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July 10, 2019

Re: ***Big Rivers Electric Corporation***

D.B. Wilson Station (AI 3319)

Assessment of Corrective Measures Report

An Assessment of Corrective Measures (ACM) for groundwater was initiated by Big Rivers Electric Corporation at the D.B. Wilson Station Landfill. The ACM was initiated based on Detection and Assessment groundwater monitoring conducted at the D.B. Wilson Station Phase II Landfill indicating one (1) constituent of concern (COC), cobalt (Co), as exceeding the applicable Groundwater Protection Standard (GWPS) at a statistically significant level (SSL).

The Coal Combustion Residuals Rule found at 40 CFR Part 257.96(a) requires that a facility initiate an ACM within 90 days of finding that any constituent listed in Appendix IV of Part 257 has been detected at a SSL exceeding the GWPS defined under 257.95(h). The ACM must be completed within 90 days. The 90-day deadline to complete the ACM may be extended for no longer than 60 days.

40 CFR Section 257.96(c) requires this assessment to include an analysis of the effectiveness of potential corrective measures in meeting the objectives for remedies. The documents contained herein fulfill the requirements of 40 CFR Part 257.96(a)(c)&(d).

Assessment of Corrective Measures Under the CCR Rule

PHASE II LANDFILL
D.B. WILSON GENERATING STATION
OHIO COUNTY, KENTUCKY

June 13, 2019

Prepared For:

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Acronyms

ACM	Assessment of Corrective Measures
ARARs	Applicable or relevant and appropriate requirements
BREC	Big Rivers Electric Corporation
C	Degrees Celsius
CAO	Corrective Action Objectives
CbR	Closure by Removal
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
CiP	Closure in Place
cm/sec	Centimeters per second
Co	Cobalt
COCs	Constituents of Concern
CSM	Conceptual Site Model
DO	Dissolved Oxygen
ft	Feet
ft amsl	Feet above mean sea level
GWPS	Groundwater Protection Standards
ICs	Institutional Controls
KGS	Kentucky Geological Survey
µS/cm	Microsiemens per centimeter
MCL	Maximum Contaminant Level
mg/L	Milligrams per liter
mV	Millivolt
NTU	Nephelometric Turbidity Unit
O&M	Operation and Maintenance
ORP	Oxidation Reduction Potential
PRB	Permeable reactive barrier
RCRA	Resource Conservation and Recovery Act
SSI	Statistically Significant Increase
SSL	Statistically Significant Level
TDS	Total Dissolved Solids
UPL	Upper Prediction Limit
USEPA	United States Environmental Protection Agency

Executive Summary

AECOM Technical Services, Inc. (AECOM) was retained by Big Rivers Electric Corporation (BREC) to prepare an Assessment of Corrective Measures (ACM) to identify appropriate corrective measures for groundwater impacted by coal combustion residuals (CCR). The subject groundwater impacts are associated with the CCR that has been historically managed within the BREC D.B. Wilson CCR Landfill (Wilson Phase II Landfill), located in Ohio County, Kentucky. Kentucky (Site). Groundwater monitoring was conducted for the CCR management unit in accordance with the United States Environmental Protection Agency's (USEPA) CCR Rule (40 Code of Federal Regulations (CFR) Section 257.90 through Section 257.95). Detection and Assessment groundwater monitoring are complete at the Wilson Phase II Landfill, and one constituent of concern (COC), cobalt (Co), has been identified based on exceedance of the applicable Groundwater Protection Standard (GWPS) at a statistically significant level (SSL).

Section 257.96(c) requires this assessment to include an analysis of the effectiveness of potential corrective measures in meeting the objectives for remedies identified under Section 257.97(b), by addressing at least the following:

(1) The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination;

(2) The time required to begin and complete the remedy;

(3) The institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy(s).

Several potential corrective measures technologies were evaluated to identify which ones could be carried forward as components of corrective measures alternatives. The results of the corrective measures technology evaluation are presented below:

Potentially Applicable Technology	Status	Description/Overview
No Action	Not retained as standalone technology, but carried forward for baseline comparisons	This technology has been included in the preliminary evaluation/screening but is not retained because it will not meet the established CAOs.
Institutional Controls (ICs)	Retained as supplement to corrective measures alternatives	The use of ICs (i.e., Environmental Covenants, groundwater use restrictions, etc.) is retained as a useful technology. However, it is noted the ICs are not anticipated to be used as a stand-alone technology. Environmental Covenants, groundwater use restrictions, etc., are expected to be combined with other applicable technologies as part of corrective measures alternatives.
Groundwater Monitoring (Assessment and Detection modes)	Retained as supplement to corrective measures alternatives	The use of groundwater monitoring (Assessment and/or Detection modes as appropriate) when combined with other applicable technologies as part of any proposed corrective measures alternative is retained to address the CAO and to track the effectiveness of the overall remedy. However, it is not retained as a stand-alone technology.

Potentially Applicable Technology	Status	Description/Overview
Hydraulic Containment	Retained	The use of hydraulic containment is retained because it is an effective means of preventing off-site migration of soluble contaminants. Hydraulic containment requires management and potential ex-situ treatment of extracted groundwater, so it is not a stand-alone technology. The Conceptual Site Model (CSM) will guide the design of any groundwater extraction system to optimize the total discharge of groundwater needed to provide hydraulic containment.
Physical Containment	Retained	The use of physical containment is retained because it can be an effective means of managing groundwater flow. Physical containment often requires pairing with hydraulic containment and/or in-situ treatment (funnel and gate style) to manage the flux of groundwater flow into the system. The CSM will guide the design of any physical barrier system, but technology limitations increase difficulty with scale.
Ex-situ Physical/Chemical/Biological Treatment	Retained	Ex-situ treatment technologies are retained as a way of removing contaminants from extracted groundwater from a hydraulic containment system. Ex-situ treatment may be paired with wastewater treatment, non-groundwater release treatment systems, or with permitted discharge to manage groundwater contamination. The CSM and data gaps investigations will guide the design of any ex-situ treatment.
In-situ Physical/Chemical Treatment	Retained	In-situ treatment technologies are retained for circumstances in which groundwater flow volumes are particularly low, source controls are effective, COCs are amenable to treatment, and impacted groundwater is not expected to persist as a treatment demand. The CSM and data gaps investigations will guide the design of any in-situ treatment.
Permeable Reactive Barriers (PRB)	Retained	The use of PRBs is retained for circumstances in which groundwater flow volumes are particularly low or in which they can be paired with physical containment to achieve passive management of impacted groundwater. The CSM, as well as bench and pilot-scale testing will guide the design of any PRB system.
Closure in Place (CiP) (of the regulated unit)	Retained	The use of CiP as a source control technology and is amenable with respect to CAO attainment.
Closure by Removal (CbR) (of the regulated unit)	Retained	The use of CbR as a source control technology is amenable with respect to CAO attainment.
Other Source Control Technologies	Retained	Control of source area non-groundwater (i.e., leachate seeps) related releases. Engineering measures, including seepage/leachate collection, lining of trenches and/or ponds, and other isolation methods are part of operational practices and/or closure technologies selected for the site.

Note: Technologies that were retained may be used as components of a corrective action alternative, but when evaluated in conjunction with other available technologies, any single technology may not be utilized.

Preliminary assembly of corrective measures alternatives was performed based on site-specific and regional geology and groundwater conditions. For the Wilson Phase II Landfill, six corrective measures alternatives were developed from this list of applicable corrective measures technologies:

- Alternative #1 – No Action and Groundwater Monitoring
- Alternative #2a – Closure in Place (CiP), Institutional Controls (ICs), Other Source Control, and Groundwater Monitoring
- Alternative #2b – Closure by Removal (CbR), ICs, and Groundwater Monitoring
- Alternative #3 – CiP, ICs, Hydraulic Containment, Other Source Control, Ex-Situ Treatment, and Groundwater Monitoring
- Alternative #4 – CiP, ICs, Other Source Control, Physical Containment, PRB, and Groundwater Monitoring
- Alternative #5 – CiP, ICs, Other Source Control, In-Situ Treatment (PRB), and Groundwater Monitoring

The assembly of corrective measures alternatives is preliminary and could be revised at a later date following detailed analysis during the remedy selection process and/or following comment from the regulatory community and public. Specifically, a public meeting is required under Section 257.96(e) at least 30 days prior to the selection of remedy so that the owner or operator may discuss the results of the corrective measures assessment with interested and affected parties.

Following submittal of the ACM, the Site will begin the remedy selection process that is set forth in Section 257.97. The selected remedy must:

- Meet the requirements of Section 257.97(b) of the CCR Rule;
- Consider the standards in Section 257.97(c), and;
- Address the schedule and other factors specified in Section 257.97(d).

Upon remedy selection, a remedy selection report will be prepared that documents details of the selected remedy and how the selected remedy meets Section 257.97 requirements. As needed to accommodate further investigation(s) and/or evaluation, Section 257.97 requires the preparation of a semiannual report that documents progress toward remedy selection and design.

1.0 INTRODUCTION

The following report presents the Assessment of Corrective Measures (ACM) for groundwater impact identified at the D.B. Wilson Coal Combustion Residuals (CCR) Landfill (Wilson Phase II Landfill), which is a coal combustion residuals (CCR) management unit located at the Big Rivers Electric (BREC) D.B. Wilson Generating Station (Wilson Station) located near Centertown, Ohio County, Kentucky (Site).

Groundwater monitoring was conducted for the unit in accordance with the United States Environmental Protection Agency's (USEPA) CCR rule (40 Code of Federal Regulations (CFR) Section 257.90 through Section 257.95). The results of Detection monitoring (per Section 257.94) identified the presence of one or more indicator constituents (Appendix III to Section 257) with downgradient concentrations representing a statistically significant increase(s) (SSI) over background or upgradient conditions. The detection of one or more SSI required the implementation of Assessment monitoring following the requirements of Section 257.95, which was initiated in April 2018. Assessment monitoring results indicated the downgradient presence of one or more constituent of concern (Appendix IV to Section 257) at concentrations that represent a SSI over background concentration, and that represent a statistically significant level (SSL) over the groundwater protection standard(s) established in accordance with to Section 257.95(h).

For the Wilson Phase II Landfill unit, the following SSL was identified:

- Cobalt (Co) in MW-10.

The identification of the SSL requires characterization of the nature and extent of impact (sufficient to support the assessment of corrective measures) in accordance with Section 257.95(g)(1) and the initiation of an ACM following the requirements of Section 257.96. Notice of ACM initiation dated January 14, 2019 was posted to BREC's publicly-accessible CCR reporting website.

Section 257.96(c) requires this ACM to include an analysis of the effectiveness of potential corrective measures in meeting the objectives for remedies identified under Section 257.97(b), by addressing at least the following:

(1) The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination;

(2) The time required to begin and complete the remedy;

(3) The institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy(s).

This report presents the ACM evaluation in the following five sections, along with their associated appendices and attachments.

2.0 DESCRIPTION OF CURRENT CONDITIONS

This section provides information related to the current use of the site, as well as the history of activities relevant to the ACM for the Wilson Phase II Landfill.

2.1 Site Background

The Wilson Phase II Landfill is located in Ohio County approximately 5 miles northwest of the town of Centertown, Kentucky (**Figure 1**). The property is located northwest and adjacent to the D.B. Wilson Generating Station (Wilson Station). The Wilson Phase II Landfill is a Kentucky permitted landfill that receives special wastes generated by burning coal (CCRs) from Wilson Station. The current Wilson Phase II Landfill footprint is approximately 92 acres (**Figure 2**). Adjacent to the Phase II Landfill on the east is the Phase I Landfill for Wilson Station, and this unit is not subject to an ACM.

The Wilson Phase II Landfill is raised above adjacent ground to a maximum elevation of approximately 520 feet above mean sea level (AMSL). The original ground surface within the landfill footprint was an irregular post-mining reclaimed surface.

2.2 Site Investigation and Interim Measures

Monitoring wells were installed in the vicinity of the Phase II Landfill in January and February 2009 prior to the implementation of the CCR Rule. However, the existing wells meet the requirements of Section 257.90 of the CCR Rule for installation of a groundwater monitoring system consisting of wells that adequately represent the quality of background groundwater and groundwater representing the downgradient waste boundary. The existing wells are located along the perimeter of the permitted footprint for the Phase II Landfill. One upgradient monitoring well (MW-8) and four downgradient monitoring wells (MW-5, MW-6, MW-7, and MW-10) were installed adjacent to the Phase II Landfill to determine the general direction of groundwater movement and to monitor groundwater at the site. The monitoring wells were installed in the uppermost saturated portion of the unconsolidated mine spoil aquifer (units characterized by varying proportions of sandstone, siltstone, shale, coal, and underclay).

Monitoring wells were installed in January and February 2009, hydraulic testing (slug tests) was performed in April 2019, and nine rounds of baseline groundwater sampling for Appendix III constituents took place quarterly between April 2016 and October 2017. Statistical evaluation for detection monitoring indicated that statistically significant increases (SSIs) over background have occurred, and therefore, assessment monitoring was triggered. Detection monitoring activities and data are presented in the annual reports that have been prepared to date, AECOM (2018 and 2019).

As part of assessment monitoring, background and downgradient wells for the Phase II Landfill were sampled for Appendix IV constituents in April, July, and October 2018. Groundwater Protection Standards (GWPSs) were established for assessment monitoring of the Appendix IV constituents, and statistical evaluation indicated exceedances of GWPSs at SSLs.

For the purposes of this ACM, the only COC identified for the Site that exceeds GWPS at SSL is Cobalt (Co) (see **Table 1**).

Table 1. Phase II Landfill Constituents of Concern (COCs)

Monitoring Well (Date)	Parameter (mg/L)
	Cobalt Background UPL 0.0016 GWPS 0.005
MW-10 (Apr 2018)	**0.0412**
MW-10 (Jul 2018)	**0.0704**
MW-10 (Oct 2018)	**0.114**

GWPS are U.S. Environmental Protection Agency primary drinking water standard maximum contaminant limits (MCL) or GWPS provided in 40 CFR 257.95(3)(h)(2),
Yellow shaded indicates a SSL above the GWPS (i.e., 95 LCL > GWPS).
mg/L = milligrams per liter;
UPL = Upper Prediction Limit.

No formal interim remedial measures have been performed at the Phase II Landfill.

2.3 Conceptual Site Model

The main purpose of a site conceptual model (CSM) is to support the decision-making process for groundwater corrective action at the Phase II Landfill.

2.3.1 Physical Setting

The Site is mapped within the Interior Low Plateaus physiographic province (https://www.nps.gov/subjects/geology/physiographic-provinces.htm). The province is part of the Interior Plains division of the United States. Characteristic features of the province include unglaciated rolling limestone plains with alluvial valleys and entrenched rivers and streams. Several large rivers are in the region, including the Ohio, the Kentucky, the Tennessee, and the Cumberland Rivers. The geology underlying the Site consists of unconsolidated materials, including loess, alluvial deposits and mine spoil, underlain by Upper to Middle Pennsylvanian-age clastics and carbonates consisting primarily of sandstone and shale. The unconsolidated materials also include mine spoil used as fill, and silty and clayey residuum. The mine spoil is also reported to contain bedrock blocks that were also placed as fill.

The Phase II Landfill at Wilson Station is located on a ridge to the east of the Green River at an elevation of approximately 420 ft., amsl, with a maximum elevation of 520 ft. amsl. Precipitation falling on the Phase II Landfill is directed to ponds in the south side of the unit and then to Elk Creek under Kentucky Pollution Discharge and Elimination System (KPDES) permit. Elk Creek is a primary tributary to the Green River, and it flows westward to the Green River.

2.3.2 Geology

Figure 3 presents a geologic map of the site and vicinity. The Site lies in the Western Kentucky Coalfields section, characterized by rolling uplands underlain by coal-bearing bedrock of the Pennsylvanian Period. In the vicinity of the site, maximum topographic relief is on the order of 80 feet. The geologic quadrangle (Geologic map of the Equality quadrangle, Ohio County, Kentucky, 1973) for the Site vicinity published by the Kentucky Geological Survey (KGS) shows the surficial material to be unconsolidated loess representing the Pleistocene and Holocene geologic epoch. The loess consists of sandy and clayey silt. The unconsolidated surficial materials, which include silty and sandy clay units, are up to approximately 25 feet in thickness.

The unconsolidated materials are shown to be underlain by bedrock of the Middle Pennsylvanian Carbondale Formation. The Carbondale Formation consists of cyclic sequences of sandstones, shales, siltstones and coals. The Carbondale sediments were deposited in a fluvial-deltaic system. As a result of this depositional environment, the lithologic units of the Carbondale tend to be lenticular bodies rather than continuous sheet-like strata. Gradational and abrupt horizontal changes in lithology are often encountered.

Cross sections were prepared during development of this ACM, and cross section locations are shown on **Figure 2**. The individual cross sections are presented on **Figures 4, 5 and 6**. These sections illustrate the sequence of geologic materials present under the Phase II Landfill as evidenced by the currently available data.

2.3.3 Hydrogeology

For purposes of compliance with the CCR Rule groundwater monitoring requirements the unconsolidated mine spoil is considered to be the uppermost aquifer underlying the Phase II Landfill. The uppermost usable aquifer is unconfined and first encountered at an elevation of approximately 400 ft., amsl at the north end of the Phase II Landfill and 395 ft. amsl at the south end. Flow direction beneath the Site is typically to the south and southeast. The mine spoil is bounded on the south (i.e., downgradient) by a headwall of undisturbed Carbondale Formation.

Slug tests were performed on April 23, 2019 at monitoring wells MW-4, MW-4D, and MW-10 to assess the hydraulic characteristics of the uppermost aquifer. The estimated hydraulic conductivity of the monitoring wells tested were 8.03 $x10^{-2}$ centimeters per second (cm/sec) in MW-4, 9.30 $x10^{-2}$ cm/sec in MW-4D, and 2.91 $x10^{-2}$ cm/sec in MW-10. Hydraulic conductivity for the Carbondale Formation is estimated from literature, and for the purposes of this ACM, a range for sandstone of 1 $x10^{-4}$ cm/sec to 1 $x10^{-5}$ cm/sec is used. Groundwater flow downgradient of the mine spoil beneath the Phase II Landfill is therefore rate-limited by the lower permeability in the Carbondale Formation.

2.3.4 Contaminants of Concern (COCs)

As described in Section 2.2, a single Appendix IV constituent, Co, was detected at concentrations exceeding GWPS at one monitoring well location (MW-10).

2.3.5 Impacted Media

Groundwater is the sole impacted media of concern addressed by this ACM.

2.3.6 COCs Distribution

Groundwater analytical data from the Site investigations through 2018 indicate that the COC concentration above GWPS is present along the southern boundary of the Phase II Landfill at MW-10. COC in groundwater that exceeds the statistically significant level (SSL) is illustrated in **Figure 7**. The area of treatment is along the southern boundary of the Phase II Landfill, and adjacent to the southeast.

Additional characterization wells, MW-4D, MW-102, MW-104, MW-105, and MW-110 were subsequently installed to estimate the downgradient extent of impacted groundwater. Sample collection for Appendix III and IV parameters took place in October and November 2018. The analytical results for Co, the sole SSL for this ACM are summarized for the characterization wells in **Table 2**.

Table 2 – Phase II Landfill Characterization Sample Results

Monitoring Well	Parameter
	UPL 0.0016 GWPS 0.005 (mg/L)
MW-4D	**0.0122**
MW-102	0.00263 J
MW-104	0.00388 J
MW-105	0.00488 J
MW-110	0.00240 J

J=Estimated concentration above minimum detection limit but below reporting limit
Bold value exceeds GWPS

The single sampling event result from the characterization well confirms the downgradient (southern) extent of COC impact at the Phase II Landfill.

2.3.7 Groundwater Quality

In addition to the presence of COCs above GWPSs, other geochemical characteristics of the shallow aquifer zone consist of the following:

- The temperature of the samples taken at the downgradient wells during the October 2018 sampling event ranged from 19.09 degrees Celsius (°C) to 22.57 °C.
- Specific conductance ranged from 1.94 to 3.48 milliSiemens per centimeter (mS/cm).
- Dissolved Oxygen (DO) concentration ranged from 0.54 to 3.62 mg/L.
- Oxidation Reduction Potential (ORP) ranged from -21 to 146 millivolts (mV).
- Turbidity of the samples ranged from 1.9 to 24.9 Nephelometric Turbidity Units (NTU).
- The pH of the samples ranged from 5.44 to 6.75.
- Total Dissolved Solids (TDS) concentration of the samples ranged from 1,750 to 3,200 mg/L.

2.3.8 Potential Receptors / Pathways

Contact with water (e.g., shallow groundwater or surface water) impacted by COCs at levels above GWPS is regarded as the exposure pathway for exposure of potential receptors. Based on data published by KGS, there are no known groundwater wells used for drinking water within a 1-mile radius of the Wilson Phase II Landfill, thus limiting the potential receptors to the surface water, i.e., the Green River and its tributary, Elk Creek. The pathways to these receptors include seepage of water from the Phase II Landfill through manmade and natural hydraulic barriers and groundwater discharge.

Other potential exposure pathways (e.g., soil or vapor) are not considered complete as the CCR material is isolated in the units. This isolation prevents direct access by individuals that might result in direct contact or ingestion. In addition, the inherent non-volatile nature of the unit-specific COCs eliminates the potential for a complete vapor pathway (i.e., vapor intrusion to indoor air). Therefore, soil and vapor pathways will not be considered within the context of this ACM.

3.0 CORRECTIVE ACTION OBJECTIVE

For CCR units, 40 CFR Parts 257.90 through 257.98 outlines the groundwater monitoring programs (Detection and Assessment) and the corrective action evaluation process, which provide the basis for the development of the site-specific Corrective Action Objective (COA). Detection and assessment groundwater monitoring are complete at the Phase II Landfill, and the COC Co has been identified based on exceedance of applicable GWPSs.

Section 257.96(c) requires this assessment to include an analysis of the effectiveness of potential corrective measures to meet the objectives for remedies identified under Section 257.97(b), by addressing at least the following:

(1) The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination;

(2) The time required to begin and complete the remedy;

(3) The institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy(s).

The subsequent remedy selection process will evaluate the following objectives for remedies, as required under Section 257.97(b):

- Protect human health and the environment;
- Attain the COC-specific GWPSs as specified pursuant to Section 257.95(h);
- Control the source(s) of releases to reduce or eliminate, to the maximum extent feasible, further releases of Appendix IV constituents into the environment;
- Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, considering factors such as avoiding inappropriate disturbance of sensitive ecosystems (applicable to material releases only); and
- Comply with standards for management of wastes as specified in Section 257.98(d).

Together, these requirements comprise the site-specific CAO that will be used during the remedy selection process.

4.0 TECHNOLOGY IDENTIFICATION AND SCREENING

As required under Section 257.97(b), source control is one element of the CAO that is intended to prevent further releases from the source, i.e. the Phase II Landfill. In adherence with the BREC's permit conditions, the Site will continue to operate as a solid waste disposal facility through its life cycle and will be closed in accordance with the requirements of the permit. Source control through landfill closure will include installation of the final cover that will prevent infiltration and contribute to groundwater quality restoration.

The identification and screening of potentially applicable corrective measures technologies for groundwater downgradient of the Phase II Landfill is presented in **Appendix A** to this report. The findings of that screening are summarized in the table below.

Table 3 – Potential Corrective Measures Options Technology Description/Overview

Potentially Applicable Technology	Status	Description/Overview
No Action	Not retained as standalone technology, but carried forward for baseline comparisons	This technology has been included in the preliminary evaluation/screening but is not retained because it will not meet the established CAOs.
Institutional Controls (ICs)	Retained as supplement to corrective measures alternatives	The use of ICs (i.e., Environmental Covenant, groundwater use restrictions, etc.) is retained as a useful technology. However, it is noted the ICs are not anticipated to be used as a stand-alone technology. Environmental Covenants, groundwater use restrictions, etc., are expected to be combined with other applicable technologies as part of corrective measures alternatives.
Groundwater Monitoring (Assessment and Detection mode)	Retained as supplement to corrective measures alternatives	The use of groundwater monitoring (Assessment and/or Detection modes as appropriate) when combined with other applicable technologies as part of any proposed corrective measures alternative is retained to address the CAO and to track the effectiveness of the overall remedy. However, it is not retained as a standalone technology.
Hydraulic Containment	Retained	The use of hydraulic containment is retained because it is an effective means of preventing offsite migration of soluble contaminants. Hydraulic containment requires management and potential ex-situ treatment of extracted groundwater, so it is not a stand-alone technology. The CSM will guide the design of any groundwater extraction system to optimize the total discharge of groundwater needed to provide hydraulic containment.
Physical Containment	Retained	The use of physical containment is retained because it can be an effective means of managing groundwater flow. Physical containment often requires pairing with hydraulic containment and/or in-situ treatment (funnel and gate style) to manage the flux of groundwater flow into the system. The CSM will guide the design of any physical barrier system, but technology limitations may increase implementation difficulty with scale.

Potentially Applicable Technology	Status	Description/Overview
Ex-situ Physical/Chemical/Biological Treatment	Retained	Ex-situ treatment technologies are retained as a way of removing contaminants from extracted groundwater from a hydraulic containment system. Ex-situ treatment may be paired with wastewater treatment, non-groundwater release treatment systems, or with permitted discharge to manage groundwater contamination. The CSM and data gaps investigations will guide the design of any ex-situ treatment
In-situ Physical/Chemical Treatment	Retained	In-situ treatment technologies are retained for circumstances in which groundwater flow volumes are particularly low, source controls are effective, COCs are amenable to treatment, and impacted groundwater is not expected to persist as a treatment demand. The CSM and data gaps investigations will guide the design of any in-situ treatment
Permeable Reactive Barriers (PRB)	Retained	The use of PRBs is retained for circumstances in which groundwater flow volumes are particularly low or in which they can be paired with physical containment to achieve passive management of impacted groundwater. The CSM, as well as bench and pilot-scale testing will guide the design of any PRB system.
Closure in Place (CiP) (of the regulated unit)	Retained	The use of CiP as a source control technology and is amenable with respect to CAO attainment.
Closure by Removal (CbR) (of the regulated unit)	Retained	The use of CbR as a source control technology is amenable with respect to CAO attainment.
Other Source Control Technologies	Retained	Control of source area non-groundwater (i.e., leachate seeps) related releases. Engineering measures, including seepage/leachate collection, lining of trenches and/or ponds, and other isolation methods are part of operational practices and/or closure technologies selected for the site.

References: Technology descriptions referenced from 1) FRTR: Federal Remediation Technologies Roundtable, CLU-IN, and/or AECOM reference materials.

5.0 CORRECTIVE ACTION ALTERNATIVES ASSEMBLY

Applicable corrective measures technologies identified in Section 4.0 above were assembled into corrective measures alternatives for evaluation (see **Appendix B** and Section 6.0). Each corrective measures alternative consists of one or more corrective measures technologies assembled into a strategy for the groundwater remedy. Six corrective measures alternatives for the Green Landfill were assembled and are described below.

- **Alternative #1** – No Action and Groundwater Monitoring
- **Alternative #2a** – Closure in Place (CiP), Institutional Controls (ICs), Other Source Control, and Groundwater Monitoring
- **Alternative #2b** – Closure by Removal (CbR), ICs, and Groundwater Monitoring
- **Alternative #3** – CiP, ICs, Hydraulic Containment, Other Source Control, Ex-Situ Treatment, and Groundwater Monitoring
- **Alternative #4** – CiP, ICs, Other Source Control, Physical Containment, PRB, and Groundwater Monitoring
- **Alternative #5** – CiP, ICs, Other Source Control, In-Situ Treatment (PRB), and Groundwater Monitoring

5.1 Assumptions for Corrective Measure Alternatives Development

In developing the corrective measures alternatives, a number of assumptions have been made based on the data available to AECOM at the time of this report and operational plans as reported by the owner/operator. The specific assumptions include:

- The currently observed dissolved-phase groundwater impacts are limited to the area from the vicinity of monitoring well location MW-10 along the southeastern corner of the Wilson Phase II Landfill extending to the vicinity of MW-4/4D at the southeastern corner of the Phase I Landfill; groundwater impacts do not extend offsite from the Wilson Station property.

- Groundwater impacts are limited to the mine spoil, in a saturated zone between the observed water table at approximate elevation 390 feet mean sea level (ft-msl) and an assumed depth below the MW-10 well screen of approximately 325 ft-msl.

- Ex-situ treatment of groundwater may involve physical/chemical methods and/or discharge to a permitted National Pollution Discharge and Elimination System (NPDES) outfall.

- Groundwater corrective measures will be conducted until the CAOs are met. The objectives may be met at an earlier date, but the alternatives analysis is based on the conservative assumption that corrective measures and the associated monitoring of groundwater conditions will be required for up to 30 years following the initiation of the corrective measures.

- CiP and Other Source Control are not included in the corrective measures alternatives as they are part of planned plant operations.

5.2 Groundwater Corrective Measures Alternatives Overview

The developed groundwater corrective measures alternatives, outlined above, are detailed in the following sections.

5.2.1 Alternative #1 – No Action and Groundwater Monitoring

Alternative #1 consists of taking no action to remedy the CCR impacts observed in the Phase II Landfill groundwater monitoring system. Under the No Action alternative, no corrective measures would be implemented to remove, control, mitigate, or minimize exposure to impacted groundwater. Groundwater monitoring (Assessment) is required by the CCR Rule during the nominal performance period of 30 years to track the effectiveness of the alternative and to identify conditions that allow the return to Detection monitoring. The No Action alternative establishes a baseline, or reference point against which each of the developed corrective measures alternatives may be compared.

5.2.2 Alternative #2a – Closure in Place (CiP), Institutional Controls (ICs), Other Source control, and Groundwater Monitoring

Alternative #2a employs a combination of four of the retained corrective measures technologies:

- CiP source control, which consists of planned Phase II Landfill closure activities;
- Implementation of ICs designed to restrict the property to industrial use and to prohibit groundwater use for potable purposes;
- Other source control consisting of collection and management of seeps emanating from the east side of the Phase II Landfill; and
- Groundwater Monitoring (Assessment) to track the effectiveness of the corrective measures and to identify conditions that allow the return to Detection monitoring and ultimately to cessation of corrective measures.

CiP was selected as the source control technology because the site's operational planning includes closure-related activities that will eventually result in placement of an engineered cap. CiP via CCR stabilization and capping would serve to control the source of COCs and thereby reduce contaminant loading to the surrounding environment.

Implementation of ICs is employed to help maintain the CiP and associated corrective measures by limiting the accessibility of the unit to unauthorized users and restricting future use of the property to those activities that may result in exposure potentials.

Seepage from CCR is present along the east side of the Phase II Landfill and the Wilson Station is in the process of designing a collection system that will convey seepage liquids to existing onsite treatment.

Groundwater monitoring of the unit is required by 40 CFR 257.90 through .98. The unit triggered Assessment-mode monitoring by the detection of indicator parameters (Appendix III of 40 CFR 257) in downgradient monitoring wells at concentrations representing a SSI over background. Continued groundwater monitoring is required under 40 CFR 257.95 until the CAOs are met. The CAOs are anticipated to be met as the effect of source control technologies are realized and as natural attenuation mechanisms (advection, dilution and dispersion) take effect.

5.2.3 Alternative #2b – Closure by Removal (CbR), ICs, Other Source Control, and Groundwater Monitoring

Alternative #2b is similar to Alternative #2a except that CiP is replaced by CbR, which consists of excavation and removal of the Phase II Landfill, implementation of ICs and an Environmental Covenant intended to restrict the unit to industrial use and prohibit groundwater use for potable purposes. The excavation of impacted CCR material would typically be completed using standard construction equipment (e.g., backhoe, excavator, wheel loader, dump trucks). The excavated materials are then placed directly into dump trucks for transport/disposal or beneficial use. Excavation limits would typically be verified with confirmation sampling to demonstrate that the underlying soil is not impacted above applicable standards.

Groundwater monitoring of the unit is required by 40 CFR 257.90 through .98. The unit triggered Assessment-mode monitoring by the detection of indicator parameters (Appendix III of 40 CFR 257) in downgradient monitoring wells at concentrations representing a SSI over background. Continued groundwater monitoring is required under 40 CFR 257.95 until the CAOs are met. The CAOs are anticipated to be met as the effect of source control technologies are realized and as natural attenuation mechanisms (advection, dilution and dispersion) take effect.

5.2.4 Alternative #3 – CiP, ICs, Other Source Control, Hydraulic Containment, Ex-Situ Treatment, and Groundwater Monitoring

Alternative #3 builds on Alternative #2a to also include the addition of Hydraulic Containment and Ex-Situ Treatment of groundwater:

- CiP source control, which consists of future planned Phase II Landfill closure activities following its operational life cycle;
- Other Source Control by means of collection and management of seepage liquids from the Landfill and conveyance to existing onsite treatment;
- Implementation of ICs designed to restrict the property to industrial use and to prohibit groundwater use for potable purposes;
- Hydraulic Containment using one or more vertical wells designed to prevent the movement of impacted groundwater past the limits of the unit to the downgradient groundwater environment and potential points of exposure;
- Ex-Situ Treatment of groundwater extracted for hydraulic containment, which involves above-ground physical/chemical treatment methods and/or permitted discharge until the CAOs are achieved;
- Groundwater Monitoring (Assessment mode) to track the effectiveness of the corrective measures and to identify conditions that allow the return to Detection-mode monitoring and ultimately to cessation of corrective measures.

Vertical groundwater recovery wells for Hydraulic Containment would be installed near the downgradient limit of the unit in the vicinity of MW-10. Due to the varying hydraulic conductivity values within the uppermost aquifer, Pre-Design Studies are anticipated to be needed to identify the appropriate number, design, and spacing of the extraction well system. For the purposes of this ACM, costing was estimated using the following specifications:

- Four vertical groundwater extraction wells;
- Extraction wells would be installed in mine spoil in a linear arrangement that would be located south/southeast of the Phase II Landfill and downgradient of monitoring well MW-10 and MW-4/MW-4D;
- Wells screen depths would be approximately 60-130 feet-below ground surface (ft-bgs);
- Estimated groundwater extraction rates of 250 gallons per minute (gpm) per well.

Alternative #3 incorporates treatment of extracted groundwater before it can be discharged to an outfall. Treatment will consist of piping the extracted groundwater to an existing surface water impoundment at the Wilson Station, which will accommodate conveyed discharge from the other source control collection and which will allow for compliance with discharge permits through an established NPDES outfall.

The COC concentrations downgradient of the hydraulic containment would also be expected to decrease over time through natural attenuation mechanisms including advection, dilution, and dispersion. As such, groundwater monitoring would be modified to include system performance monitoring, which may require installation of wells at new locations to evaluate the efficacy of hydraulic containment and to identify when CAOs have been achieved.

5.2.5 Alternative #4 – CiP, ICs, Other Source Control, Physical Containment (Funnel-Gate), PRB, and Groundwater Monitoring

Alternative #4 consists of BREC's planned unit closure activities, other source control, physical containment of impacted groundwater via installation of a funnel-gate system, and in-situ treatment of contained groundwater via PRB installed at the containment gate. Impacted groundwater would be contained by slurry wall constructed in a funnel-and-gate arrangement that directs the flow of groundwater to the PRB. The slurry wall would be installed by trenching equipment, and the length of the barrier would be 2,700 feet, with the target depth would be approximately 60 ft. A PRB would be installed at the "gate," and treatability studies would be required to design the reactive media, which would include granular zero-valent iron (ZVI), for treatment of Co.

5.2.6 Alternative #5 – CiP, ICs, Other Source Control, In-Situ Treatment (via PRB), and Groundwater Monitoring

Alternative #5 consists of BREC's planned unit closure activities, other source control, and in-situ treatment of groundwater via a PRB installed into the mine spoil in a linear arrangement downgradient of the Phase II Landfill. Impacted groundwater would be treated in-situ as it migrates through the PRB made of granular ZVI material. Treatability studies would be required to design the reactive media. The PRB would be installed with conventional drilling and injection methods along the south and southeast boundaries of the Phase II Landfill in the vicinity of MW-10 and MW-4/MW-4D.

6.0 ALTERNATIVE EVALUATION

The formal remedy selection process, in accordance with the CCR Rule 40 CFR Section 257.97, will begin following submission of the ACM Report. The subsequent remedy selection process will evaluate the following objectives for remedies, as required under Section 257.97(b):

- Protect human health and the environment;
- Attain the COC-specific GWPSs as specified pursuant to Section 257.95(h);
- Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of Appendix IV constituents into the environment;
- Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems (applicable to material releases only); and
- Comply with standards for management of wastes as specified in Section 257.98(d).

6.1 Potential Data Gaps

No data gaps investigation in projected at this time.

Depending on which alternative is selected, a data gap investigation may be needed to further refine the targeted areas for corrective measures. Potential data gaps may include the following:

1) Supplemental Groundwater Investigation – This investigation would consist of additional monitoring well installation and sampling to refine the existing CSM as well as to provide data related to the hydraulic characteristics of the subsurface.

2) If either in-situ or ex-situ treatment is incorporated into a corrective action alternative, further detailed evaluation and/or bench- and pilot-scale studies would be necessary to identify technically effective treatment technologies given the inorganic COCs.

7.0 REFERENCES

AECOM, 2018. Annual Groundwater Monitoring and Corrective Action Report, 2016-2017; D.B. Wilson CCR Landfill, Ohio County, Kentucky.

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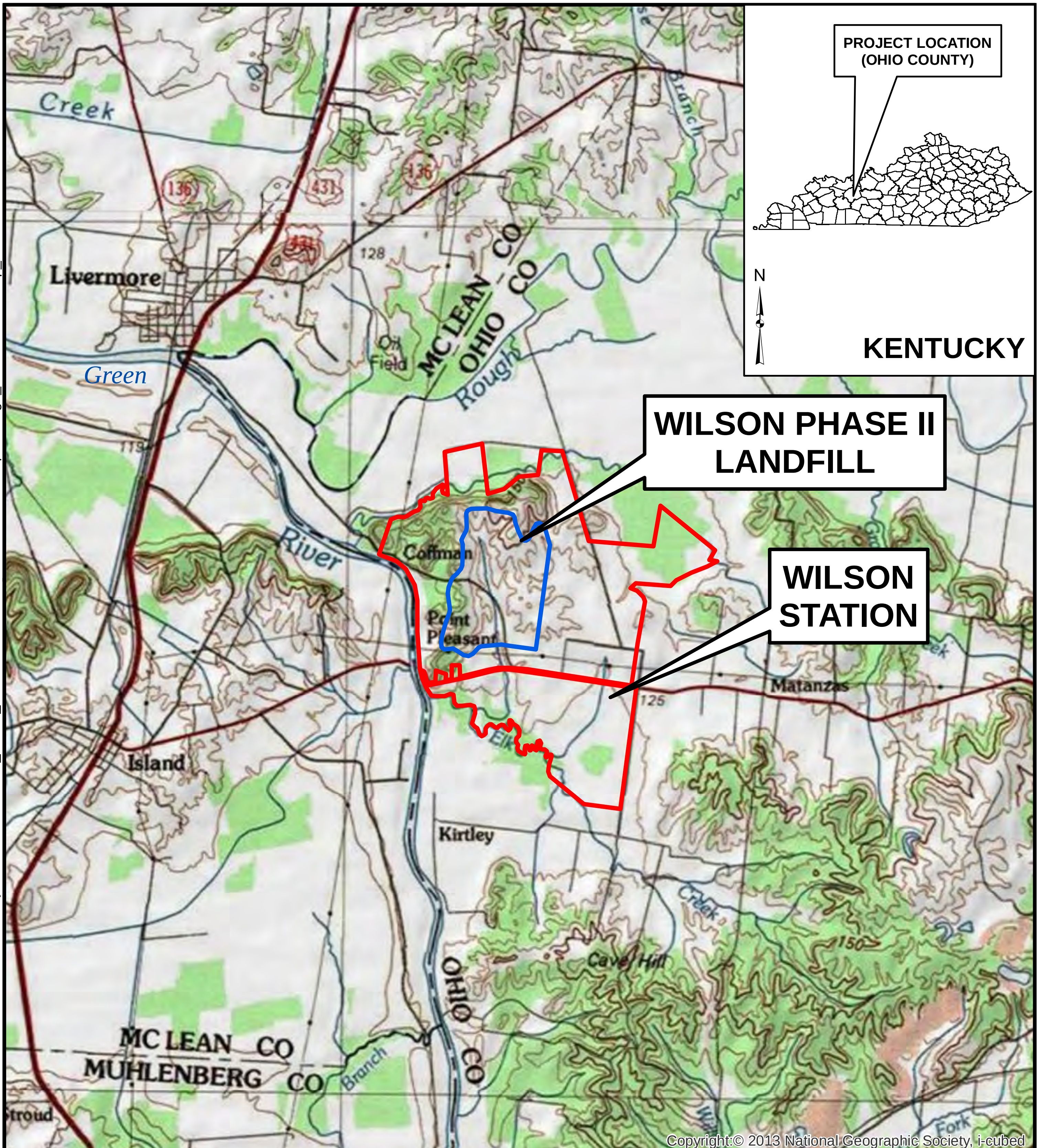
Figures

Document Path: G:\Cincinnati\DCS\Projects\ENV\60579935_BREC_WilGW\900-CAD-GIS\920-GIS or Graphics\Fig1_Site Location Map_Wilson ACM Revised.mxd



UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

EQUALITY QUADRANGLE
(https://viewer.nationalmap.gov/basic/)

0 3,000 6,000
Feet

N

Big Rivers
ELECTRIC CORPORATION

Wilson Station
Ohio County, Kentucky

FIGURE 1
SITE LOCATION MAP

DATE: 5/21/2019	SCALE: 1IN = 1,500 FEET
CREATED BY: ALW	
JOB NO. 60602363	

Legend

- Property Boundary
- CCR Phase 2 Landfill Permitted Area
- CCR Phase 2 Landfill (Active)
- KAR Permit Area
- CCR Phase 1 Landfill
- Downgradient CCR Monitoring Well Location
- Upgradient CCR Monitoring Well Location
- Characterization Monitoring Well Location
- Piezometer Location (Water Level Only)
- Monitoring Well Location (Water Level Only)
- Seep
- Water Table Contour (Inferred from Available Monitoring Data)
- Groundwater Flow Direction
- 409.69 Groundwater Elevation (Feet, NAD27) Measured December 11, 2018

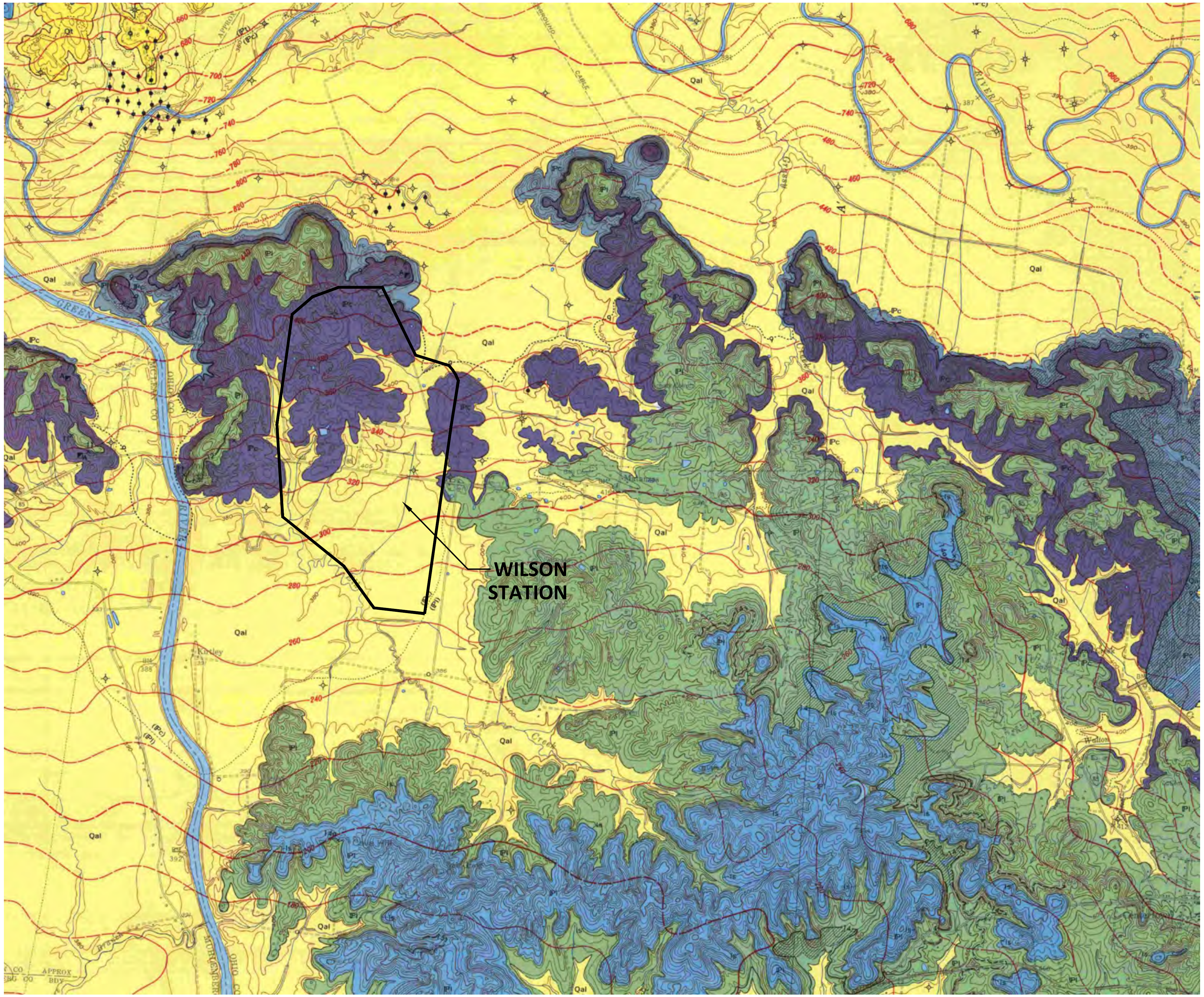
A —— A'
Transect Line

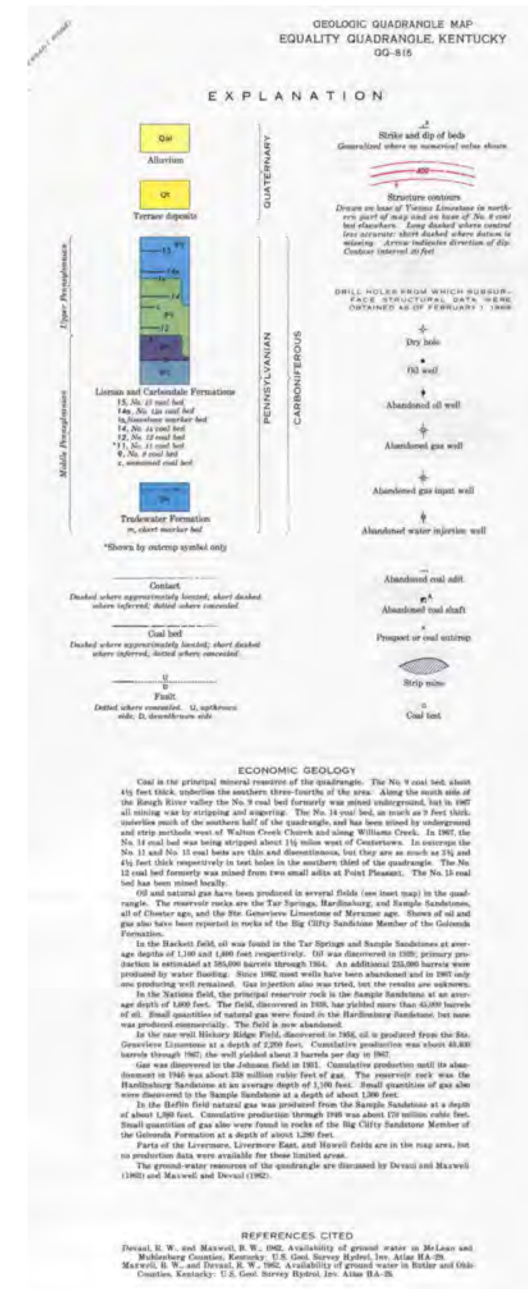
0 750 1,500
Feet

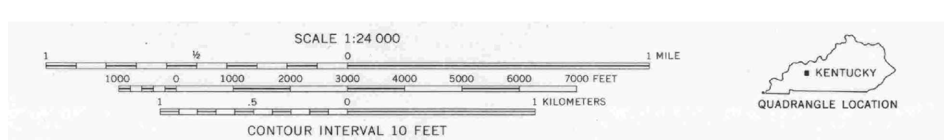
Wilson Station Landfill
Ohio County, Kentucky

FIGURE 2
CCR GROUNDWATER
MONITORING SYSTEM

DATE: 5/16/2019	SCALE: 1IN = 750 FEET
CREATED BY: ALW	
JOB NO. 60579935	





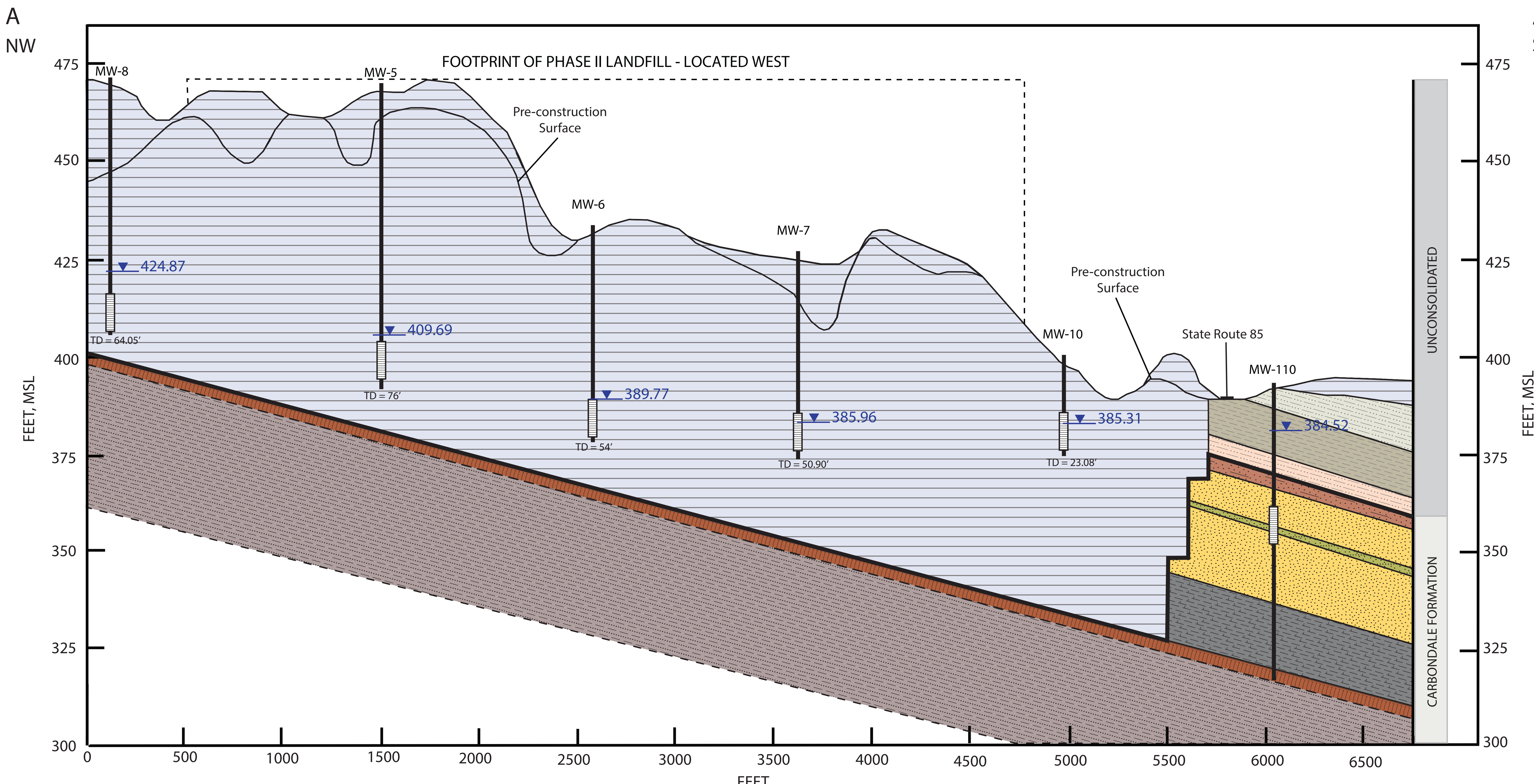


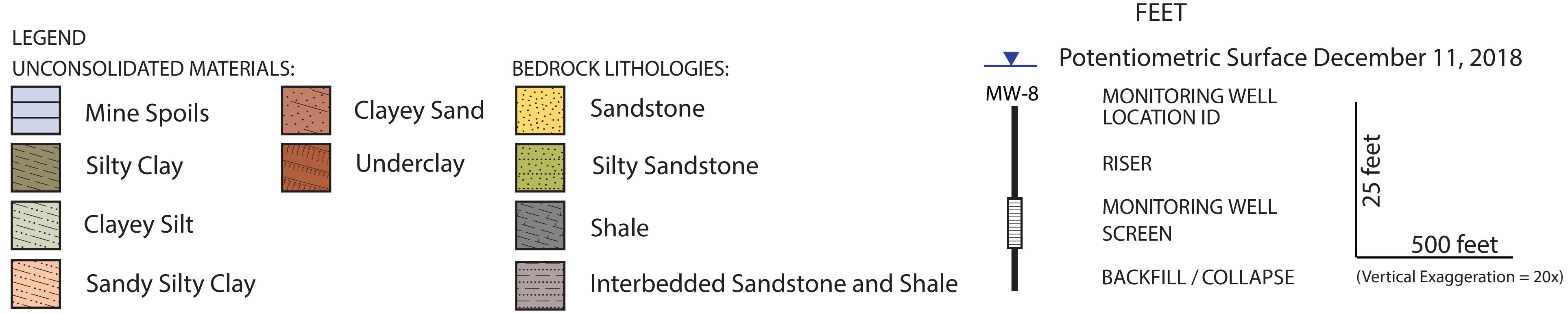
Big Rivers Electric Corporation

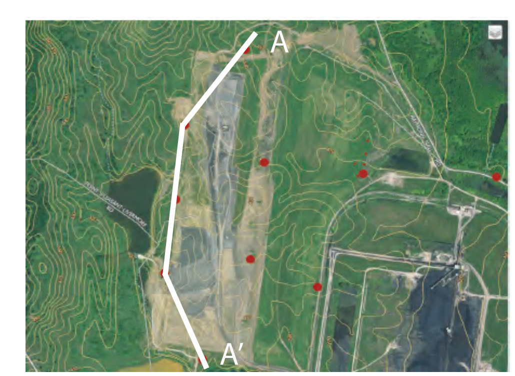
Wilson Station
Ohio County, Kentucky

FIGURE 3
SITE GEOLOGIC MAP
(KENTUCKY GEOLOGICAL SURVEY)

DATE: 05/21/2019	SCALE: AS SHOWN
CREATED BY: DAS	
JOB NO. 60602365	







Big Rivers ELECTRIC CORPORATION

Wilson Station Landfill
Ohio County, Kentucky

FIGURE 4
CCR GROUNDWATER
MONITORING SYSTEM

DATE: 5/17/2019	SCALE:1 IN = 25 x 500 FEET
CREATED BY: MRH	
JOB NO. 60579935	

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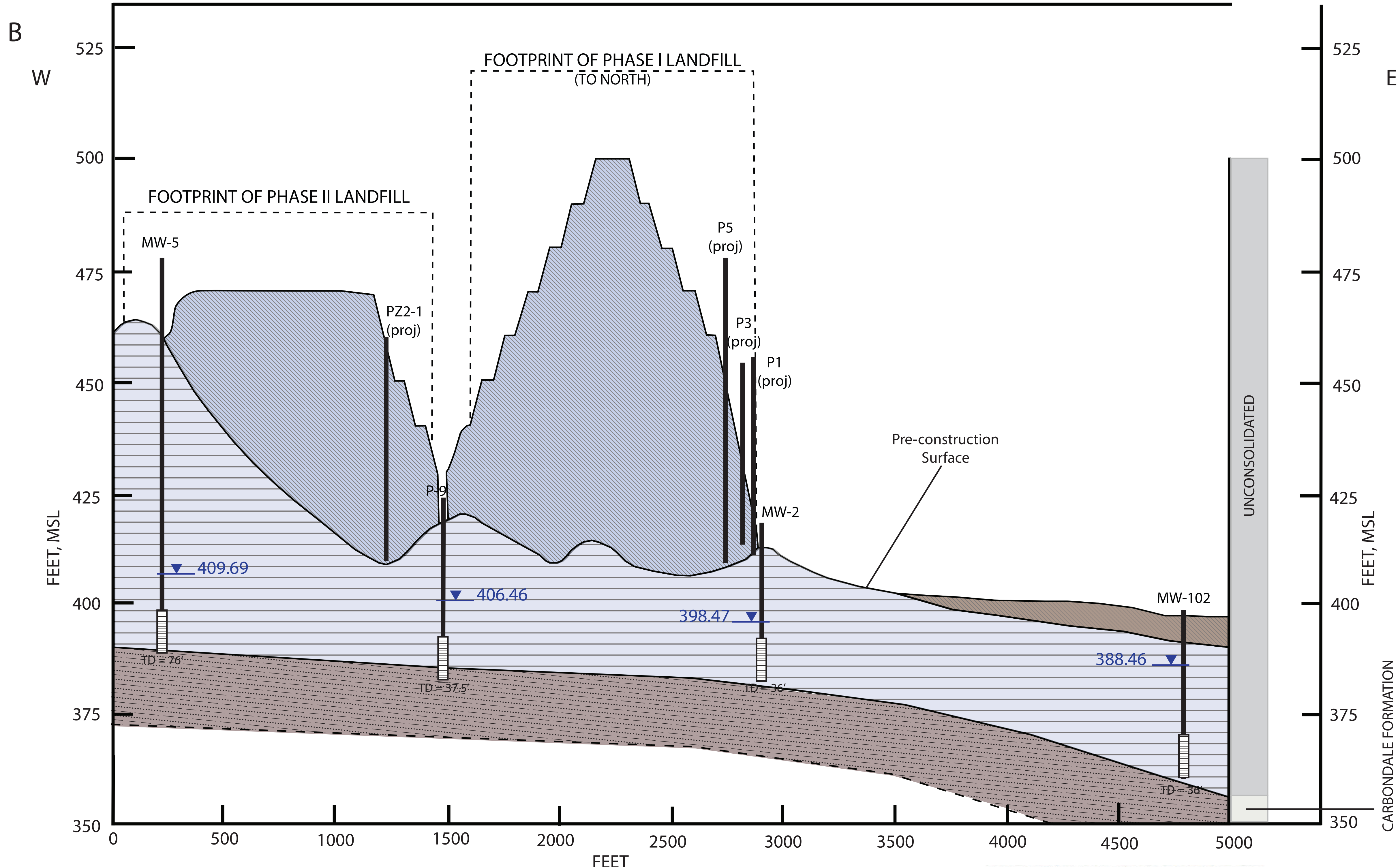


LEGEND

UNCONSOLIDATED MATERIALS:

- CCR Material
- Mine Spoils
- Fill

BEDROCK LITHOLOGIES:

- Interbedded Sandstone and Shale

Potentiometric Surface December 11, 2018

MW-5 — MONITORING WELL LOCATION ID

RISER

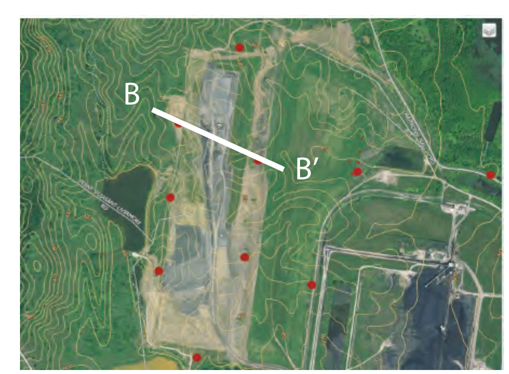
MONITORING WELL SCREEN

BACKFILL / COLLAPSE

25 feet

500 feet

(Vertical Exaggeration = 20x)



Big Rivers ELECTRIC CORPORATION

Wilson Station Landfill
Ohio County, Kentucky

FIGURE 5
CCR GROUNDWATER
MONITORING SYSTEM

DATE: 5/17/2019	SCALE:1 IN = 25 x 500 FEET
CREATED BY: MRH	
JOB NO. 60579935	

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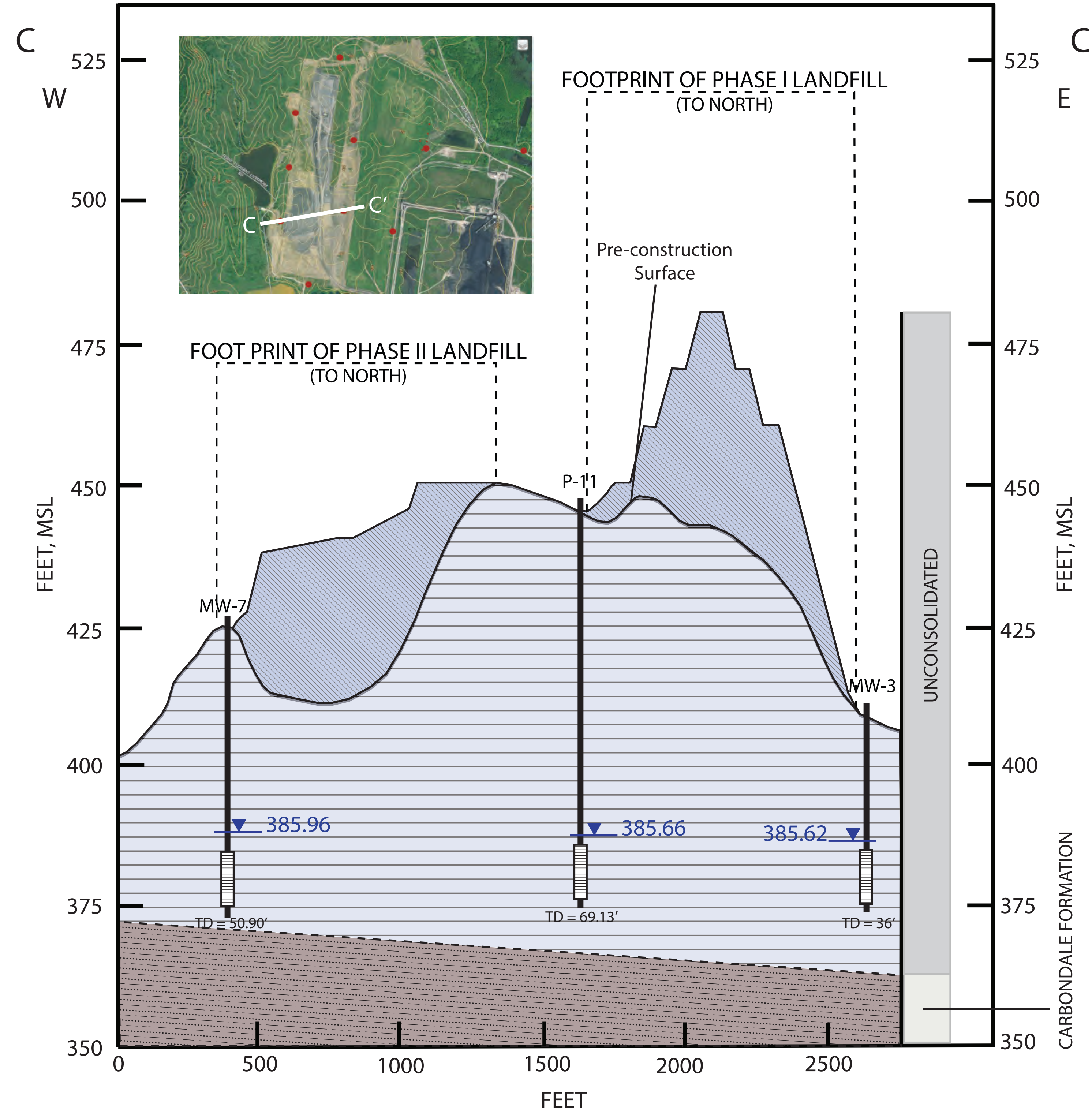

LEGEND

UNCONSOLIDATED MATERIALS: Potentiometric Surface December 11, 2018

CCR Materials

Mine Spoils

BEDROCK LITHOLOGIES:

Interbedded Sandstone and Shale

MW-7 MONITORING WELL LOCATION ID

RISER

MONITORING WELL SCREEN

BACKFILL / COLLAPSE

25 feet

500 feet

(Vertical Exaggeration = 20x)

Big Rivers ELECTRIC CORPORATION

Wilson Station Landfil I
Ohio County, Kentucky

FIGURE 6
CCR GROUNDWATER
MONITORING SYSTEM

DATE: 5/17/2019	SCALE:1 IN = 25 x 500 FEET
CREATED BY: MRH	
JOB NO. 60579935	

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Legend

- Property Boundary
- CCR Phase 2 Landfill Permitted Area
- CCR Phase 2 Landfill (Active)
- KAR Permit Area
- CCR Phase 1 Landfill
- Downgradient CCR Monitoring Well Location
- Upgradient CCR Monitoring Well Location
- Characterization Monitoring Well Location
- Piezometer Location (Water Level Only)
- Monitoring Well Location (Water Level Only)
- Seep
- Water Table Contour (Inferred from Available Monitoring Data)
- Groundwater Flow Direction
- 409.69 Groundwater Elevation (Feet, NAD27) Measured December 11, 2018

0 750 1,500
Feet

Big Rivers Electric Corporation

Wilson Station
Ohio County, Kentucky

FIGURE 7
COC DISTRIBUTION

DATE: 06/04/2019	SCALE: 1IN = 750 FEET
CREATED BY: DAS	
JOB NO. 60602363	

Appendix A

Corrective Measures Technologies and Alternatives Evaluation Process

Appendix A
Corrective Measures Technologies and Alternatives Screening Process

CONTENTS

A1.0 CORRECTIVE MEASURES EVALUATION PROCESS

This appendix describes the overall process used in the selection and screening of corrective measures technologies that are considered potentially applicable to Coal Combustion Residuals (CCR) groundwater impacts. This appendix also describes the process for assembling corrective measures alternatives from one or more applicable technologies and evaluating these alternatives.

A1.1 Potential Remedial Technologies

Section 257.96(c) requires this assessment to include an analysis of the effectiveness of potential corrective measures to meet the objectives for remedies under Section 257.97(b), addressing at least the following:

(1) The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination;

(2) The time required to begin and complete the remedy;

(3) The institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy(s).

The following corrective measures technologies are regarded as potentially applicable to corrective measures for CCR groundwater impact:

- No Action (Included as a baseline case)
- Institutional Controls (ICs)
- Groundwater Monitoring
- Hydraulic Containment
- Physical Containment
- Ex-situ Physical/Chemical/Biological Treatment
- In-situ Physical/Chemical/Biological Treatment
- Permeable Reactive Barriers (PRB)
- Closure in Place (CiP) (of the regulated unit)
- Closure by Removal (CbR) (of the regulated unit)

A brief overview of these technologies is provided below in **Table A1**.

Table A1 – Potential Corrective Measures Technologies

Potential Technology	Description/Overview
No Action	Default baseline approach against which other options are evaluated. No corrective action would be taken to remove, control, mitigate or minimize exposure to impacted media.
Institutional Controls (ICs)	Non-engineering measures, such as administrative and/or legal controls that help to minimize the potential for human exposure to contamination, and/or to protect the integrity of a remedy by limiting land or resource use (United States Environmental Protection Agency [USEPA), *Institutional Control Data Standard* EX000015.1, January 6, 2006).
Groundwater Monitoring	Groundwater monitoring (Assessment and/or Detection modes) to assess effectiveness of corrective measures performance, as well as natural subsurface processes such as dilution, adsorption, and chemical reactions that together serve to reduce inorganic COC concentrations to acceptable levels.
Hydraulic Containment	Hydraulic containment is a common method for remediating groundwater impacted with metals and other inorganics. Groundwater is pumped from wells or collection trenches to aboveground discharge point or to a treatment system that removes the contaminants. The extraction network would be designed to provide hydraulic containment of the impacted groundwater, preventing it from flowing downgradient towards surface water or other receptors.
Physical Containment	Physical barriers are walls constructed below the ground surface to control or restrict the flow of groundwater. They are constructed by injection grouting or by the use of excavator or deep trenching equipment to insert and thoroughly mix a selected amendment to create a homogenized impermeable wall that prevents impacted groundwater from flowing downgradient. The bottom of the physical containment structure is typically keyed into a low-permeability soil or bedrock (confining layer) to keep groundwater from seeping beneath the wall. To provide hydraulic control of the impacted groundwater behind (upgradient of) the physical barrier and to prevent impacted water from flowing around the edges of the wall, extraction wells would be installed behind the vertical barrier (VB) and the extracted groundwater processed through a treatment system.
Ex-situ Physical/Chemical/Biological Treatment	Ex-situ treatment requires pumping of groundwater and engineering for equipment, possible permitting, and material handling. Physical/chemical treatment uses the physical properties of the contaminants or the contaminated medium to destroy (i.e., chemically convert), separate, or contain the contamination. Physical/chemical treatment can be completed in short time periods (in comparison with biological treatment). Equipment is readily available. Treatment residuals from separation techniques will require treatment or disposal.

Potential Technology	Description/Overview
In-situ Physical/Chemical Treatment	With in-situ treatment, groundwater is treated without being brought to the surface. In-situ processes, however, generally require longer time periods. Physical/chemical treatment uses the physical properties of the contaminants or the contaminated medium to destroy (i.e., chemically convert), or separate the contamination.
Permeable Reactive Barriers (PRB)	A PRB is a constructed subsurface barrier designed to intercept groundwater flow and react with the entrained COCs. PRBs can be established through trench injection or direct-push injection (on closely spaced grids) of reactive material. PRBs are typically installed to the depth of impacted groundwater (often the bottom of the shallow aquifer) and along the length of the impacted zone. The amendment used to generate the PRB is generally permeable as or more permeable than the surrounding material, encouraging impacted groundwater to flow through the reactive material. The reactive material then causes chemical reactions to occur, resulting in adsorption, precipitation, or degradation of the COC. PRBs are commonly used to control organic contamination in groundwater and have been successfully used to remediate metals.
Closure in Place (CiP) (of the regulated unit)	Landfill caps can be installed to minimize generation of leachate and to minimize infiltration into underlying waste. Landfill caps also may be applied to waste masses that are so large that other treatment is impractical. By providing a suitable base for the establishment of vegetation. In conjunction with water diversion and detention structures, landfill caps may be designed to route surface water away from the waste area while minimizing erosion
Closure by Removal (CbR) (of the regulated unit)	Removal of contaminated media for disposal in off-site facility or alternate on-site facility. Media would likely require characterization for proper disposal. Pre-treatment may be necessary to meet land disposal restrictions (LDRs). Once excavated, confirmatory samples would be collected to verify clean-up criteria have been met; the excavation would then be backfilled and covered.

References: Technology descriptions referenced from 1) FRTR: Federal Remediation Technologies Roundtable, CLU-IN, and/or AECOM reference materials.

A1.2 Other Source Control Technologies

In addition to the groundwater corrective measures technologies summarized above, CCR impacts are also mitigated through a variety of engineering measures, including leachate collection, lining of trenches and/or ponds, and other isolation methods for source control.

A1.3 No Action

No Action is included in the evaluation as a baseline against which other technologies are evaluated. With this option, no corrective action would be taken to remove, control, mitigate or minimize exposure to impacted media. In the event that the other identified alternatives do not offer substantial benefits, No Action is the default baseline approach.

Under this alternative, existing impacted media (i.e., CCR materials and impacted soil/groundwater along the exposure pathway) would remain. No capital costs would be incurred, and no cleanup standards would be considered.

No Action does not meet the performance requirement of attaining the established Corrective Action Objective (CAO). Although implementation would be very easy, the required state approval for "No Action" would likely not occur. Safety impacts, cross-media impacts, and residual CCR exposure control would be no different from current conditions. Therefore, No Action is not an appropriate standalone technology. However, it is retained for use as a baseline against which other technologies and alternatives are evaluated.

A1.4 Institutional Controls (ICs)

The potential use of ICs is considered the least aggressive corrective action technology for CCR impacts.

ICs would not change the concentration or mobility of COCs and therefore would not meet the performance requirement of attaining the established CAO as a standalone technology unless it can be demonstrated that impacted groundwater is not leaving the facility. ICs would be used in combination with other corrective measures to limit human exposures and would be easy to implement, consisting of preparation and recording of Environmental Restrictive Covenants [ERC(s)]. Safety impacts and cross-media impacts would be identical to current conditions. Because ICs would control exposure and thus enhance protection of human health and the environment, the use of ICs can be a component of corrective measures alternatives. The use of ICs as a standalone technology will not be considered.

A1.5 Groundwater Monitoring

The use of groundwater monitoring is only applicable for dissolved-phase groundwater impacts, and it will take place in Assessment and/or Detection modes as appropriate for the current phase of CCR activity. Groundwater monitoring is not a standalone technology, but instead will be combined with other remedial technologies in order to track progress of the overall remedy, which also incorporates natural attenuation processes.

The use of groundwater monitoring as a stand-alone corrective measures technology will not be considered; instead the incorporation of groundwater monitoring in conjunction with other technologies will be used to monitor effectiveness of a given corrective measures alternative to attain the CAO at points immediately downgradient over an extended period of time. Data reliability is controlled by adherence to the site's groundwater monitoring plan. Implementation of the existing groundwater monitoring plan is easy because it is currently underway. Safety impacts are minimized by use of the existing Health and Safety Plan and there are no construction activities required. There are no cross-media impacts or institutional requirements, nor is there any residual CCR exposure control.

A1.6 Hydraulic Containment

The use of hydraulic containment as a potential remedial technology is considered. The use of groundwater extraction can be effective at hydraulically controlling long-term downgradient dissolved phase impacts.

Hydraulic containment through groundwater extraction and subsequent treatment has historically been a common method for management of groundwater impacted with metals and other inorganics. Groundwater is pumped from wells (vertical or horizontal) or collection trenches to a discharge point (e.g., a permitted outfall) or to an aboveground treatment system. The extraction network would be designed, constructed and operated to provide a hydraulic barrier between the impacted groundwater and the migration pathway to potential receptors.

Hydraulic containment through groundwater extraction and subsequent treatment has historically been a common method for management of groundwater impacted with metals and other inorganics. Groundwater is pumped from wells (vertical or horizontal) or collection trenches to a discharge point (e.g., a permitted outfall) or to an aboveground treatment system. The extraction network would be designed, constructed, and operated to provide a hydraulic barrier between the impacted groundwater and the migration pathway to potential receptors.

This technology attains the established CAO because hydraulic containment rapidly eliminates the offsite migration of impacted groundwater, thereby eliminating the exposure pathway. Performance and reliability would be controlled by adherence to the operations and maintenance plan prepared for the extraction and treatment systems. Implementation would be difficult because of areas of limited access for drilling equipment and uneven groundwater flow in the uppermost aquifer materials that consist of interbedded sandstone and shale having hydraulic conductivity values spanning several orders of magnitude. Potential safety impacts during construction, operation, and maintenance of the system would be mitigated by health and safety plans prepared for these tasks. There would be no cross-media impacts. Hydraulic containment will reduce mobility due to COCs capture provided by the groundwater extraction system and treatment to remove COCs from the environment. The time period for CAO attainment may be relatively short, but system operation will need to continue until CCR source loading of COCs to groundwater ceases. For institutional requirements, treated discharge would occur under existing or modified National Pollution Discharge Elimination System (NPDES) permit.

Based on the preliminary screening, hydraulic containment is a potentially viable corrective measures technology and will be retained for further consideration.

A1.7 Physical Containment

The use of physical containment to isolate the impacted materials associated with a CCR unit is considered. Physical containment typically consists of a barrier or wall (i.e., slurry wall, sheet pile wall, or injection grouting) constructed below the ground surface to control or restrict the flow of groundwater. The barrier is typically constructed by excavators and/or deep trenching equipment that thoroughly mix bentonite/cement slurry to create a homogenized impermeable wall, or by driving sheet pile. The construction of the barrier would prevent impacted groundwater from flowing downgradient. Where possible, the bottom of the barrier would be keyed into the low-permeability soil or bedrock (confining layer) at the bottom of the aquifer, keeping groundwater from seeping beneath it. To provide hydraulic control of the impacted groundwater behind the barrier and prevent impacted water from flowing around the edges, a hydraulic containment system would be installed behind the wall. Extracted groundwater would then be discharged or processed through a groundwater treatment system, as needed. Extraction flow rates for this option will generally be lower than in a standalone hydraulic containment option, because the pumping rates will only need to accommodate natural groundwater flow rates, rather than providing a hydraulic barrier. However, pumping would need to be performed indefinitely to maintain water levels behind the barrier. It is also noted that physical barriers can also be utilized in a funnel-and-gate arrangement to direct the flow of groundwater to a small, more permeable area (i.e., the gate) where reactive material can be used to treat the metals in-situ. The “gate” can also be configured as a single extraction point for impacted groundwater directed to it by the “funnel.”

This technology attains the established CAO after combined physical and hydraulic containment eliminates the offsite migration of impacted groundwater, thereby eliminating the exposure pathway. In the long term, this technology will maintain compliance with the established CAO after final cover construction at the Phase II Landfill, which will end the source loading to the groundwater, and groundwater flushes through the aquifer. Performance and reliability would be controlled by adherence to the operations and maintenance plan prepared for the extraction and treatment systems. The technology would pose substantial challenges to the installation and operation of the physical barrier such as areas of limited access and highly variable depths to bedrock. Potential safety impacts during construction, operation, and maintenance of the system would be mitigated by health and safety plans prepared for these tasks. Cross-media impacts include the potential for airborne fugitive dust issues during construction, which would be mitigated by construction contingency planning. The time period for attainment is based on construction of the barrier. For institutional requirements, treated discharge would occur under existing or modified National Pollution Discharge Elimination System (NPDES) permit.

Based on the preliminary screening, physical containment is potentially viable as a potential corrective measures alternative component, especially when combined with supplemental groundwater extraction and treatment.

A1.8 Ex-Situ Physical/Chemical/Biological Treatment

Ex-situ treatment requires the use of groundwater extraction with related engineering, equipment, permitting, and material handling necessary to convey the waste stream to above-ground treatment. Treatment technologies would be designed to remove the specific constituents from groundwater to meet regulatory discharge requirements; treatment options for the varied constituents may include pH adjustment, filtration, coagulation/chemical precipitation, membrane filtration, ion exchange, carbon adsorption, reverse osmosis, chemical reduction, and other potential treatment technologies. Multiple treatment technologies would potentially be needed to effectively remove the different types of contaminants. If this technology is incorporated into a corrective action alternative, further detailed evaluation and/or bench- and pilot-scale studies would be necessary to identify technically effective treatment technologies given the inorganic COCs.

This is not a standalone technology but would be used in combination with hydraulic containment. System reliability would be controlled by adherence to an operation and maintenance plan prepared for the system. Implementation is expected to be straightforward based on well-established water treatment principles and experience. Potential safety impacts during construction, operation, and maintenance of the system would be mitigated by health and safety plans prepared for these tasks. There would be no cross-media impacts, nor would there be exposure to residual CCR materials. The time period for attainment is based on performance of the overall corrective measure, of which ex-situ treatment would be a component. For institutional requirements, treated discharge would occur under existing or modified National Pollution Discharge Elimination System (NPDES) permit.

Based on the preliminary screening, ex-situ treatment is a potentially viable corrective measures technology and will be retained for further consideration.

A1.9 In-Situ Physical/Chemical/Biological Treatment

For the inorganic COCs at CCR site, in-situ treatment involves enhancement of natural attenuation processes such as dilution, adsorption, and chemical reactions to reduce concentrations to acceptable levels. This technology is appropriate for site in which groundwater flow volumes are low, source controls are effective, and impacted groundwater is not expected to be long-lived. If this technology is incorporated into a corrective action alternative, further detailed evaluation and/or bench- and pilot-scale studies would be necessary to identify effective in-situ treatment amendments for the COCs.

Based on the preliminary screening, in-situ treatment is a potentially viable corrective measures technology and will be retained for further consideration.

A1.10 Permeable Reactive Barriers (PRB)

A PRB is an in-situ treatment method consisting of subsurface trench filled with reactive material installed to intercept and react with impacted groundwater. PRBs can be established through direct-push injection (on closely spaced grids) or emplaced as a continuous trench of reactive material. PRBs are typically installed to the depth of impacted groundwater (often the bottom of the shallow aquifer) and are oriented perpendicular to the flow of impacted groundwater. The amendment used to generate the PRB is generally as permeable as or more permeable than the surrounding material, encouraging impacted groundwater to flow through the reactive material. The reactive material then causes chemical reactions to occur within the PRB, resulting in adsorption, precipitation, or degradation.

PRBs are commonly used to control organic contamination in groundwater, and have been successfully used to remediate some metals. Bench-scale, column, and pilot testing processes are likely necessary for the design of a PRB to determine the effectiveness of the treatment zone(s).

Based on the preliminary screening, PRB is a potentially viable corrective measures technology and will be retained for further consideration.

A1.11 Closure-in-Place (CiP) [of the regulated unit]

CiP would entail capping and restoration of the unit that contains the CCR material. Capping would minimize infiltration into the CCR material, thereby minimizing the potential for leachate to impact underlying soil and shallow groundwater. Capping would reduce potential exposure pathways and thus enhance protection of human health and the environment.

CiP will help attain the established CAO after final cover construction ends the source loading to the groundwater, and impacted groundwater flushes through the aquifer. This technology is easily implemented, as CiP is required by conditions of the solid waste permit and re-design of the southern storm water pond requires nominal engineering and construction efforts. Potential safety impacts during construction, operation, and maintenance of the final cover are governed by conditions of the solid waste permit and are mitigated by health and safety plans prepared for these tasks. There are no cross-media impacts associated with CiP, and it will provide for significant reduction in mobility of COCs upon implementation of the CiP source control. Final cover for the Phase II Landfill is anticipated as part of facility operations. Institutional requirements will consist of solid waste permit renewal(s) and state and community acceptance of the final remedy.

Based on the preliminary screening, CiP is a potentially viable corrective measures technology and will be retained for further consideration.

A1.12 Closure by Removal (CbR) [of the regulated unit]

CbR is a proven remedy that can effectively remove the source of contamination. The excavation of impacted CCR material would typically be completed using standard construction equipment (e.g., backhoe, excavator, wheel loader, dump trucks). The excavated materials are then placed directly into dump trucks for transport/disposal or beneficial use. Excavation limits would typically be verified with confirmation sampling to demonstrate that the underlying soil is not impacted above applicable standards.

This technology would help attain the established CAO after CCR removal ends and the source loading to groundwater is eliminated. This technology would be difficult to implement, because of the large-scale construction effort required and resulting disruption to station operations and community impact. Potential safety impacts during excavation and backfilling would be mitigated by health and safety planning. However, the volume of truck traffic for waste and fill hauling would be a significant community safety issue. Potential airborne fugitive dust issues during excavation and hauling would be significant, but would be mitigated by construction contingency planning. CbR will eliminate exposure through removal of the CCR. CbR would begin following state and community approvals, and duration of excavation activities is anticipated to be many years. In addition to state and community acceptance of the proposed remedy, excavation and backfilling may require local building permits and local municipality input and approval. Excavation dewatering discharge would occur under existing or modified NPDES permit.

Based on the preliminary screening, CbR is a potentially viable corrective measures technology and will be retained for further consideration.

A1.13 Screened Corrective Measures Technologies Summary

A summary of the results of the corrective measures technologies screening is presented below in **Table A2**. The design and specific application of the retained technologies, either as stand-alone or part of a treatment train, will be crucial in the success of the corrective action.

Table A2 – Screened Corrective Measures Technologies

Potentially Applicable Technology	Status	Description/Overview
No Action	Not retained as standalone technology, but carried forward for baseline comparisons	This technology has been included in the preliminary evaluation/screening but is not retained because it will not meet the established CAOs.
Institutional Controls (ICs)	Retained as supplement to corrective measures alternatives	The use of ICs (i.e., Environmental Covenant, groundwater use restrictions, etc.) is retained as a useful technology. However, it is noted the ICs are not anticipated to be used as a stand-alone technology. Environmental Covenants, groundwater use restrictions, etc., are expected to be combined with other applicable technologies as part of corrective measures alternatives.
Groundwater Monitoring (Assessment and Detection mode)	Retained as supplement to corrective measures alternatives	The use of groundwater monitoring (Assessment and/or Detection modes as appropriate) when combined with other applicable technologies as part of any proposed corrective measures alternative is retained to address the CAO and to track the effectiveness of the overall remedy. However, it is not retained as a standalone technology.
Hydraulic Containment	Retained	The use of hydraulic containment is retained because it is an effective means of preventing offsite migration of soluble contaminants. Hydraulic containment requires management and potential ex-situ treatment of extracted groundwater, so it is not a stand-alone technology. The Conceptual Site Model (CSM) will guide the design of any groundwater extraction system to optimize the total discharge of groundwater needed to provide hydraulic containment.
Physical Containment	Retained	The use of physical containment is retained because it can be an effective means of managing groundwater flow. Physical containment often requires pairing with hydraulic containment and/or in-situ treatment (funnel and gate style) to manage the flux of groundwater flow into the system. The CSM will guide the design of any physical barrier system, but technology limitations increase the difficulty with scale.

Potentially Applicable Technology	Status	Description/Overview
Ex-situ Physical/Chemical/Biological Treatment	Retained	Ex-situ treatment technologies are retained as a way of removing contaminants from extracted groundwater from a hydraulic containment system. Ex-situ treatment may be paired with wastewater treatment, non-groundwater release treatment systems, or with permitted discharge to manage groundwater contamination. The CSM and data gaps investigations will guide the design of any ex-situ treatment
In-situ Physical/Chemical Treatment	Retained	In-situ treatment technologies are retained for circumstances in which groundwater flow volumes are particularly low, source controls are effective, COCs are amenable to treatment, and impacted groundwater is not expected to persist as a treatment demand. The CSM and data gaps investigations will guide the design of any in-situ treatment
Permeable Reactive Barriers (PRB)	Retained	The use of PRBs is retained for circumstances in which groundwater flow volumes are particularly low or in which they can be paired with physical containment to achieve passive management of impacted groundwater. The CSM, as well as bench and pilot-scale testing will guide the design of any PRB system.
Closure in Place (CiP) (of the regulated unit)	Retained	The use of CiP as a source control technology and is amenable with respect to CAO attainment.
Closure by Removal (CbR) (of the regulated unit)	Retained	The use of CbR as a source control technology is amenable with respect to CAO attainment.
Other Source Control Technologies	Retained	Control of source area non-groundwater (i.e., leachate seeps) related releases. For the purposes of this groundwater ACM, management of non-groundwater releases are not included in the alternatives evaluation. Engineering measures, including seepage/leachate collection, lining of trenches and/or ponds, and other isolation methods are regarded as part of operational practices and/or closure technologies selected by other means for the site.

References: Technology descriptions referenced from 1) FRTR: Federal Remediation Technologies Roundtable, CLU-IN, and/or AECOM reference materials.

A2.0 CORRECTIVE MEASURES ALTERNATIVES

Corrective measures technologies from the initial screening and evaluation (see **Table A2**) were utilized to create corrective measures alternatives. Professional judgment was used to assemble technically efficient pairings of technologies for each corrective measures alternative in consideration of the range of site-specific COCs and concentrations.

The corrective measures alternatives typically incorporate the use of technologies that will require additional investigation needed to 1) finalize the alternative selection, 2) delineate the assumed corrective action areas, 3) provide for full-scale cost estimation and design, and 4) demonstrate alternative efficacy. To this end, data gaps will be identified and addressed as needed.

It should be emphasized that the technology screening and alternatives assembly employed for this ACM is qualitative in nature. The formal remedy selection process, in accordance with the CCR Rule 40 CFR Section 257.97, will begin following submission of the ACM Report. The subsequent remedy selection process will evaluate the following objectives for remedies, as required under Section 257.97(b):

- Protect human health and the environment;
- Attain the COC-specific GWPSs as specified pursuant to Section 257.95(h);
- Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of Appendix IV constituents into the environment;
- Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems (applicable to material releases only); and
- Comply with standards for management of wastes as specified in Section 257.98(d).