REMEDY SELECTION PROGRESS REPORT

REID/HMP&L SURFACE IMPOUNDMENT
SEBREE GENERATING STATION
WEBSTER COUNTY, KENTUCKY

December 9, 2019

Prepared For:

Big Rivers Electric Corporation
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1.0 INTRODUCTION

In accordance with provisions of the United States Environmental Protection Agency's (USEPA) coal combustion residual (CCR) rule, Title 40 of the Code of Federal Regulations (CFR) Section 257.97, Big Rivers Electric Cooperation (BREC) is in the process of selecting a remedy for groundwater impacts at the Reid/Henderson Municipal Power & Light (Reid/HMP&L) Surface Impoundment (the Unit) at the Sebree Generating Station located in Webster County, Robards, Kentucky **(Figure 1)**.

Assessment monitoring results indicate the presence of lithium at a Statistically Significant Level (SSL) above the Ground Water Protection Standard (GWPS) in one monitoring well (MW-10) at the Unit. A map illustrating the site with location of all program monitoring wells is presented as **Figure 2**.

In response to the SSL exceedance, BREC evaluated the nature and extent of groundwater impacts as required by Title 40 CFR Section 257.95(g) for characterization monitoring. In addition, BREC performed an Assessment of Corrective Measures (ACM), to identify applicable remedial technologies to address lithium impacts in groundwater pursuant to Tile 40 CFR Section 257.96. A notice of ACM initiation dated January 14, 2019 was posted to BREC's publicly-accessible CCR reporting website. A report summarizing the results of the ACM (AECOM, June 2019) was posted to BREC's publicly-accessible CCR reporting website on June 14, 2019.

Title 40 CFR Section 257.97(a) requires that progress reports be prepared on a semi-annual basis describing progress made in selecting and designing a remedy. The following sections provide an overview of BREC's activities previously performed, currently underway, and planned in the future to select a remedy that meets the requirement of Title 40 CFR Section 257.97 (b) as follows:

(1) Be protective of human health and the environment;

(2) Attain the GWPS as specified pursuant to Section 257.95(h);

(3) 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;

(4) 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;

(5) Comply with standards for management of wastes as specified in Section 257.98(d).

2.0 SITE BACKGROUND

2.1 Site Description

BREC operates the Sebree Station, which is a coal-fired power generating facility located on the Green River northeast of Sebree, Kentucky. Sebree Station is composed of Green Station and Reid/HMP&L Station. BREC owns Green and Reid Stations, while the City of Henderson owns HMP&L Station 2. The Sebree Station is bounded by Interstate-69 to the west and the Green River to the east (see **Figure 1**). Reid Unit 1 (66 Megawatts) began commercial operation in 1966 and it will be converted from coal to natural gas in the future. The Reid Combustion Turbine (72 MW) was commercialized in 1976. HMP&L Station 2, Units 1 (167 MW) and 2 (168 MW) began commercial operation in 1973 and 1974 respectively. Both HMP&L units were retired as of February 1, 2019. Green Station Units 1 (242 MW) and 2 (242 MW) began commercial operation in 1979 and 1981, respectively.

The location of the Reid/HMP&L Station Surface Impoundment is illustrated in **Figure 2**. The Surface Impoundment has been in place for more than 40 years and is used for the placement of CCR material. As stated in the published CCR monitoring well network certification, available on the BREC website, the Reid/HMP&L Station Surface Impoundment is a combined incised/dike earthen embankment structure. It is diked on the west, south and east sides, while the north side is incised. The south dike has the greatest height, reaching approximately 20 feet. Most of the central portion of the south dike was constructed on a subdued ridge.

2.2 Groundwater Investigation Summary

Monitoring wells were installed around the perimeter of the Unit in December 2015 prior to the implementation of the CCR Rule. These wells meet the requirements of §257.90 of the CCR Rule for installation of a groundwater monitoring system. Under these requirements monitoring wells must adequately represent the quality of background groundwater and groundwater representing the downgradient waste boundary. The existing wells are located along the perimeter of the footprint for the Unit. One upgradient monitoring well (MW-7) and three downgradient monitoring wells (MW-8, MW-9, and MW-10) were installed adjacent to the Unit to determine the general direction of groundwater movement and to monitor groundwater impacts. The monitoring wells were installed in the uppermost saturated portion of the sandstone bedrock aquifer.

Nine rounds of Baseline groundwater sampling was conducted between March 2016 and October 2017. Statistical evaluation of Appendix III constituents monitored 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, upgradient and downgradient wells for the Unit were sampled for Appendix IV constituents in April, July, and September 2018. GWPS were established for Assessment monitoring of the Appendix IV constituents, and statistical evaluation indicated exceedances of GWPSs at SSLs, as detailed in **Table 1** below.

Table 1 – Reid/HMP&L Surface Impoundment Constituents of Concern

Monitoring Well (Date)	Parameter
	Lithium GWPS 0.04 (mg/L)
MW-10 (Apr 2018)	**0.694**
MW-10 (Jul 2018)	**0.630**
MW-10 (Sep 2018)	**0.570**

GWPSs are the greater of the site-specific background concentrations, the USEPA primary drinking water standard maximum contaminant limits (MCL), or GWPS provided in 40 CFR 257.95(3)(h)(2)

An additional characterization well, MW-110, was subsequently installed to estimate the downgradient extent of impacted groundwater. Sample collection for Appendix III and IV parameters took place in March and April 2019. The analytical results for lithium in MW-110 were below the GWPS. The additional characterization data are summarized in **Table 2** below.

Table 2 – Reid/HMP&L Surface Impoundment Characterization Sample Results

Monitoring Well (Date)	Parameter
	Lithium GWPS 0.04 (mg/L)
MW-110 (March 2019)	0.0299
MW-110 (April 2019)	0.0303

The results from both characterization sampling events helped to confirm the downgradient (southwestern) extent of COC impacts above GWPS at the Unit.

2.3 Conceptual Site Model

A Conceptual Site Model (CSM) has been developed to support the remedy selection process for groundwater corrective action at the Unit.

2.3.1 Physical Setting

The Unit is located within the Interior Low Plateaus physiographic province. 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 Green, the Ohio, the Kentucky, the Tennessee, and the Cumberland Rivers. The geology underlying the Unit consists of unconsolidated materials, including loess and alluvial deposits, underlain by Upper to Middle Pennsylvanian-age clastics and carbonates consisting primarily of sandstone and shale. The unconsolidated materials also include fill, silty and clayey residuum, and minor amounts of sandy, and clayey channel fill alluvium.

The Unit is located on upland area near the west bank of the Green River. The uppermost edge of the earthen embankment is situated at an elevation of approximately 429 feet above mean sea level (amsl). Although the Green River is located less than 0.5 miles from the site, the structure does not extend significantly into the floodplain. Underlying preconstruction soils consisted of Loring-Grenada, Loring-Zanesville-Wellston (Henderson County) and Loring-Wellston-Zanesville (Webster County) soil associations which are generally characterized as well drained to moderately well drained soils on nearly level to sloping uplands (Associated Engineers 2016, Hydrologic and Hydraulic Capacity Assessment and Initial Inflow Design Flood Control System Plan). The immediate watershed that drains to the unit, and in which the unit is considered to be located, is unnamed and 25.45 acres in size. The unnamed watershed discharges from the Unit outflow structure and is routed, under a Kentucky Pollution Discharge and Elimination System permit, to the Green River.

2.3.2 Geology

The Unit lies in the Western Kentucky Coalfields section of the Interior Low Plateaus physiographic province, characterized by rolling uplands underlain by coal-bearing bedrock of the Pennsylvanian Period. Near the Unit, maximum topographic relief is on the order of 80 feet. The geologic quadrangle (Geologic map of the Robards quadrangle, Henderson and Webster Counties, Kentucky, 1973) for the area published by the Kentucky Geologic Survey (KGS) shows the surficial material in portions of the western half of the Unit to be unconsolidated loess representing the Pleistocene geologic epoch. The loess consists of sandy and clayey silt. Underlying the loess deposits in places are broadly distributed Pleistocene and Holocene alluvium deposits consisting of intermixed and interlensing clay, silt, sand, and gravel. In close proximity to the Unit, the alluvium is generally a low permeability unit that forms terraces along the Green River at elevations of roughly 380 and 395 ft., amsl. The unconsolidated surficial materials range from approximately 24 feet (MW-7) to 47 feet (MW-110) in thickness surrounding the Unit.

The unconsolidated materials are underlain by bedrock of the Upper Pennsylvanian Shelburn Formation [formerly identified as the Lisman Formation (Fairer, 1973)] and the Middle Pennsylvanian Carbondale Formation. At the base of the Shelburn Formation is the Providence Limestone Member, consisting of two distinct limestone beds separated by a sandy shale, but this member is absent in much of the area due to erosional channeling. The underlying 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.

2.3.3 Hydrogeology

For purposes of compliance with the CCR Rule groundwater monitoring requirements, the interbedded sandstone and shale of the Carbondale Formation is considered the uppermost aquifer underlying the Unit. The uppermost aquifer is hydraulically confined and first encountered at an elevation of approximately 413.4 ft., amsl at the northeast end (at MW-7), and 341.6 ft. amsl at the west end of the Unit (at MW-8). Flow direction beneath the Unit is typically to the southwest towards an unnamed tributary to Groves Creek located west/southwest of the impoundment.

Slug tests were performed between April 24, 2019 and April 25, 2019 at monitoring wells MW-10, and MW-110 to assess the hydraulic characteristics of the uppermost aquifer. The estimated hydraulic conductivity of the monitoring wells tested ranged from 3×10^{-6} to 5×10^{-4} centimeters per second (cm/sec).

Although previous site-specific investigations have noted the presence of perched zones of saturation in the overlying unconsolidated materials, these discontinuous zones do not qualify as an uppermost aquifer under the CCR Rule because they do not produce usable quantities of groundwater.

2.3.4 Constituents of Concern (COC)

As discussed above, a single Appendix IV COC (lithium) was detected at concentrations exceeding GWPS in one monitoring well location (MW-10). As a result, the corrective measure evaluation is confined to the area adjacent to this monitoring well.

2.3.5 Potential Receptors/Exposure Pathways

Contact with water (e.g., shallow groundwater or surface water) impacted by COCs at levels above GWPS is regarded as the potential 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 Unit, thus limiting the potential receptors to the surface water, i.e., the Green River and its tributary, Groves Creek. The pathways to these receptors include seepage of water from the Unit through manmade and natural hydraulic barriers.

Other potential exposure pathways (e.g., soil or vapor) are not considered complete as the CCR material is isolated in the Unit. 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).

2.4 Interim Corrective Measures

No interim corrective measures have been performed at the Unit for groundwater impacts.

2.5 Assessment of Corrective Measures Summary

Title 40 CFR Section 257.96(c) requires that the ACM 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; and
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 in **Table 3** 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 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.
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 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.
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.
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.

Potentially Applicable Technology	Status	Description/Overview
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 related releases. For the purposes of this groundwater ACM, management of non-groundwater releases are not included in the alternatives evaluation. Engineering measures, including leachate collection, lining of trenches and/or ponds, and other isolation methods are regarded as part of closure technologies selected by other means.

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 Reid/HMP&L Station Surface Impoundment, five 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), 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, Physical Containment, Ex-Situ Treatment, and Groundwater Monitoring

The assembly of corrective measures alternatives presented in the ACM is considered 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.

3.0 REMEDY SELECTION PROGRESS

Five corrective measure alternatives were identified during the ACM process for potential implementation at the Unit to address groundwater impacts. Each corrective measure alternative consists of one or more corrective measures technologies assembled into a strategy for the groundwater remedy. Each alternative is discussed in more detail below.

3.1 Potential Corrective Action Alternatives

3.1.1 Alternative #1 – No Action and Groundwater Monitoring

Alternative #1 consists of taking no action to address groundwater impacts at the Unit. Under the No Action alternative, no corrective action would be implemented to remove, control, mitigate, or minimize exposure to impacted groundwater. The No Action alternative establishes a baseline or reference point against which each of the corrective measure alternatives is compared.

Since Alternative #1 would not attain the CAOs for the Unit, this alternative would not likely be acceptable to stakeholders. Therefore, Alternative #1 is not recommended for further consideration.

3.1.2 Alternative #2a – Closure in Place (CiP), Institutional Controls (ICs), and Groundwater Monitoring

Alternative #2a as currently envisioned would employ a combination of three corrective measures technologies:

- CiP source control, which consists of planned Reid/HMP&L Surface Impoundment closure activities;
- Implementation of ICs designed to restrict the property to industrial use and to prohibit groundwater use for potable purposes; and
- Groundwater monitoring (Assessment) to document the effectiveness of the corrective measures.

Alternative #2a is recommended for further evaluation.

3.1.3 Alternative #2b – Closure by Removal (CbR), ICs, and Groundwater Monitoring

Alternative #2b as currently envisioned would be similar to Alternative #2a except that CiP is replaced by CbR, which consists of excavation and removal of the Unit. Given that Alternative #2b is likely cost prohibitive, this alternative is not recommended for further consideration.

3.1.4 Alternative #3 – CiP, Hydraulic Containment, Ex-Situ Treatment, ICs, 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 planned Surface Impoundment closure activities;
- 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;
- Implementation of ICs designed to restrict the property to industrial use and to prohibit groundwater use for potable purposes; and
- 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.

Alternative #3 is recommended for further evaluation.

3.1.5 Alternative #4 – CiP, ICs, Physical Containment, Ex-Situ Treatment, and Groundwater Monitoring

Alternative #4 consists of BREC's planned unit closure activities, physical containment of impacted groundwater via installation of a funnel-gate system, and ex-situ treatment of contained groundwater via an extraction well installed at the containment gate. Impacted groundwater would be contained by grout curtain constructed in a funnel-and-gate arrangement that directs the flow of groundwater to an extraction point. The grout curtain would be installed by drilling two lines of grout injection points that extend northwestward and northeastward from the southeast corner of the unit. The length of each limb of the barrier would be 500 feet, and the target depth would be approximately 325 ft-amsl. A single extraction well would be installed at the "gate" with a screened interval of 50 to 100 ft-bgs and a pumping capacity of up to 20 gpm. Groundwater will be pumped and conveyed to an existing surface water impoundment at the Sebree Station, which will allow for compliance with discharge permits through an established NPDES outfall.

CiP via ash stabilization and capping would control the source of COCs and thereby reduce contaminant loading to the extraction system. Concentrations downgradient of the physical barrier would be expected to decrease over time through several natural attenuation mechanisms including advection, dilution, and dispersion. Groundwater Monitoring (Assessment) would continue to track the effectiveness of the corrective measures and to identify conditions that allow the return to Detection monitoring and ultimately

Alternative #4 is recommended for further evaluation.

3.2 Remedy Evaluation

Currently BREC considers three (3) potential corrective action alternatives as viable options to address groundwater impacts at the Unit, including:

- Alternative #2a;
- Alternative #3; and
- Alternative #4;

To evaluate each alternative, additional data collection will likely be required. BREC is currently evaluating data collection needs in the following areas to assist with remedy selection:

1) Nature and Extent – groundwater trends, influence of non-groundwater remedies, etc.

2) Physical Characteristics – available data on the physical characteristics of the landfill and retention pond
3) Performance Modeling – data needed to develop digital models demonstrating the effectiveness of potential alternatives
4) Engineering – feasibility, cost estimates, etc.

BREC is working to establish a comprehensive list of data collection needs to proceed forward with remedy evaluation and anticipates providing additional data in future semi-annual remedy selection progress reports.

4.0 CONCLUSION

Additional updates regarding remedy selection, including any additional corrective measures being considered, will be presented twice a year in future remedy selection progress reports. Once sufficient data has been collected to select an effective comprehensive remedy for the Unit, a public meeting will be held 30 days prior to formal remedy selection, followed by a detailed Remedy Selection Report describing the remedy and proposed schedule for implementation.

If needed, the next remedy selection progress report for the Unit is expected in June 2020.

5.0 REFERENCES

AECOM, 2018. Annual Groundwater Monitoring and Corrective Action Report, 2016-2017; Reid/HMP&L Station Surface Impoundment, Webster County, Kentucky.

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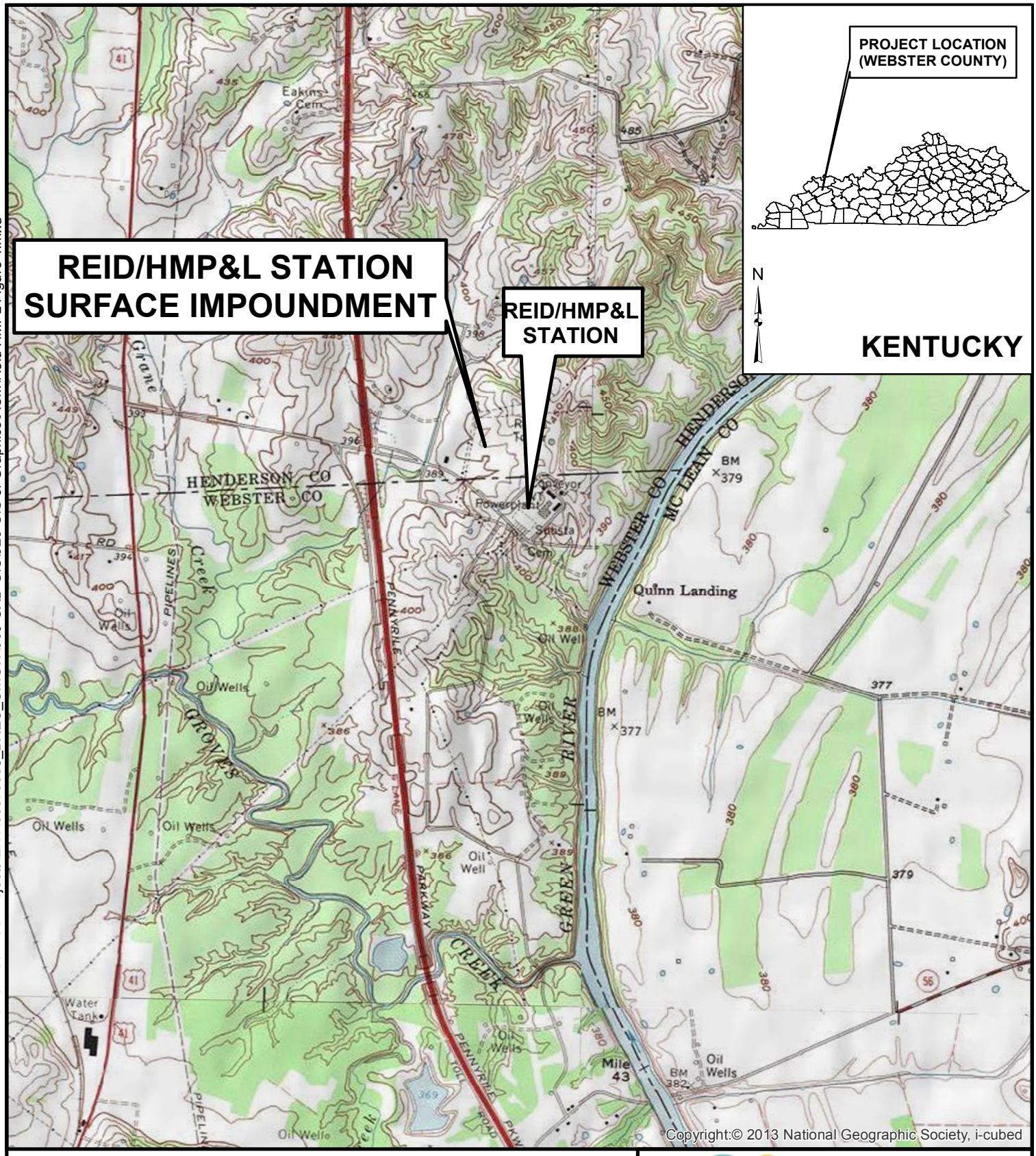
Figures



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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

ROBARDS QUADRANGLE
DELAWARE QUADRANGLE
(FROM ARCGIS ONLINE Copyright:© 2011 National Geographic Society, i-cubed)

0 2,000 4,000 Feet

N

Big Rivers ELECTRIC CORPORATION

Reid/HMPL Station
Webster County, Kentucky

FIGURE 1
SITE LOCATION MAP

DATE: 4/30/2019	SCALE: 1IN = 2,000 FEET
CREATED BY: ALW	
JOB NO. 60602365	

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Legend

- Unit Boundary
- Property Line
- Downgradient CCR Monitoring Well
- Upgradient CCR Monitoring Well
- Characterization Well

0 300 600

Feet

N

Big Rivers Electric Corporation

Reid/HMPL Station
Webster County, Kentucky

FIGURE 2
WELL LOCATION MAP

DATE: 12/9/2019	SCALE: 1IN = 200 FEET
CREATED BY: ALW	
JOB NO. 60602365	

REMEDY SELECTION PROGRESS REPORT

GREEN LANDFILL
SEBREE STATION
WEBSTER COUNTY, KENTUCKY

December 9, 2019

Prepared For:

Big Rivers Electric Corporation
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In accordance with provisions of the United States Environmental Protection Agency's (USEPA) coal combustion residual (CCR) rule, Title 40 of the Code of Federal Regulations (CFR) Section 257.97, Big Rivers Electric Cooperation (BREC) is in the process of selecting a remedy for groundwater impacts at the Green Station CCR Landfill (the Unit) at the Sebree Generating Station located in Webster County, Robards, Kentucky **(Figure 1)**.

Assessment monitoring results indicate the presence of lithium at a Statistically Significant Level (SSL) above the Ground Water Protection Standard (GWPS) in four monitoring wells (MW-3A, MW-4, MW-5, and MW-6) at the Unit. A map illustrating the site with location of all program monitoring wells is presented as **Figure 2**.

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2.0 SITE BACKGROUND

2.1 Site Description

BREC owns and operates Sebree Station, which is a coal-fired power generating facility located on the Green River northeast of Sebree, Kentucky. Sebree Station is composed of Green Station and Reid/Henderson Municipal Power & Light (HMP&L) Station. The Sebree Station is bounded by Interstate-69 to the west and the Green River to the east (see **Figure 1**). Reid Unit 1 (66 Megawatts [MW]) began commercial operation in 1966 and it will be converted from coal to natural gas in the future. The Reid Combustion Turbine (72 MW) was commercialized in 1976. HMP&L Station 2, Units 1 (167 MW) and 2 (168 MW) began commercial operation in 1973 and 1974 respectively. Both HMP&L units were retired as of February 1, 2019. Green Station Units 1 (242 MW) and 2 (242 MW) began commercial operation in 1979 and 1981, respectively.

The location of the Green Landfill is illustrated on **Figure 1**. The Green Landfill is located directly south of Sebree Station, situated south of the Green Station CCR Surface Impoundment. The Green Landfill is a Kentucky permitted landfill (Permit No. SW11700007) that receives special wastes generated by burning coal (CCRs) from Green and Reid/HMP&L Stations. The landfill began receiving CCR wastes in 1980. The current Green Landfill footprint is approximately 170 acres.

As stated in the published CCR monitoring well network certification, available on the BREC website (http://www.bigrivers.com/), the original ground surface within the landfill footprint was irregular and the dominant features were small stream valleys draining towards the Green River, which is located just east of the landfill; and towards Groves Creek, which is located just south of the landfill. There was also historic oil and gas production at and in the immediate vicinity of the Green Landfill. A review of the records from the Kentucky Geological Survey (KGS) showed that at or immediately adjacent to the Site, there were a number of dry exploratory oil/gas exploration holes, oil production wells, one gas production well, and one secondary recovery injection well. There were also former brine ponds at the Site. Most of these wells were abandoned in accordance with applicable regulations by BREC in 1997 and 1998. The last existing oil well was decommissioned in 2019.

2.2 Groundwater Investigation Summary

Monitoring wells were installed at the Unit beginning in November 1996 prior to the implementation of the CCR Rule. However, the existing wells meet the requirements of Title 40 CFR Section 257.90 of the CCR Rule for installation of a groundwater monitoring system. These requirements are that wells must adequately represent the quality of background groundwater and groundwater representing the downgradient waste boundary. The existing wells are located along the perimeter of the landfill footprint (**Figure 2**). One upgradient monitoring well (MW-1) and five downgradient monitoring wells (MW-2, MW-3A, MW-4, MW-5 and MW-6) were installed at the Unit to determine the general direction of groundwater movement and to monitor groundwater impacts. The monitoring wells were installed in the uppermost saturated portion of the sandstone bedrock aquifer.

Nine rounds of Baseline groundwater sampling for Appendix III constituents were conducted between March 2016 and October 2017. Statistical evaluation for Detection monitoring indicated that SSIs over background had 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).

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monitoring of the Appendix IV constituents, and statistical evaluation indicated exceedances of GWPSs at SSLs, as detailed in **Table 1** below.

Table 1 Green Station CCR Landfill Constituents of Concern

Monitoring Well (Date)	Parameter
	Lithium GWPS 0.04 (mg/L)
MW-3A (Jun 2018)	**0.699**
MW-3A (Jul 2018)	**0.790**
MW-3A (Sep 2018)	**0.766**
MW-4 (Jun 2018)	**1.81**
MW-4 (Jul 2018)	**1.91**
MW-4(Sep 2018)	**1.81**
MW-5(Jun 2018)	**0.459**
MW-5 (Jul 2018)	**0.481**
MW-5 (Sep 2018)	**0.425**
MW-6 (Jun 2018)	**0.0650**
MW-6 (Jul 2018)	**0.0590**
MW-6 (Sep 2018)	**0.0558**

GWPSs are the greater of the site-specific background concentrations, the USEPA primary drinking water standard maximum contaminant limits (MCL), or GWPS provided in 40 CFR 257.95(3)(h)(2)

An additional characterization well, MW-104, was subsequently installed to estimate the downgradient extent of impacted groundwater. Sample collection for Appendix III and IV parameters took place in March and April 2019. The analytical results for lithium were below the GWPS. The additional characterization data are summarized in **Table 2** below.

Table 2 – Green Station CCR Landfill Characterization Sample Results

Monitoring Well (Date)	Parameter
	Lithium UPL 0.008 GWPS 0.04 (mg/L)
MW-104 (March 2019)	0.0281
MW-104 (April 2019)	0.0288

The results from both characterization sampling events helped to confirm the downgradient (southwestern) extent of COC impacts above GWPS at the Green Landfill. However, downgradient characterization is limited due to the presence of the Green River immediately adjacent to the Unit.

2.3 Conceptual Site Model

A Conceptual Site Model (CSM) has been developed to support the remedy selection process for groundwater corrective action at the Unit.

2.3.1 Physical Setting

The Unit is located within the Interior Low Plateaus physiographic province. 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 Green, the Ohio, the Kentucky, the Tennessee, and the Cumberland Rivers. The geology underlying the Unit consists of unconsolidated materials, including loess and alluvial deposits, underlain by Upper to Middle Pennsylvanian-age clastics and carbonates consisting primarily of sandstone and shale. The unconsolidated material also include fill, silty and clayey residuum, and minor amounts of sandy, clayey channel fill alluvium.

The Unit is located on an upland adjacent to the west bank of the Green River at an elevation of approximately 436 feet, above mean sea level [ft., amsl] (at the north end of the landfill) and 397 ft., amsl (at the south end of the landfill), with a maximum elevation of 608 ft., amsl at the landfill crest. Precipitation falling within the Green Landfill is directed to ponds on the north and south sides of the Unit and then to the river under Kentucky Pollution Discharge and Elimination System permit. Underlying preconstruction soils consisted of Loring-Grenada, Loring-Zanesville-Wellston (Henderson County) and Loring-Wellston-Zanesville (Webster County) soil associations which are generally characterized as well drained to moderately well drained soils on nearly level to sloping uplands (Associated Engineers 2016, Hydrologic and Hydraulic Capacity Assessment and Initial Inflow Design Flood Control System Plan). The Unit does not have a leachate collection and management system, although systems are being constructed as part of Interim Corrective Measures for non-groundwater impacts.

2.3.2 Geology

The Unit lies in the Western Kentucky Coalfields section, characterized by rolling uplands underlain by coal-bearing bedrock of the Pennsylvanian Period. Near the Unit, maximum topographic relief is on the order of 80 feet. The geologic quadrangle (Geologic map of the Robards quadrangle, Henderson and Webster Counties, Kentucky, 1973) for the area published by the Kentucky Geologic Survey (KGS) shows the surficial material in portions of the western half of the Unit to be unconsolidated loess representing the Pleistocene geologic epoch. The loess consists of sandy and clayey silt. Underlying the loess deposits and exposed at the surface on the eastern half of the Unit are broadly distributed Pleistocene and Holocene alluvium deposits consisting of intermixed and interlensing clay, silt, sand, and gravel. In close proximity to the Unit, the alluvium is generally a low permeability unit that forms terraces along the Green River at elevations of roughly 380 and 395 ft., amsl. The unconsolidated surficial materials range from approximately 10 feet (MW-5) to 52 feet (MW-104) in thickness surrounding the Unit.

The unconsolidated materials are underlain by bedrock of the Upper Pennsylvanian Shelburn Formation [formerly identified as the Lisman Formation (Fairer, 1973)] and the Middle Pennsylvanian Carbondale Formation. At the base of the Shelburn Formation is the Providence Limestone Member, consisting of two distinct limestone beds separated by a sandy shale. The member is exposed in a streambed near the northwest corner of the Unit but is absent over much of the Unit footprint due to erosional channeling. The underlying 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.

2.3.3 Hydrogeology

For purposes of compliance with the CCR Rule groundwater monitoring requirements, the interbedded sandstone and shale of the Carbondale Formation is considered the uppermost aquifer underlying the Unit. The uppermost aquifer is hydraulically confined and first encountered at an elevation of approximately 401 ft., amsl at the northwest end of the landfill, and 367 ft., amsl at the southeast end of the landfill (AECOM, 2019). Flow direction beneath the Unit is typically southeast towards the Green River.

Slug tests were performed on April 25, 2019 at monitoring wells MW-3A, MW-4, MW-6, and MW-104 to assess the hydraulic characteristics of the uppermost aquifer. The estimated hydraulic conductivity of the monitoring wells tested ranged from $2x10^{-5}$ to $3x10^{-3}$ centimeters per second (cm/sec).

Although previous site-specific investigations have noted the presence of perched zones of saturation in the overlying unconsolidated materials, these discontinuous zones do not qualify as an uppermost aquifer under the CCR Rule because they do not produce usable quantities of groundwater.

2.3.4 Constituents of Concern (COC)

As discussed above, a single Appendix IV COC (lithium) was detected at concentrations exceeding GWPS in multiple monitoring well locations. As a result, the corrective measure evaluation is confined to the area between and adjacent to the wells in which the exceedances were identified (MW-3A, MW-4, MW-5, and MW-6).

2.3.5 Potential Receptors/Exposure Pathways

Contact with water (e.g., shallow groundwater or surface water) impacted by COCs at levels above GWPS is regarded as the potential 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 Unit, thus limiting the potential receptors to the surface water, i.e., the Green River and its tributary, Groves Creek. The pathways to these receptors include seepage of water from the Unit through manmade and natural hydraulic barriers.

Other potential exposure pathways (e.g., soil or vapor) are not considered complete as the CCR material is isolated in the Unit. 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).

2.4 Interim Corrective Measures

No formal interim corrective measures have been performed at the Green Landfill for groundwater, but corrective measures for known non-groundwater releases are underway. The compatibility of those corrective measures with potential groundwater remedies is being evaluated as part of the remedy selection process.

2.5 Assessment of Corrective Measures Summary

Title 40 CFR Section 257.96(c) requires that the ACM 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; and
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 in **Table 3** 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 Corrective Action Objectives (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 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
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 related releases. For the purposes of this groundwater ACM, management of non-groundwater releases are not included in the alternatives evaluation. Engineering measures, including leachate collection, lining of trenches and/or ponds, and other isolation methods are regarded as part of closure technologies selected by other means.

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 Unit, 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), and Groundwater Monitoring
- Alternative #2b – Closure by Removal (CbR), ICs, and Groundwater Monitoring
- Alternative #3 – CiP, Hydraulic Containment, Other Source Control (consisting of seepage collection and treatment), Ex-Situ Treatment, ICs, and Groundwater Monitoring
- Alternative #4 – CiP, Physical Containment, Ex-Situ Treatment, ICs, and Groundwater Monitoring
- Alternative #5 – CiP, Other Source Control, ICs, and Groundwater Monitoring

The assembly of corrective measures alternatives presented in the ACM is considered 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.

3.0 REMEDY SELECTION PROGRESS

Six corrective measure alternatives were identified during the ACM process for potential implementation at the Unit to address groundwater impacts. Each corrective measure alternative consists of one or more corrective measures technologies assembled into a strategy for the groundwater remedy. Each alternative is discussed in more detail below.

3.1 Potential Corrective Action Alternatives

3.1.1 Alternative #1 – No Action and Groundwater Monitoring

Alternative #1 consists of taking no action to address groundwater impacts at the Unit. Under the No Action alternative, no corrective action would be implemented to remove, control, mitigate, or minimize exposure to impacted groundwater. The No Action alternative establishes a baseline or reference point against which each of the corrective measure alternatives is compared.

Since Alternative #1 would not attain the CAOs for the Unit, this alternative would not likely be acceptable to stakeholders. Therefore, Alternative #1 is not recommended for further consideration.

3.1.2 Alternative #2a – Closure in Place (CiP), Institutional Controls (ICs), and Groundwater Monitoring

Alternative #2a as currently envisioned would employ a combination of three corrective measures technologies:

- CiP source control, which consists of which consists of routine cover management during landfill operation, and planned closure activities for the Green Landfill;
- Implementation of ICs designed to restrict the property to industrial use and to prohibit groundwater use for potable purposes; and
- Groundwater monitoring (Assessment) to document the effectiveness of the corrective measures.

Alternative #2a is recommended for further evaluation.

3.1.3 Alternative #2b – Closure by Removal (CbR), ICs, and Groundwater Monitoring

Alternative #2b as currently envisioned would be similar to Alternative #2a except that CiP is replaced by CbR, which consists of excavation and removal of the Unit. Given that Alternative #2b is likely cost prohibitive, this alternative is not recommended for further consideration.

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

Alternative #3 as currently envisioned would build upon Alternative #2a to also include the addition of hydraulic containment, using vertical groundwater recovery wells, other source control (i.e., draining and lining the South Pond, and managing existing non-groundwater seeps), and ex-situ treatment of groundwater, which involves above-ground physical/chemical treatment methods and/or permitted discharge until CAOs are achieved.

Alternative #3 is recommended for further evaluation.

3.1.5 Alternative #4 – CiP, ICs, Physical Containment (Funnel-Gate), Permeable Reactive Barrier, and Groundwater Monitoring

Alternative #4 as currently envisioned would consist of CiP (BREC's planned unit closure activities), physical containment of impacted groundwater via installation of a grout curtain with an extraction well at the gate, and ex-situ treatment of extracted groundwater by physical/chemical treatment methods and/or permitted discharge.

Alternative #4 is recommended for further evaluation.

3.1.6 Alternative #5 – CiP, ICs, Other Source Control, and Groundwater Monitoring

Alternative #5 is similar to Alternative #2a except for the addition of other source control, in the form of draining and lining the South Pond and managing existing non-groundwater seeps.

Alternative #5 is recommended for further evaluation.

3.2 Remedy Evaluation

Currently BREC considers four (4) potential corrective action alternatives as viable options to address groundwater impacts at the Unit, including:

- Alternative #2a;
- Alternative #3;
- Alternative #4; and
- Alternative #5.

To evaluate each alternative, additional data collection will likely be required. BREC is currently evaluating data collection needs in the following areas to assist with remedy selection:

1) Nature and Extent – groundwater trends, influence of non-groundwater remedies, etc.
2) Physical Characteristics – available data on the physical characteristics of the landfill and retention pond
3) Performance Modeling – data needed to develop digital models demonstrating the effectiveness of potential alternatives
4) Engineering – feasibility, cost estimates, etc.

BREC is working to establish a comprehensive list of data collection needs to proceed forward with remedy evaluation and anticipates providing additional data in future semi-annual remedy selection progress reports.

In Fall 2019, BREC constructed a series of collection trenches around the perimeter of the Unit to address non-groundwater releases. The 2020 groundwater monitoring program will assist in evaluating the success of the non-groundwater release remedies and provide relevant and important information to be considered in the final groundwater remedy selection.

4.0 CONCLUSION

Additional updates regarding remedy selection, including any additional corrective measures being considered, will be presented twice a year in future remedy selection progress reports. Once sufficient data has been collected to select an effective comprehensive remedy for the Unit, a public meeting will be held 30 days prior to formal remedy selection, followed by a detailed Remedy Selection Report describing the remedy and proposed schedule for implementation.

If needed, the next remedy selection progress report for the Unit is expected in June 2020.

5.0 REFERENCES

AECOM, 2018. Annual Groundwater Monitoring and Corrective Action Report, 2016-2017; Green Station CCR Landfill, Webster County, Kentucky.

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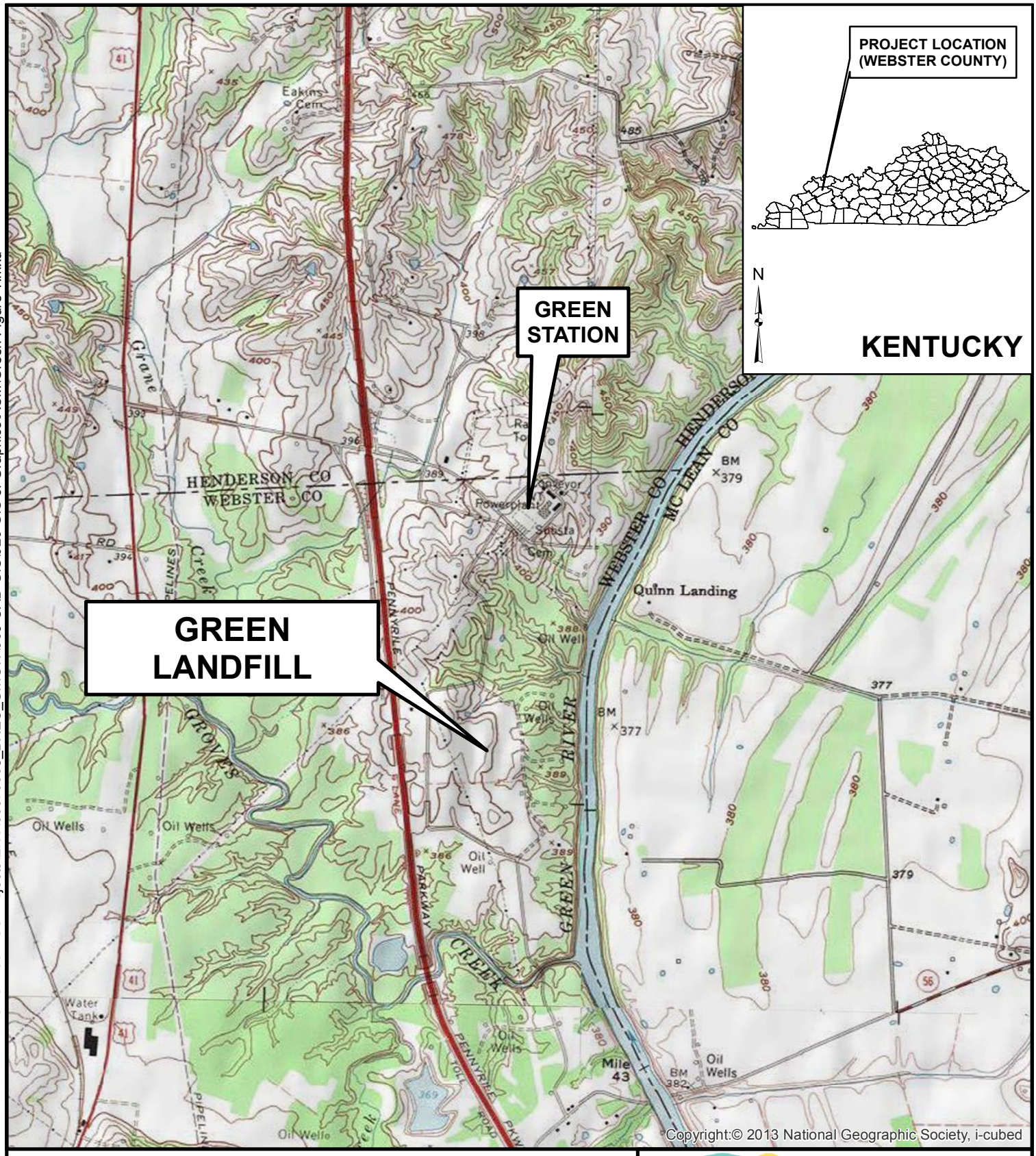
Figures



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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

ROBARDS QUADRANGLE
DELAWARE QUADRANGLE
(FROM ARCGIS ONLINE Copyright:© 2011 National Geographic Society, i-cubed)

0 2,000 4,000 Feet

N

Big Rivers ELECTRIC CORPORATION

Green Station
Webster County, Kentucky

FIGURE 1
SITE LOCATION MAP

DATE: 4/30/2019	SCALE: 1IN = 2,000 FEET
CREATED BY: ALW	
JOB NO. 60602364	

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Legend

- Property Line
- KAR Permit Area
- CCR Fill Area
- Downgradient CCR Monitoring Well
- Upgradient CCR Monitoring Well
- Characterization Well

0 400 800
Feet

N

Big Rivers Electric Corporation

Green Station
Webster County, Kentucky

FIGURE 2
WELL LOCATION MAP

DATE: 12/9/2019	SCALE: 1IN = 300 FEET
CREATED BY: ALW	
JOB NO. 60602364	