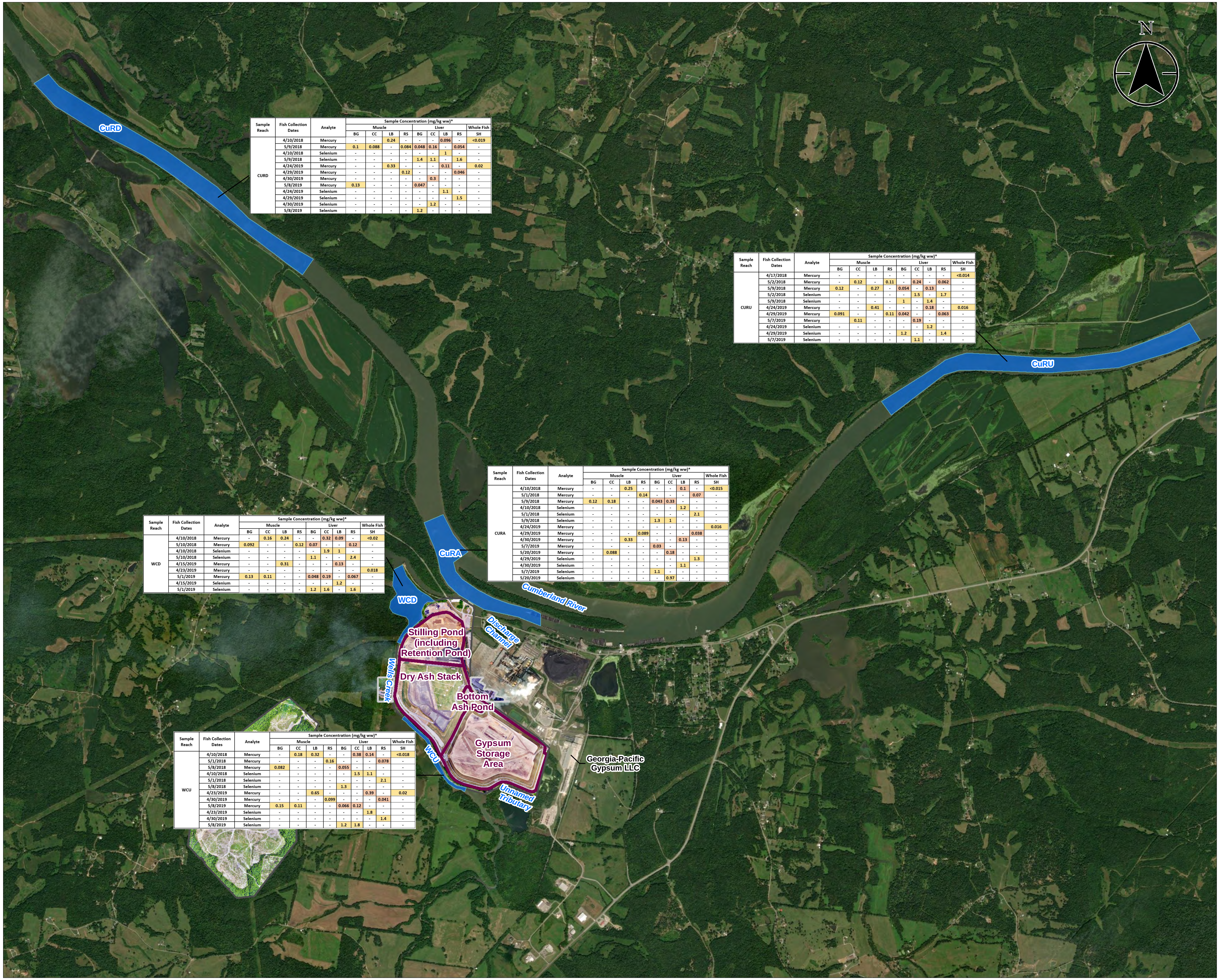
Chronic Ecological Screening Values	
% Ash	20%
Arsenic	9.8 mg/kg
Barium	240 mg/kg
Beryllium	1.2 mg/kg
Molybdenum	38 mg/kg
Nickel	22.7 mg/kg

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by Bing Imagery



Stantec TVA



Sample Reach	Fish Collection Dates	Analyte	Sample Concentration (mg/kg ww)*								
			Muscle				Liver				Whole Fish
			BG	CC	LB	RS	BG	CC	LB	RS	SH
CURD	4/10/2018	Mercury	-	-	0.24	-	-	-	0.096	-	<0.019
	5/9/2018	Mercury	0.1	0.088	-	0.084	0.048	0.16	-	0.054	-
	4/10/2018	Selenium	-	-	-	-	-	-	1	-	-
	5/9/2018	Selenium	-	-	-	-	1.4	1.1	-	1.6	-
	4/24/2019	Mercury	-	-	0.33	-	-	-	0.11	-	0.02
	4/29/2019	Mercury	-	-	-	0.12	-	-	-	0.046	-
	4/30/2019	Mercury	-	-	-	-	-	0.3	-	-	-
	5/8/2019	Mercury	0.13	-	-	-	0.047	-	-	-	-
	4/24/2019	Selenium	-	-	-	-	-	-	1.1	-	-
	4/29/2019	Selenium	-	-	-	-	-	-	-	1.5	-
	4/30/2019	Selenium	-	-	-	-	-	1.2	-	-	-
	5/8/2019	Selenium	-	-	-	-	1.2	-	-	-	-

Sample Reach	Fish Collection Dates	Analyte	Sample Concentration (mg/kg ww)*								
			Muscle				Liver				Whole Fish
			BG	CC	LB	RS	BG	CC	LB	RS	SH
CURU	4/17/2018	Mercury	-	-	-	-	-	-	-	-	<0.014
	5/2/2018	Mercury	-	0.12	-	0.11	-	0.24	-	0.062	-
	5/9/2018	Mercury	0.12	-	0.27	-	0.054	-	0.13	-	-
	5/2/2018	Selenium	-	-	-	-	-	1.5	-	1.7	-
	5/9/2018	Selenium	-	-	-	-	1	-	1.4	-	-
	4/24/2019	Mercury	-	-	0.41	-	-	-	0.18	-	0.016
	4/29/2019	Mercury	0.091	-	-	0.11	0.042	-	-	0.063	-
	5/7/2019	Mercury		0.11	-	-	-	0.19	-	-	-
	4/24/2019	Selenium	-	-	-	-	-	-	1.2	-	-
	4/29/2019	Selenium	-	-	-	-	1.2	-	-	1.4	-
	5/7/2019	Selenium	-	-	-	-	-	1.1	-	-	-

Sample Reach	Fish Collection Dates	Analyte	Sample Concentration (mg/kg ww)*								
			Muscle				Liver				Whole Fish
			BG	CC	LB	RS	BG	CC	LB	RS	SH
CURA	4/10/2018	Mercury	-	-	0.25	-	-	-	0.1	-	<0.015
	5/1/2018	Mercury	-	-	-	0.14	-	-	-	0.07	-
	5/9/2018	Mercury	0.12	0.18	-	-	0.043	0.33	-	-	-
	4/10/2018	Selenium	-	-	-	-	-	-	1.2	-	-
	5/1/2018	Selenium	-	-	-	-	-	-	-	2.1	-
	5/9/2018	Selenium	-	-	-	-	1.3	1	-	-	-
	4/24/2019	Mercury	-	-	-	-	-	-	-	-	0.016
	4/29/2019	Mercury	-	-	-	0.089	-	-	-	0.038	-
	4/30/2019	Mercury	-	-	0.33	-	-	-	0.13	-	-
	5/7/2019	Mercury	-	-	-	-	0.03	-	-	-	-
	5/20/2019	Mercury	-	0.088	-	-	-	0.18	-	-	-
	4/29/2019	Selenium	-	-	-	-	-	-	-	1.3	-
	4/30/2019	Selenium	-	-	-	-	-	-	1.1	-	-
	5/7/2019	Selenium	-	-	-	-	1.1	-	-	-	-
	5/20/2019	Selenium	-	-	-	-	-	0.97	-	-	-

Sample Reach	Fish Collection Dates	Analyte	Sample Concentration (mg/kg ww)*								
			Muscle				Liver				Whole Fish
			BG	CC	LB	RS	BG	CC	LB	RS	SH
WCD	4/10/2018	Mercury	-	0.16	0.24	-	-	0.32	0.09	-	<0.02
	5/10/2018	Mercury	0.092	-	-	0.12	0.07	-	-	0.12	-
	4/10/2018	Selenium	-	-	-	-	-	1.9	1	-	-
	5/10/2018	Selenium	-	-	-	-	1.1	-	-	2.4	-
	4/15/2019	Mercury	-	-	0.31	-	-	-	0.13	-	-
	4/23/2019	Mercury	-	-	-	-	-	-	-	-	0.018
	5/1/2019	Mercury	0.13	0.11	-	-	0.048	0.19	-	0.067	-
	4/15/2019	Selenium	-	-	-	-	-	-	1.2	-	-
	5/1/2019	Selenium	-	-	-	-	1.2	1.6	-	1.6	-

Sample Reach	Fish Collection Dates	Analyte	Sample Concentration (mg/kg ww)*								
			Muscle				Liver				Whole Fish
			BG	CC	LB	RS	BG	CC	LB	RS	SH
WCU	4/10/2018	Mercury	-	0.18	0.32	-	-	0.38	0.14	-	<0.018
	5/1/2018	Mercury	-	-	-	0.16	-	-	-	0.078	-
	5/8/2018	Mercury	0.082	-	-	-	0.055	-	-	-	-
	4/10/2018	Selenium	-	-	-	-	-	1.5	1.1	-	-
	5/1/2018	Selenium	-	-	-	-	-	-	-	2.1	-
	5/8/2018	Selenium	-	-	-	-	1.3	-	-	-	-
	4/23/2019	Mercury	-	-	0.65	-	-	-	0.39	-	0.02
	4/30/2019	Mercury	-	-	-	0.099	-	-	-	0.041	-
	5/8/2019	Mercury	0.15	0.11	-	-	0.066	0.12	-	-	-
	4/23/2019	Selenium	-	-	-	-	-	-	1.8	-	-
	4/30/2019	Selenium	-	-	-	-	-	-	-	1.4	-
	5/8/2019	Selenium	-	-	-	-	1.2	1.8	-	-	-

Exhibit No.

7-6

Title

Fish Tissue Sampling Results Equal to or Above Critical Body Residue Values

Client/Project

Tennessee Valley Authority
Cumberland Fossil Plant (CUF) TDEC Order

Project Location 175568209

Stewart County, Tennessee

Prepared by DMB on 2022-12-05
Technical Review by CA on 2022-12-05

0 1,500 3,000 4,500 6,000 Feet

1:18,000 (At original document size of 22x34)

Legend

- Fish Sampling Reaches
- 2021 Imagery Boundary
- 2022 Imagery Boundary
- CCR Unit Area (Approximate)
- Concentration > CBR NOAEL
- Concentration > CBR LOAEL

Abbreviations:

BG Bluegill
CC Channel Catfish
LB Largemouth Bass
RS Redear Sunfish
SH Shad

CuR = Cumberland River
WC = Wells Creek
U = Upstream
A = Adjacent
D = Downstream

CBR - Critical Body Residue
NOAEL - No Observed Adverse Effects Value
LOAEL - Lowest Observed Adverse Effects Value

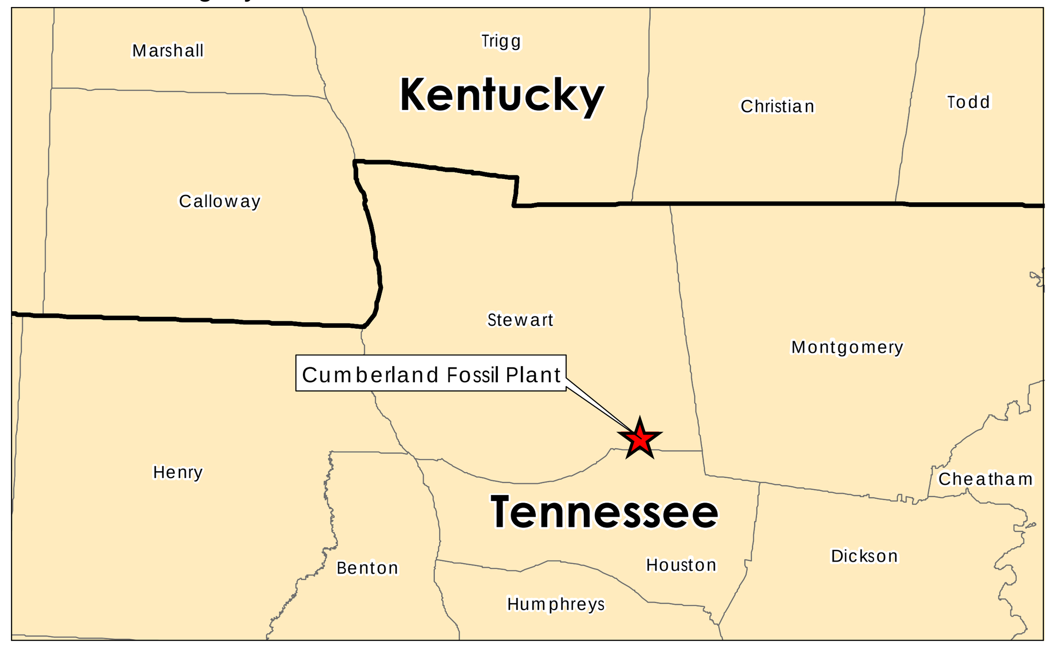
* Selenium concentrations reported as mg/kg wet weight (ww) for liver tissue and mg/kg dry weight for whole body, muscle, and ovary samples to permit direct comparison to the selenium CBRs for these tissues.

	Critical Body Residue Values							
	Whole Body Fish Tissue		Liver Tissue		Muscle Tissue		Ovary Tissue	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Mercury	0.006	0.06	0.0009	0.009	0.08	0.8	NA	NA
Selenium	8.5	8.5	0.524	5.24	11.3	11.3	15.1	15.1

CBR NOAEL and LOAEL values are provided in Table 1-5 and Appendix A.2

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (5/21/2021 and 5/12/2022) and Esri World Imagery



Stantec TVA

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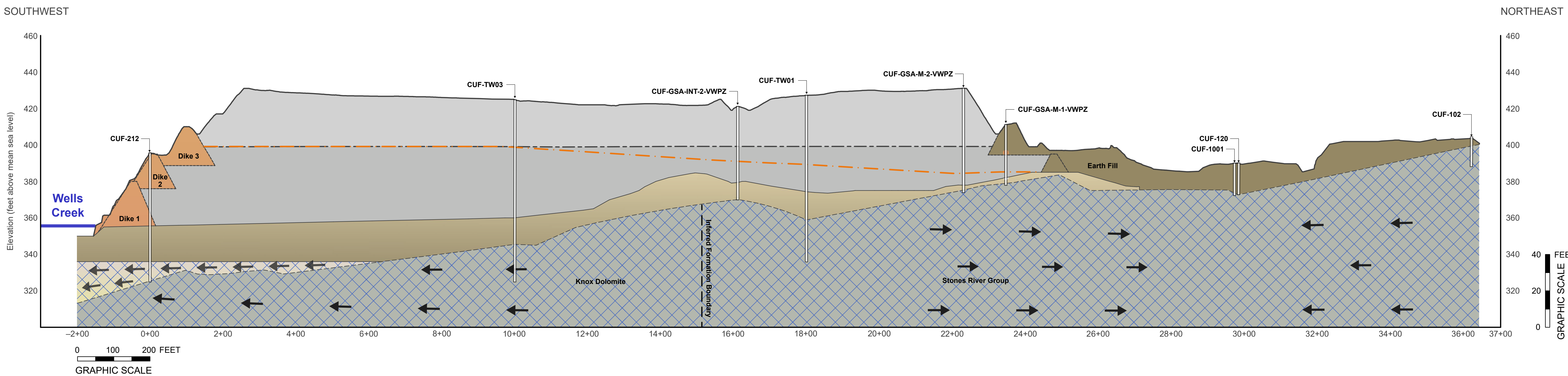
GYPSUM STORAGE AREA

LANDFILL



1 CCR Material

- CCR material is gypsum above sluiced fly ash and bottom ash, and the estimated total volume of CCR based on the EI is about 11.7 million cubic yards.
- Global and veneer slope stability meet the established factor of safety criteria for static load cases. For seismic load cases, the veneer slope stability meets the established factor of safety criteria and the pseudostatic global and post-earthquake global load cases will meet the criteria as TVA implements targeted regrading as part of its ongoing gypsum harvesting activities.
- The structural integrity of the CCR management unit is adequate and there is no evidence of voids/cavities in bedrock that could lead to loss of structural support and potential release of overlying CCR material.

2 Groundwater Quality

- Generally, the available groundwater level data indicated that pore water levels were up to 20 feet higher than groundwater levels in the uppermost aquifer. This suggests that the low permeability of the perimeter dikes and the clays and silts that comprise the aquitard at the base of the units impedes lateral and vertical flow of pore water.
- Groundwater concentrations for most CCR Parameters are below GSLs. Lithium (well 93-3), cobalt (well CUF-212 and CUF-1006) and molybdenum (CUF-1006) were detected above GSLs. Potential groundwater impacts will be further evaluated in the CARA Plan.

3 Potential Seep

- One active seep was identified during the EI and subsequently mitigated; monitoring is ongoing in accordance with the CUF Plant NPDES permit.

4 Surface Stream, Sediment and Ecology

- Boron and calcium have been detected in surface stream water above chronic ESVs within the Unnamed Tributary; concentrations decrease downstream. These CCR Parameters will be further evaluated in the CARA Plan.
- Arsenic, barium, molybdenum, and selenium have been detected above chronic ESVs in sediment samples in Ponds 3A and 3B of the Unnamed Tributary. Molybdenum was detected above chronic ESVs in Pond 2, and beryllium and nickel were above their respective chronic ESVs at one location in Pond 1. Potential sediment impacts will be further evaluated in the CARA Plan.
- Sediment ash results are above 20% in Ponds 3A and 3B of the Unnamed Tributary. These results, in conjunction with the CCR Parameter results, indicate that potential impacts are limited and CCR material is present. These constituents will be further evaluated in the CARA Plan. Sediment sampling results are less than chronic ESVs downstream.
- Based on EI and other ongoing monitoring results, this CCR management unit has had minimal, if any, potential impacts on the surface stream water quality, sediment, the benthic macroinvertebrate community, and mayfly and fish tissues in Wells Creek or the Cumberland River.

Legend

Gypsum

Sluiced Ash

Clay Dike

Earth Fill

Alluvial Deposits (Primarily Silt and Clay)

Alluvial Deposits (Primarily Sand and Gravel)

Bedrock

Underdrain Layer

Bottom of CCR Management Unit

Pore Water Phreatic Surface (September 9, 2019)

Uppermost aquifer

GSLs – Groundwater Screening Levels

Generalized groundwater flow direction within the uppermost aquifer

The purpose of the arrows is to show the inferred generally horizontal groundwater flow direction within the uppermost aquifer. They are not intended to illustrate the flow between coarse-grained alluvium and bedrock.

Note: The pore water phreatic surfaces shown herein do not correspond to a closed condition or reflect recent decanting of the Main Ash Pond and dewatering activities at the Stilling Pond (including Retention Pond). The phreatic surfaces are expected to decrease after capping of CCR management units if the units were to be closed with CCR material in place.

Cross section transect line is shown on Exhibit D-1.

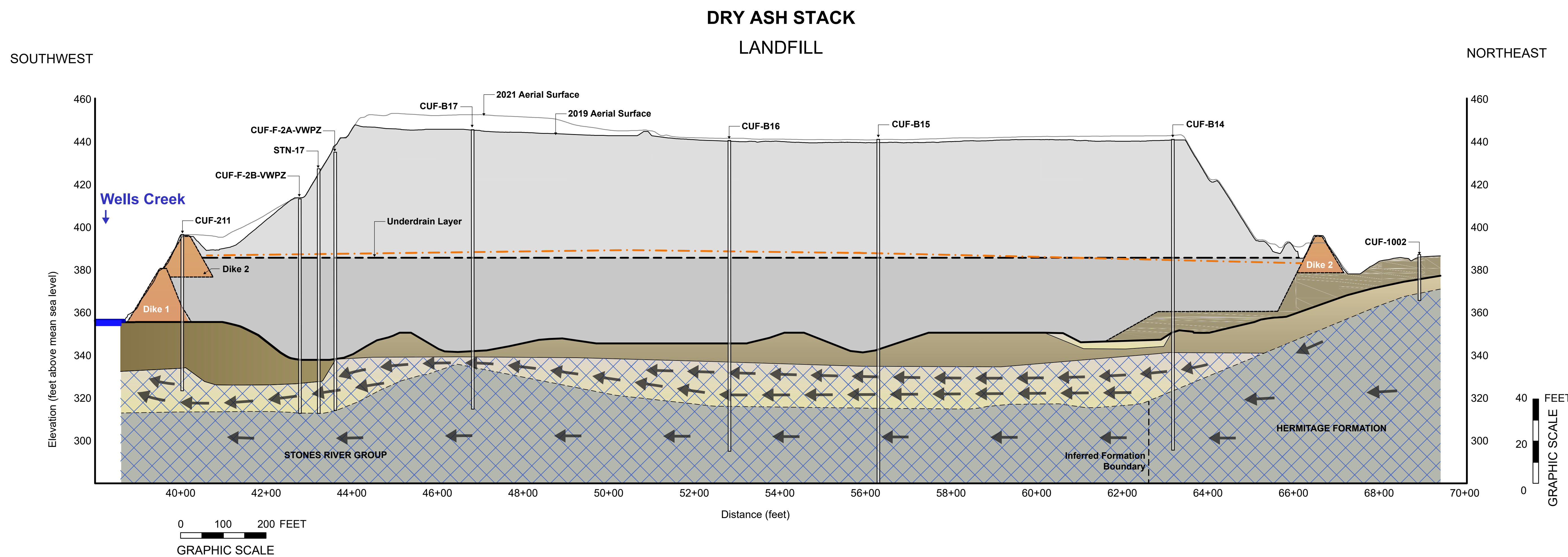
Stantec TVA

Exhibit No.
8-1

Title
GYPSUM STORAGE AREA CROSS SECTION A–A'
CONCEPTUAL SITE MODEL

Client/Project
Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location
Stewart County, Tennessee
175568209
Prepared by KB on 2021-11-25



1 CCR Material

- CCR material is sluiced fly ash and bottom ash overlain by stacked fly ash and bottom ash, and the estimated total volume of CCR based on the EI is about 11.7 million cubic yards.
- Global and veneer slope stability meet the established factor of safety criteria for the static and seismic load cases.
- The structural integrity of the CCR management unit is adequate and there is no evidence of voids/cavities in bedrock that could lead to loss of structural support and potential release of overlying CCR material.

2 Groundwater Quality

- Generally, the available groundwater level data indicated that pore water levels were up to 20 feet higher than groundwater levels in the uppermost aquifer. This suggests that the low permeability of the perimeter dikes and the clays and silts that comprise the aquitard at the base of the units impedes lateral and vertical flow of pore water.
- Groundwater concentrations for most CCR Parameters are below GSLs. Molybdenum (well CUF-209), arsenic (well CUF-93-1), and cobalt (wells CUF-93-1 and CUF-211) were detected above GSLs. Potential groundwater impacts will be further evaluated in the CARA Plan.

3 Potential Seeps

- No potentially active seeps were identified during the EI.

4 Surface Stream, Sediment and Ecology

- Beryllium was detected in one sediment sample slightly above the chronic ESV in Wells Creek. This occurrence will be further evaluated in the CARA Plan. Ash was not detected above 20% and beryllium has not been detected in groundwater above the GSL at this unit, suggesting that beryllium detected in sediment is not from this unit.
- Based on EI and other ongoing monitoring results, this CCR management unit has had minimal, if any, potential impacts on the surface stream water quality, sediment, benthic macroinvertebrate community, and mayfly and fish tissues in Wells Creek or the Cumberland River.

Legend

- Stacked Ash
- Sluiced Ash
- Clay Dike
- Earth Fill
- Alluvial Deposits (Primarily Silt and Clay)
- Alluvial Deposits (Primarily Sand and Gravel)
- Bedrock
- Underdrain Layer
- Bottom of CCR Management Unit
- Pore Water Phreatic Surface (September 9, 2019)
- Uppermost aquifer
- GSLs – Groundwater Screening Levels
- Generalized groundwater flow direction within the uppermost aquifer

The purpose of the arrows is to show the inferred generally horizontal groundwater flow direction within the uppermost aquifer. They are not intended to illustrate the flow between coarse-grained alluvium and bedrock.

Note: The pore water phreatic surfaces shown herein do not correspond to a closed condition or reflect recent decanting of the Main Ash Pond and dewatering activities at the Stilling Pond (including Retention Pond). The phreatic surfaces are expected to decrease after capping of CCR management units if the units were to be closed with CCR material in place.

Cross section transect line is shown on Exhibit D-1.

Stantec TVA

Exhibit No.
8-2

Title
DRY ASH STACK CROSS SECTION B–B' CONCEPTUAL SITE MODEL

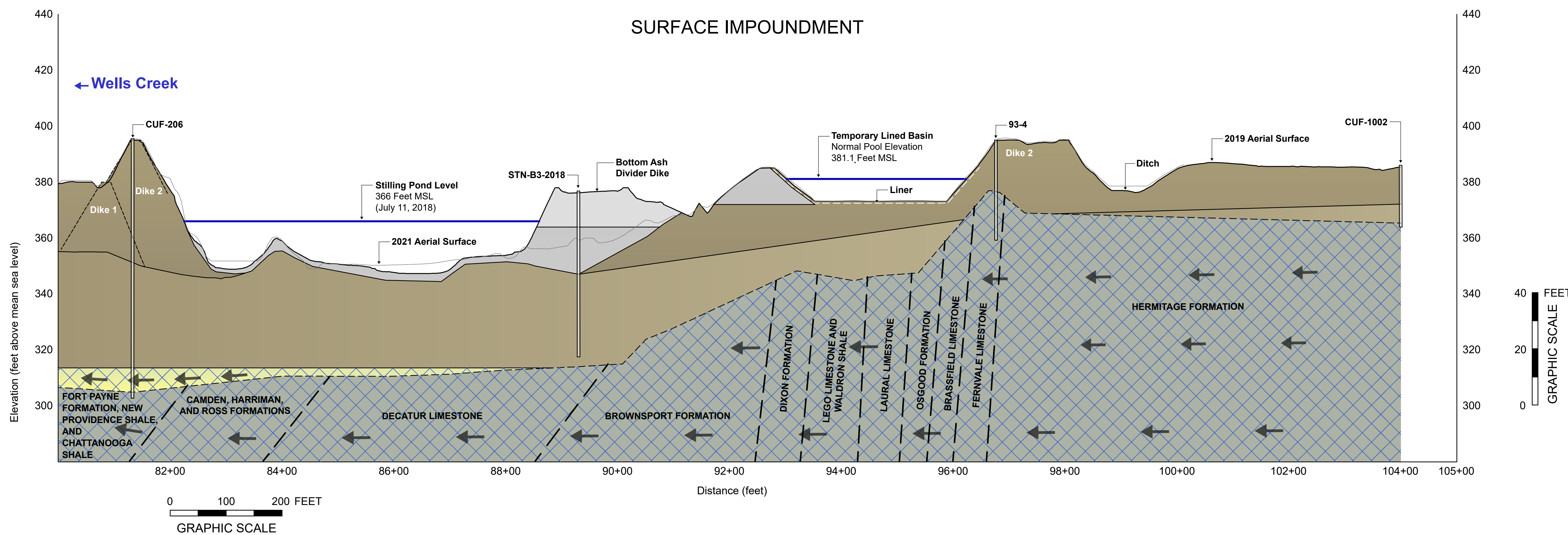
Client/Project
Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location
Stewart County, Tennessee

175568209

Prepared by KB on 2021-08-23

STILLING POND (INCLUDING RETENTION POND)



1 CCR Material

- CCR material is sluiced fly ash and bottom ash, and the estimated total volume of CCR based on the EI is about 1.5 million cubic yards.
- Global and veneer slope stability meet the established factor of safety criteria for the static and seismic load cases.
- The structural integrity of the CCR management unit is adequate and there is no evidence of voids/cavities in bedrock that could lead to loss of structural support and potential release of overlying CCR material.
- Ongoing repurposing construction activities are expected to positively impact conditions by lowering the pore water phreatic surface.

2 Groundwater Quality

- Groundwater concentrations for most CCR Parameters are below GSLs. Arsenic (well CUF-206) was detected above the GSL.

3 Potential Seeps

- No potentially active seeps were identified during the EI.

4 Surface Stream, Sediment and Ecology

- Beryllium was detected in one sediment sample slightly above its ESV. This occurrence will be further evaluated in the CARA Plan. Beryllium has not been detected in groundwater above the GSL at this unit, suggesting that the beryllium detected in sediment is not a result of groundwater migration.
- Based on EI and other ongoing monitoring results, this CCR management unit has had minimal, if any, potential impacts on the surface stream water quality, sediment, benthic macroinvertebrate community, and mayfly and fish tissues in Wells Creek or the Cumberland River.

Legend

- Bottom Ash
- Stacked Ash
- Sluiced Ash
- Alluvial Deposits (Primarily Silt and Clay)
- Fill
- Alluvial Deposits (Primarily Sand and Gravel)
- Bedrock
- Uppermost aquifer
- GSLs – Groundwater Screening Levels
- Inferred Formation Boundary
- Generalized groundwater flow direction within the uppermost aquifer

The purpose of the arrows is to show the inferred generally horizontal groundwater flow direction within the uppermost aquifer. They are not intended to illustrate the flow between coarse-grained alluvium and bedrock.

Note: The pore water phreatic surfaces shown herein do not correspond to a closed condition or reflect recent decanting of the Main Ash Pond and dewatering activities at the Stilling Pond (including Retention Pond). The phreatic surfaces are expected to decrease after capping of CCR management units if the units were to be closed with CCR material in place.

Cross section transect line is shown on Exhibit D-1.

Stantec TVA

Exhibit No.
8-3

Title
STILLING POND (INCLUDING RETENTION POND) CROSS SECTION C–C' CONCEPTUAL SITE MODEL

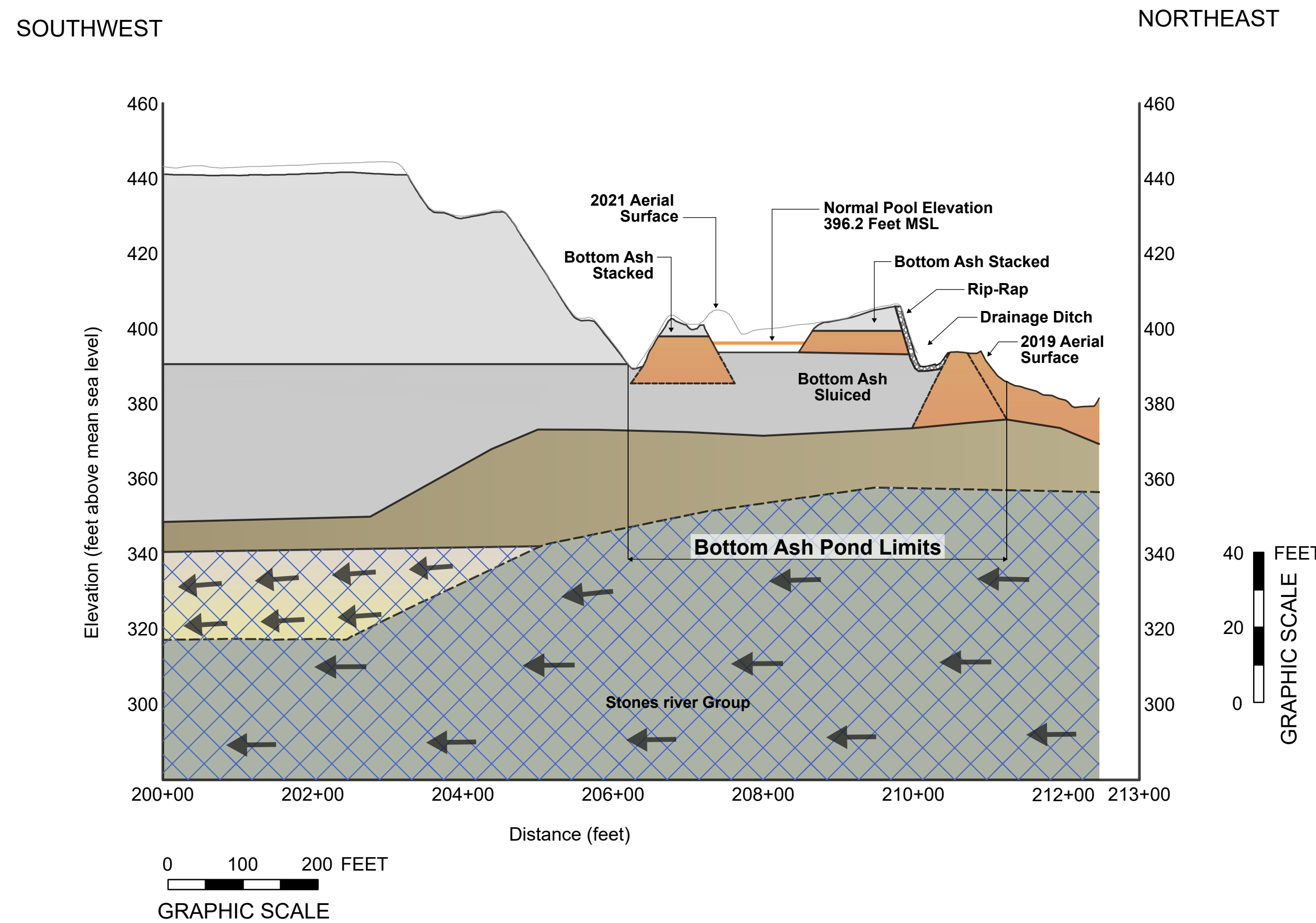
Client/Project
Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location
Stewart County, Tennessee

175568209
Prepared by KB on 2021-12-01

BOTTOM ASH POND

SURFACE IMPOUNDMENT



1 CCR Material

- CCR material is sluiced fly ash and bottom ash, and the estimated total volume of CCR based on the EI is about 400,000 million cubic yards.
- Global and veneer slope stability meet the established factor of safety criteria for the static and seismic load cases.
- The structural integrity of the CCR management unit is adequate and there is no evidence of voids/cavities in bedrock that could lead to loss of structural support and potential release of overlying CCR material.

2 Groundwater Quality

- Groundwater quality for the CCR management unit is monitored as part of the groundwater monitoring system for the Dry Ash Stack and Gypsum Storage Area.

3 Potential Seeps

- No potentially active seeps were identified during the EI.

4 Surface Stream, Sediment and Ecology

- Potential impacts for these media are evaluated as part of the Gypsum Storage Area, Dry Ash Stack, and Stilling Pond (including Retention Pond).

Legend

Stacked Ash

Sluiced Ash

Clay

Alluvial Deposits (Primarily Silt And Clay)

Alluvial Deposits (Primarily Sand and Gravel)

Bedrock

Uppermost aquifer

GSLs – Groundwater Screening Levels

Generalized groundwater flow direction within the uppermost aquifer

The purpose of the arrows is to show the inferred generally horizontal groundwater flow direction within the uppermost aquifer. They are not intended to illustrate the flow between coarse-grained alluvium and bedrock.

Note: The pore water phreatic surfaces shown herein do not correspond to a closed condition or reflect recent decanting of the Main Ash Pond and dewatering activities at the Stilling Pond (including Retention Pond). The phreatic surfaces are expected to decrease after capping of CCR management units if the units were to be closed with CCR material in place.

Cross section transect line is shown on Exhibit D-1.

Stantec TVA

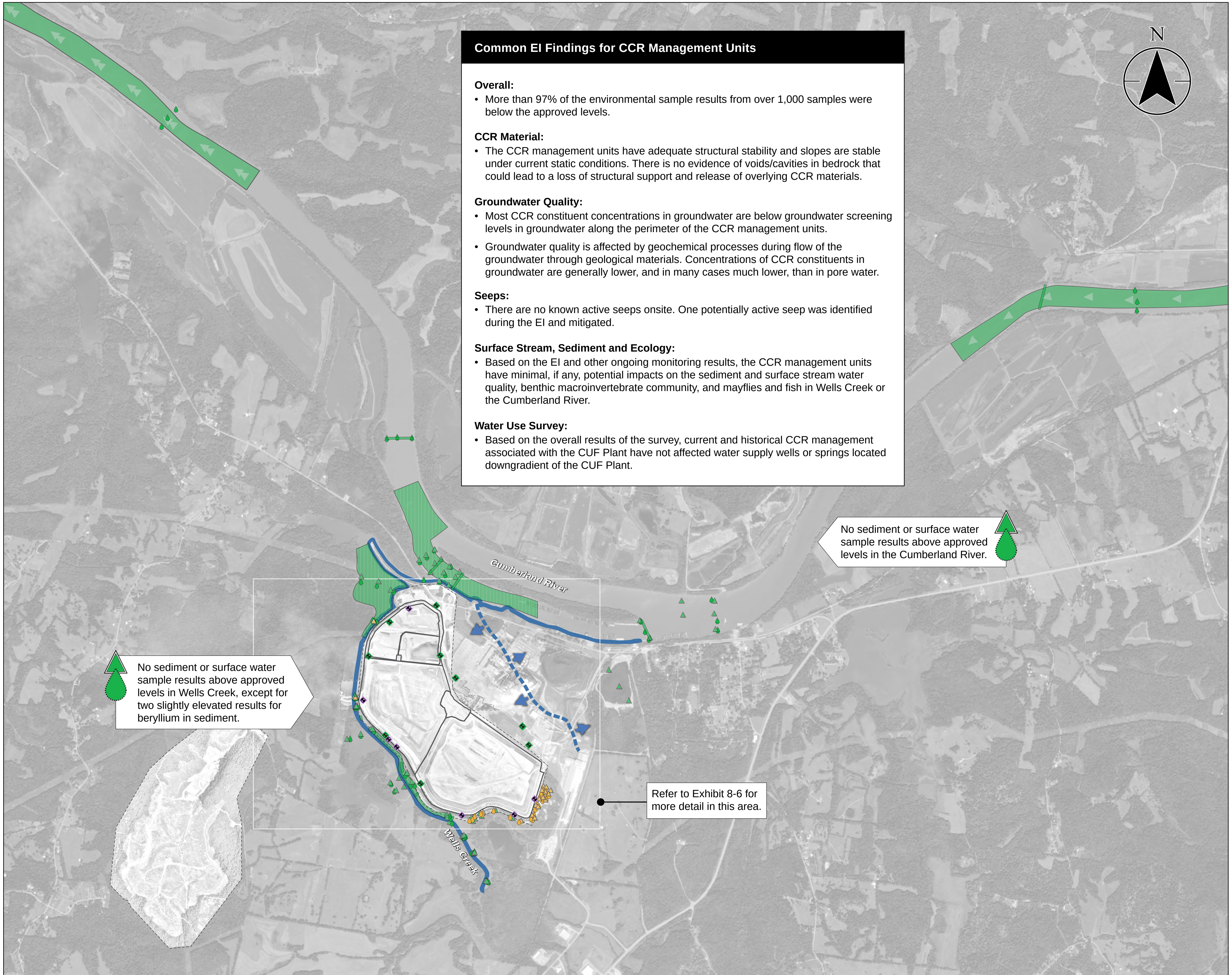
Exhibit No.
8-4

Title
BOTTOM ASH POND CROSS SECTION D–D' CONCEPTUAL SITE MODEL

Client/Project
Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location
Stewart County, Tennessee

175568209
Prepared by KB on 2021-12-01



Common EI Findings for CCR Management Units

Overall:
- More than 97% of the environmental sample results from over 1,000 samples were below the approved levels.

CCR Material:
- The CCR management units have adequate structural stability and slopes are stable under current static conditions. There is no evidence of voids/cavities in bedrock that could lead to a loss of structural support and release of overlying CCR materials.

Groundwater Quality:
- Most CCR constituent concentrations in groundwater are below groundwater screening levels in groundwater along the perimeter of the CCR management units.
- Groundwater quality is affected by geochemical processes during flow of the groundwater through geological materials. Concentrations of CCR constituents in groundwater are generally lower, and in many cases much lower, than in pore water.

Seeps:
- There are no known active seeps onsite. One potentially active seep was identified during the EI and mitigated.

Surface Stream, Sediment and Ecology:
- Based on the EI and other ongoing monitoring results, the CCR management units have minimal, if any, potential impacts on the sediment and surface stream water quality, benthic macroinvertebrate community, and mayflies and fish in Wells Creek or the Cumberland River.

Water Use Survey:
- Based on the overall results of the survey, current and historical CCR management associated with the CUF Plant have not affected water supply wells or springs located downgradient of the CUF Plant.

Exhibit No.
8-5

Title
Overall Investigation Area Findings

Client/Project
Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location 175568209
Stewart County, Tennessee
Prepared by KB on 2021-10-20

0 1,000 2,000 3,000 4,000 Feet

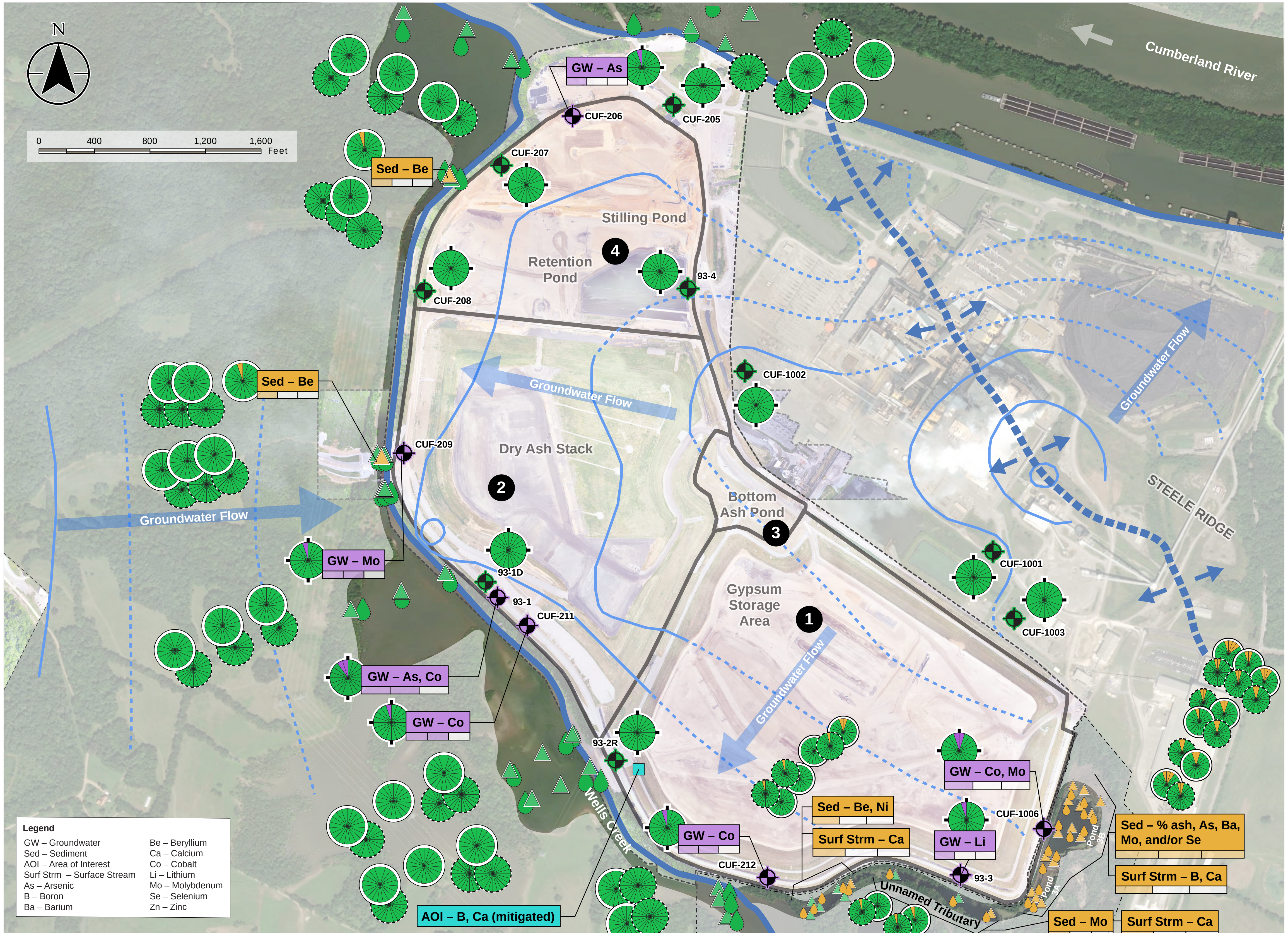
Legend

- Groundwater results below Groundwater Screening Levels
- Groundwater results above Groundwater Screening Levels
- Sediment sample results below chronic Ecological Screening Values
- Sediment sample results above chronic Ecological Screening Values
- Surface water sample results below chronic Ecological Screening Values
- Surface water sample results above chronic Ecological Screening Values
- Benthic macroinvertebrate community sampling transect (See Surface Stream, Sediment and Ecology note on exhibit)
- Upstream mayfly and fish tissue sampling reach (See Surface Stream, Sediment and Ecology note on exhibit)
- Adjacent mayfly and fish tissue sampling reach (See Surface Stream, Sediment and Ecology note on exhibit)
- Downstream mayfly and fish tissue sampling reach (See Surface Stream, Sediment and Ecology note on exhibit)
- Surface stream that bounds groundwater flow
- Hydrogeological Divide
- Generalized groundwater flow direction
- 2021 Imagery Boundary
- 2022 Imagery Boundary
- CCR Unit Area (Approximate)

Abbreviations:
CCR: Coal combustion residuals
EI: Environmental Investigation

Imagery Provided by: Tuck Mapping (c. 2017); TVA (5/21/2021and 5/12/2022); Bing imagery ©2022 Microsoft Corporation ©2022 Maxar ©CNES (2022) Distribution Airbus DS

Stantec
TVA



Potential groundwater, surface stream water and sediment impacts described below will be further evaluated in the CARA Plan

1 Gypsum Storage Area

CCR Material:

- CCR material is gypsum above sluiced fly ash and bottom ash; the estimated volume of CCR is ~ 11.7 million cubic yards.
- Global and veneer slope stability meet the established factor of safety criteria for static load cases. For seismic load cases, the veneer slope stability meets the established factor of safety criteria and the pseudostatic global and post-earthquake global load cases will meet the criteria as TVA implements targeted regrading as part of its ongoing gypsum harvesting activities.

Groundwater Quality:

- Lithium (well 93-3), cobalt (well CUF-212, CUF-1006) and molybdenum (CUF-1006) were detected above GSLs.

Seeps:

- One active seep (AOI) was identified during the EI and mitigated; monitoring is ongoing.

Surface Stream, Sediment and Ecology:

- Boron and calcium were detected in surface stream water above chronic ESVs within the Unnamed Tributary; concentrations decrease downstream.
- Percent ash above 20% and arsenic, barium, molybdenum, and/or selenium above chronic ESVs were detected in sediment in Ponds 3A and 3B of the Unnamed Tributary. Molybdenum was detected above chronic ESVs in Pond 2, and beryllium and nickel were above their respective chronic ESVs at one location in Pond 1. These results indicate that potential impacts are limited and suggest CCR material may be present in Ponds 3A and 3B. These constituents will be further evaluated in the CARA Plan.

2 Dry Ash Stack

CCR Material:

- CCR material is sluiced fly ash and bottom ash overlain by stacked fly ash and bottom ash; the estimated volume of CCR is ~ 11.7 million cubic yards.
- Global and veneer slope stability meet the established factor of safety criteria for the static and seismic load cases.

Groundwater Quality:

- Molybdenum (well CUF-209), arsenic (well CUF-93-1), and cobalt (wells CUF-93-1, CUF-211) were detected above GSLs.

Surface Stream, Sediment and Ecology:

- Beryllium was detected in one sediment sample slightly above the chronic ESV in Wells Creek. Ash was not detected above 20% and beryllium has not been detected in groundwater above GSLs at this unit, suggesting that beryllium detected in sediment is not from this unit.

3 Bottom Ash Pond

CCR Material:

- CCR material is sluiced bottom ash and fly ash; the estimated volume of CCR is ~ 400,000 cubic yards.
- The global and veneer slope stability meet the established factor of safety criteria for the static and seismic load cases.

Groundwater Quality:

- Groundwater quality for the CCR management unit is monitored as part of the groundwater monitoring system for the Dry Ash Stack and Gypsum Storage Area.

Surface Stream, Sediment and Ecology:

- Potential impacts for these media are evaluated as part of the Gypsum Storage Area, Dry Ash Stack, and Stilling Pond (including Retention Pond).

4 Stilling Pond (including Retention Pond)

CCR Material:

- CCR material is sluiced fly ash and bottom ash; the estimated volume of CCR is ~ 1.5 million cubic yards.
- The global and veneer slope stability meet the established factor of safety criteria for the static and seismic load cases.
- Ongoing repurposing construction activities are expected to positively impact conditions by lowering the pore water phreatic surface.

Groundwater Quality:

- Arsenic (well CUF-206) has been detected above the GSL.

Surface Stream, Sediment and Ecology:

- Beryllium was detected in one sediment sample slightly above the ESV in Wells Creek. Ash was not detected above 20% and beryllium has not been detected in groundwater above the GSL at this unit, suggesting that beryllium detected in sediment is not from this unit.

Legend

- Groundwater results below Groundwater Screening Levels
- Groundwater results above Groundwater Screening Levels
- Sediment / Surface water sample results below chronic Ecological Screening Values (ESVs)
- Sediment / Surface water sample results above chronic Ecological Screening Values (ESVs)

Sections colored in the chart indicate the number of constituents at a sampling location above screening levels

Number of constituents compared:

- Groundwater: 20
- Sediment: 19
- Cumberland River Surface water: 26
- Wells Creek Surface water: 24
- Unamed Tributary Surface water: 24

Counts represent total metals sample results. Total metals sample results less than screening levels (see Appendix J.1)

- Interpolated Groundwater Contour
- Groundwater Contour (5 ft interval; elevations are in ft amsl)
- Surface stream that bounds groundwater flow
- Hydrogeological Divide
- 2021 Imagery Boundary
- 2022 Imagery Boundary
- Bing Imagery Boundary
- CCR Unit Area (Approximate)

CCR: Coal combustion residuals

- 1–4 X above screening levels
- 5–9 X above screening levels
- >10 X above screening levels

Notes:

Groundwater contours included to illustrate general groundwater flow directions. See Exhibit 5-2, Groundwater Elevation Contour Map Event #2 (July 8, 2019), for actual groundwater elevations and groundwater contours.

Sample locations and charts have been summarized in the Unnamed Tributary area. See exhibits 7.4 and 7.5 for more detailed information.

Stantec TVA

Exhibit No.
8-6

Title
Overall Findings Near CUF Plant CCR Management Units

Client/Project
Tennessee Valley Authority
Cumberland Fossil (CUF) Plant TDEC Order

Project Location
Stewart County, Tennessee

175568209
Prepared by KB on 2023-06-20