AECOM
500 W Jefferson St.
Suite 1600
Louisville, KY 40202
www.aecom.com

502-569-2301 tel
502-569-2304 fax

AECOM

October 17, 2018

Big Rivers Electric Corporation
Sebree Generating Station
9000 Highway 2096
Robards, Kentucky 42452

**Engineer's Certification of Unstable Areas Demonstration**
**Existing Green CCR Landfill**
**EPA Final CCR Rule**
**Sebree Station**
**Robards, Kentucky**

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## 1.0 PURPOSE

The purpose of this document is to certify that the Unstable Areas Demonstration for the Sebree Station existing Green CCR Landfill is in compliance with the Unstable Areas demonstration specified in the Final CCR Rule at 40 CFR §257.64. Presented below is the project background, summary of findings, limitations and certification.

## 2.0 BACKGROUND

AECOM performed a site assessment to evaluate the current conditions of the existing CCR landfill in accordance with the unstable area requirements of location restrictions under the USEPA CCR Rule §257.64. As part of the site assessment, AECOM has reviewed available historical information and completed site reconnaissance visits and geotechnical explorations.

## 3.0 SUMMARY OF FINDINGS

Based upon our review of the available historical data and our engineering analyses, AECOM has concluded that the Green CCR Landfill will meet the CCR Rule requirements for Unstable Areas found in 40 CFR §257.64 (a) and (b).

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## 4.0 CERTIFICATION

I, Michael Brian Cole, being a Registered Professional Engineer in good standing in the State of Kentucky, do hereby certify, to the best of my knowledge, information, and belief, that the information contained in this certification has been prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Unit, that the demonstration regarding the location of the CCR Unit in unstable areas as included in the Unstable Areas Demonstration for Coal Combustion Residuals dated October 17, 2018 meets the requirements of 40 CFR § 257.64(a) and § 257.64(b).

M. Brian Cole
*Printed Name*

October 17, 2018
*Date*


ADDRESS: AECOM
500 W Jefferson St Suite 1600
Louisville, KY 40202

TELEPHONE: (502)-569-2301

ATTACHMENTS: Unstable Area Demonstration for Coal Combustion Residuals

Big Rivers ELECTRIC CORPORATION

Your Touchstone Energy® Cooperative

# Existing Green CCR Landfill

## Disposal of Coal Combustion Residuals (CCR) from Electric Utilites Final Rule
## Unstable Areas Demonstration for CCR

**October 17, 2018**

**Prepared by**

AECOM

**Project Number: 60570534**

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### FIGURES

# 1.0 BACKGROUND

## 1.1 OBJECTIVE

The purpose of this Unstable Areas Demonstration report is to document compliance with 40 CFR 257.64(a) of the Environmental Protection Agency Final Coal Combustion Residual Rule (EPA Final CCR Rule). This unstable areas demonstration is based on existing documentation such as construction drawings, record drawings, and any other pertinent data and/or investigations to support historic conditions and operations at Green CCR Landfill at the Big Rivers Electric Corporation (BREC) Sebree Generating Station.

## 1.2 RULE REQUIREMENT

According to *§257.64(a)* of the EPA Final CCR Rule, any existing or new CCR landfills, existing and new CCR surface impoundments, and all lateral expansions of CCR units must not be located in an unstable area unless the owner or operator demonstrates that recognized and generally good engineering practices have been incorporated into the design of the CCR unit to ensure that the integrity of the structural components of the CCR unit will not be disrupted.

In accordance with *§257.64(b)* the owner or operator must consider all of the following factors, at a minimum, when determining whether an area is unstable:

- §*257.64(b)(1*) – On-site or local soil conditions that may result in significant differential settling;
- *§257.64(b)(2)* – On-site or local geologic or geomorphic features, and
- *§257.64(b)(c)* – On-site or local human made features or events (both surface and subsurface).

## 1.3 SITE BACKGROUND

The Green CCR Landfill is used for the placement of coal combustion residual material; currently fly ash, bottom ash and related material. The landfill rises from adjacent ground elevation of about 400 feet to a maximum elevation of about 608 feet above mean sea level. The original ground surface within the landfill footprint was irregular and the predominant 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.

A site location plan of the Sebree Station is supplied as **Figure 1**. An aerial photograph of Green CCR Landfill is shown on the next page in **Figure 2**.

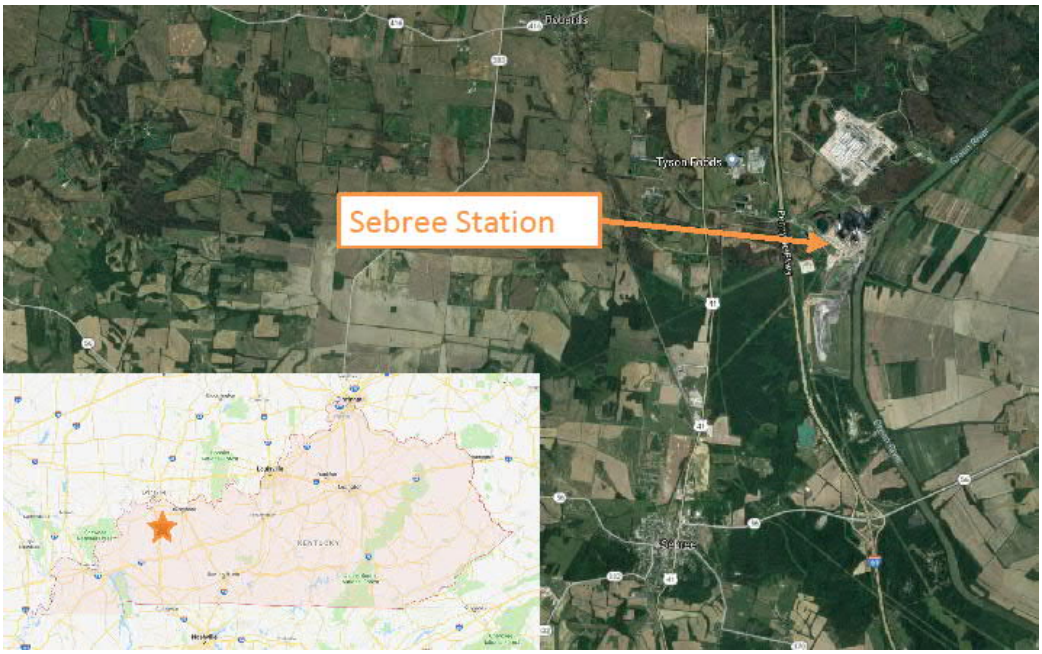


Figure 1: Big Rivers Sebree Site Location


**Figure 2:** Site Overview

# 2.0 SITE ASSESSMENT

## 2.1 SITE RECONNAISSANCE AND DATA REVIEW

AECOM engineering staff conducted detailed site reconnaissance as part of the site assessment to visually monitor existing conditions. Where practical, existing conditions were visually compared with available design and construction records. During the field reconnaissance at the Green CCR Landfill, AECOM did not observe any structural safety conditions that required immediate action. AECOM noted the landfill and associated structures and conduits appeared to be well maintained and routinely inspected by Station staff.

Design drawings (Burns & Roe, 1977) were reviewed as part of this assessment. Historical geotechnical investigations and evaluations (HDR, 2016) were reviewed to evaluate subsurface conditions for this demonstration.

## 2.2 SUBSURFACE INVESTIGATIONS

The 2016 geotechnical data exploration consisted of drilling five (5) borings along the west embankment of the landfill. The borings were advanced through the Poz-O-Tec material in order to sample the underlying materials. The borings were advanced to Standard Penetration Test (SPT) refusal within weathered bedrock, which occurred at depths ranging from about 31 to 54 feet bgs.

AECOM performed a geotechnical exploration to supplement the HDR evaluation in July and August 2018, consisting of eight (8) soil borings drilled around the perimeter and along the east embankment of the Green CCR Landfill. AECOM subcontracted the drilling to Geotechnology Inc. An AECOM geotechnical specialist observed and logged the soil borings.

The borings were advanced with a CME 850 ATV mounted drill rig using 3.25-inch inside diameter hollow stem augers to SPT refusal in weathered bedrock, which occurred at depths ranging from about 21.5 to 65.4 feet bgs. In boring B-6, NQ size rock core tools were used to advance the hole into shale bedrock from a depth of 37 feet to 46.3 feet.

Soil samples were obtained under the direction of the AECOM geotechnical specialist using a 2-inch outer diameter split spoon sampler driven with an automatic hammer in accordance with the standard penetration test (ASTM D-1586). Thin-walled 3-inch diameter Shelby tube (ASTM D1587) samples were obtained in cohesive materials. The soil samples were contained in a thin-wall sleeve.

The boring was logged in the field based upon recovered samples, cuttings, and drilling characteristics. The boring log was subsequently modified as appropriate based on laboratory tests. Upon completion, the borings were backfilled to the existing ground surface with cement bentonite grout. Representative soil samples were selected for soil classification in accordance with the USCS soil classification systems.

Laboratory tests performed on samples recovered from the borings included natural moisture content (ASTM D- 2216), Atterberg limits (ASTM D-4318), sieve analysis (ASTM D-1140), and consolidated undrained triaxial testing (ASTM D4767).

### 2.3 SITE GEOLOGY

The USGS Geologic Map of the Robards Quadrangle indicates the site is underlain by bedrock consisting of units associated with the lower Lisman and upper Carbondale Formations. These units are comprised of interbedded shale and sandstone, with minor limestone, coal, and fireclay beds. The No. 11, 12, and 13 coal beds occurring in these units are thin to absent. No faults are mapped in the vicinity of the site.

Alluvial deposits associated with the Green River typically occur above bedrock in the lower topographical areas. Loess and residual soils typically occur above bedrock in the upland areas. Alluvial deposits are comprised of silt, clay, sand, and gravel. Silt and clay may be in part of lacustrine origin in lower valleys of large streams. Sand is very fine to coarse, well to poorly sorted; consists mainly of subrounded to rounded quartz grains. Gravel is described as medium-brown to gray in color, comprised of iron-stained sandstone, quartz, coal, black shale and small amounts of pyrite. Unit includes slope wash along valley sides and at heads of tributary streams.

## 3.0 FOUNDATION CONDITIONS

The foundation conditions are summarized below based on the boring logs and laboratory data from the 2016 Geotechnical Data Report by HDR, and 2018 exploration by AECOM .

### 3.1 SITE SPECIFIC SOIL AND ROCK CONDITIONS

#### 3.1.1 COVER MATERIALS

Based on the conditions encountered in the borings, the landfill cover varies from 1.5 feet thick to 4.5 feet thick. The cover material consists of lean clay (CL) with roots and organics. Moisture content test results ranged from about 23 to 24 percent.

#### 3.1.1 POZ-O-TEC (CCR)

The landfill contents consist of dry stacked Poz-O-Tec (fly ash and scrubber sludge, fixated with lime)(CCR). Based on SPT N-values recorded in the CCR, the consistency ranged from medium stiff to very stiff. Based on laboratory results, the CCR is mainly characterized as non-plastic silt (ML) with some high-plastic silt (MH). Moisture content test results ranged from about 16 to 60 percent. Atterberg Limits tests performed on the native soils indicated liquid limit values ranging from 46 to 50, and plasticity index value of 2. A grain size analysis test performed on the CCR indicated about 74 percent fines.

### 3.1.2 NATIVE SOILS

Soil material recovered from the standard penetration tests classified as silty sand, sandy silt, sandy silty clay, sandy lean clay, and clayey sand designated SM, ML, CL-ML, MH, CL, and SC, respectively, in accordance with the Unified Soil Classification System.

Native soils were encountered in the borings below the CCR and primarily consist of lean clay (CL) and fat clay (CH). Exceptions were noted at Borings B-6 and B-8, where a layer of poorly graded sand (SP) was encountered at depths of about 28 and 20.5 feet bgs, and extended to depths of about 31 and 24 feet bgs, respectively. The thickness of the native soils ranged from about 11 to 35.5 feet and was underlain by weathered shale and sandstone.

The SPT N-values recorded in the clay native soils ranged from 7 to 25 bpf, indicating medium stiff to very stiff consistency. Natural moisture content test results ranged from about 14 to 22 percent for the native soils. Atterberg Limits tests performed on the clay native soils indicated liquid limit values ranging from 40 to 55, and plasticity index values ranging from 21 to 29. The sand layer was medium dense, with an SPT N-value of 13 bpf recorded.

### 3.1.3 BEDROCK

Highly weathered shale and sandstone units were encountered below the native soils in each boring. NQ size rock coring tools were used at Boring B-6 to advance 10 feet and obtain intact rock cores of the underlying bedrock. The rock core run had 99.5 percent recovery, and Rock Quality Designation (RQD) was 99.5 percent.

### 3.1.4 SUBSURFACE WATER

Groundwater was measured immediately following drilling operations and 24 hours to 72 hours after completion of the advanced borings. Water levels measured in boreholes drilled along the toe of the landfill typically indicated free water at depths ranging from about 6 to 19 feet bgs. An exception was noted at B-3, along the west toe, which encountered water at about 1.3 feet bgs. Water levels measured at borings drilled from the lower bench indicated water within the Poz-O-Tec fill, with depths ranging from about 9 to 20 feet bgs. Groundwater levels are anticipated to vary in response to seasonal climatic cycles and/or intense rainfall events.

## 3.2 NATURAL UNSTABLE AREAS

Based on review of historical data and observations in the borings performed during the geotechnical exploration, native soil was encountered below the CCR materials. The native soils, primarily consist of lean clay (CL) with some fat clay (CH). Some isolated layers of poorly graded sand (SP) were encountered in two borings with thickness of about 3 feet. The SPT N-values recorded within the native clay soils typically ranged from 7 to 25 bpf, indicating medium stiff to stiff consistency.

Considering the typically medium-stiff to very stiff consistency of the native soils, natural unstable areas were not encountered during the explorations performed at the site.

### 3.2.1 LIQUEFACTION POTENTIAL

Based on review of the Geotechnical Data Report (HDR, 2016), and the conditions encountered in the borings during the 2018 AECOM exploration, native soils primarily consist of lean clay (CL) and fat clay (CH). Exceptions were noted at Borings B-6 and B-8, where a layer of poorly graded sand (SP) was encountered at depths of about 28 and 20.5 feet bgs, and extended to depths of about 31 and 24 feet bgs, respectively.

This sand interval is at a risk of liquefaction, where it is fully or partially saturated. The boring information data suggests that localized, limited seams of sandy material may be present and could be prone to liquefaction in a strong earthquake. However, these zones are not likely to be continuous as only one, thin layer of sand with potential for liquefaction was identified in two of the borings. Therefore we anticipate that largescale, liquefaction and associated slope failures are very unlikely. Critical cross-sections at the landfill were found to have factors of safety that exceed the CCR Rule required FS of 1.2 for the post-earthquake loading condition, as summarized in **Table 1** below.

**Table 1. Results of Post-Earthquake Global Slope Stability Analysis**

| Loading Condition | Target FOS Criteria | Section A | Section B | Section C |
|---|---|---|---|---|
| Post-Earthquake | FS ≥ 1.2 | 2.02 | 1.63 | 2.39 |

The results of these analyses indicate the structural components of the landfill are anticipated to retain stability.

## 3.3 MAN MADE UNSTABLE AREAS

As previously discussed in Section 3.1, the cover material is comprised of fill materials described as lean clay (CL). The CCR material consists of dry stacked Poz-O-Tec. During the field investigation, no soft spots were encountered and the SPT values indicate that cover and CCR materials were well compacted during construction. Based on the SPT N-values and strength characteristics of the cover and CCR materials, man-made unstable areas are not present at the landfill.

### 3.3.1 SETTLEMENT

Considering the type of construction and documented performance of the Green CCR Landfill, traditional one-dimensional consolidation settlement is not a significant concern in performance. Most primary settlement should have been completed with negligible amounts of additional settlement caused by completion of the landfill. Observations by AECOM and others indicate that additional secondary consolidation-type settlement is not significant, and no significant distress appears to have been observed or reported along the slopes of the Green CCR Landfill

Considering the type of construction and documented performance of the Green CCR Landfill, traditional one-dimensional consolidation settlement is not a significant concern in performance. Most primary settlement should have been completed with negligible amounts of additional settlement caused by completion of the landfill. Observations by AECOM and others indicate that additional secondary consolidation-type settlement is not significant, and no significant distress appears to have been observed or reported along the slopes of the Green CCR Landfill

## 4.0 REMEDIAL ACTION

No record or knowledge of historical structural instabilities have been identified for Green CCR Landfill. Based on the history of structural stability and ongoing observations of the CCR unit, no remedial actions are recommended for Green CCR Landfill.

## 5.0 CONCLUSIONS

Based upon our review of the available historical data and our engineering analyses, AECOM has concluded that the Green CCR Landfill will meet the CCR Rule requirements for Unstable Areas found in 40 CFR §257.64 (a) and (b).

## 6.0 REFERENCES

- HDR, Inc. (2016) Geotechnical Data Report for Green CCR Landfill, Phase I Combination Wall, November 23, 2016.
- USGS (2016). “Topographic Quadrangle Map, Robards Quadrangle, Kentucky”; United States Geological Survey 7.5 minute Series; scale 1:24,000.

AECOM
500 W Jefferson St.
Suite 1600
Louisville, KY 40202
www.aecom.com

502-569-2301 tel
502-569-2304 fax

AECOM

October 17, 2018

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**Engineer's Certification of Unstable Areas Demonstration**
**Existing Green CCR Surface Impoundment**
**EPA Final CCR Rule**
**Sebree Station**
**Robards, Kentucky**

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## 1.0 PURPOSE

The purpose of this document is to certify that the Unstable Areas Demonstration for the BREC Sebree "Green" Existing CCR Surface Impoundment is in compliance with the Unstable Areas demonstration requirements specified in the Final CCR Rule at 40 CFR §257.64. Presented below is the project background, summary of findings, limitations and certification.

## 2.0 BACKGROUND

AECOM performed an evaluation of the current conditions of the existing CCR surface impoundment in accordance with the unstable area requirements of location restrictions under the USEPA CCR Rule §257.64. As part of the site evaluation, AECOM reviewed available historical information and completed site reconnaissance visits.

## 3.0 SUMMARY OF FINDINGS

Based upon our review of the available historical data and our engineering analyses, AECOM has concluded that the Green CCR Surface Impoundment meets the CCR Rule requirements for Unstable Areas found in 40 CFR §257.64 (a) and (b).

AECOM

## 4.0 CERTIFICATION OF DEMONSTRATION

I, Michael Brian Cole, being a Registered Professional Engineer in good standing in the State of Kentucky, do hereby certify, to the best of my knowledge, information, and belief, that the information contained in this certification has been prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Unit, that the demonstration regarding the location of the CCR Unit in unstable areas as included in the Unstable Areas Demonstration for Coal Combustion Residuals dated October 17, 2018 meets the requirements of 40 CFR § 257.64(a).

M. Brian Cole
*Printed Name*


October 17, 2018
*Date*

ADDRESS: AECOM
500 W Jefferson St Suite 1600
Louisville, KY 40202

TELEPHONE: (502)-569-2301

ATTACHMENTS: Unstable Areas Demonstration for Coal Combustion Residuals

Big Rivers ELECTRIC CORPORATION

Your Touchstone Energy® Cooperative

# Green Existing CCR Surface Impoundment

## Disposal of Coal Combustion Residuals (CCR) from Electric Utilites Final Rule
## Unstable Areas Demonstration for Coal Combustion Residuals (CCR)

**October 17, 2018**

**Prepared by**

AECOM

**Project Number: 60570534**

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### FIGURES

# 1.0 BACKGROUND

## 1.1 OBJECTIVE

The purpose of this Unstable Areas Demonstration report is to document compliance with 40 CFR 257.64(a) of the Environmental Protection Agency Final Coal Combustion Residual Rule (EPA Final CCR Rule). This unstable areas demonstration is based on existing documentation such as construction drawings, record drawings, and other pertinent data and/or investigations that support historic conditions and operations at Green CCR Surface Impoundment at the Big Rivers Electric Corporation (BREC) Sebree Generating Station.

## 1.2 RULE REQUIREMENT

According to *§257.64(a)* of the EPA Final CCR Rule, any new CCR landfills, existing, and new CCR surface impoundments, and all lateral expansions of CCR units must not be located in an unstable area unless the owner or operator demonstrates that recognized and generally good engineering practices have been incorporated into the design of the CCR unit to ensure that the integrity of the structural components of the CCR unit will not be disrupted.

In accordance with *§257.64(b)* the owner or operator must consider all of the following factors, at a minimum, when determining whether an area is unstable:

- §*257.64(b)(1*) – On-site or local soil conditions that may result in significant differential settling;
- *§257.64(b)(2)* – On-site or local geologic or geomorphic features, and
- *§257.64(b)(c)* – On-site or local human made features or events (both surface and subsurface).

## 1.3 SITE BACKGROUND

The CCR unit has been in existence for more than 40 years. The CCR unit operator has general maintenance and repair procedures in place as they determine necessity. There are no known occurrences of structural instability of the CCR unit. A site location plan of the Sebree Station is supplied as **Figure 1**. The current Green CCR Surface Impoundment footprint is approximately 21 acres. An aerial photograph of Green CCR Surface Impoundment is shown on the next page in **Figure 2**.

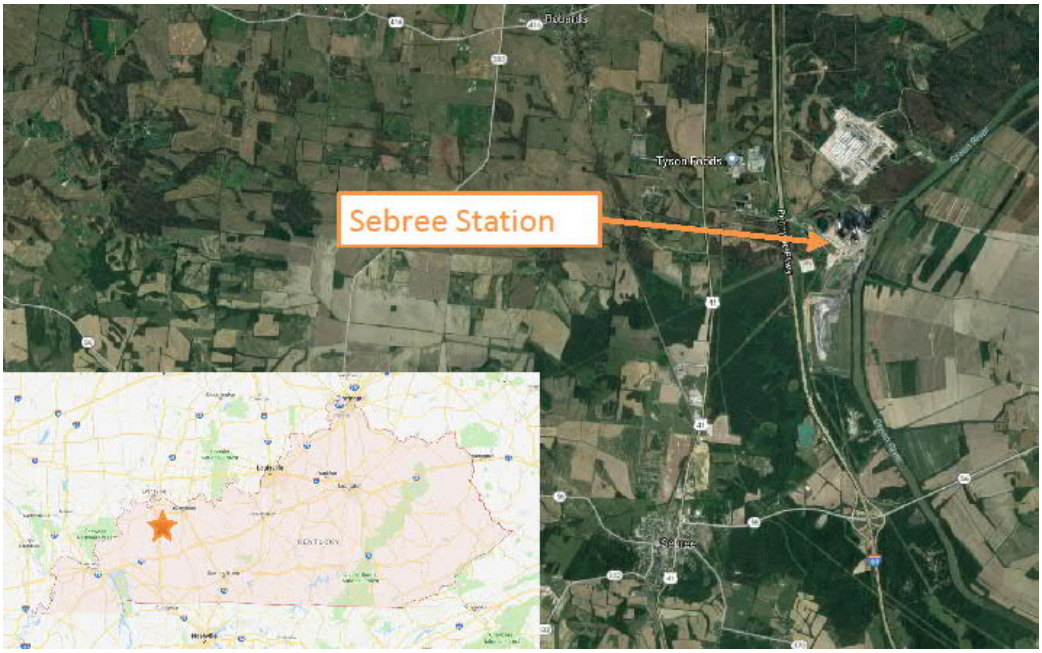


Figure 1: Big Rivers Sebree Site Location


**Figure 2:** Site Overview

The CCR unit is a combined incised/earthen embankment structure with a footprint area of approximately 25 acres. Embankments form the west, south and east sides of the impoundment and the north side is incised. The Green River is located approximately 400 feet east of the structure.

The west dike is generally less than 5 feet in height and the south dike reaches a maximum height of 19.5 feet. The east dike reaches a maximum height of approximately 8 feet and is buttressed with a secondary parallel embankment that serves as a 40 foot wide roadway. Design site grading plans show the original construction layout and ground contours for the impoundment site (Burns & Roe, 1977). Bottom ash has been placed above the normal pool along the inboard side, essentially creating reclaimed land.

# 2.0 SITE ASSESSMENT

## 2.1 SITE RECONNAISSANCE AND DATA REVIEW

AECOM engineering staff conducted detailed site reconnaissance as part of the site assessment to visually monitor existing conditions. Where practical, existing conditions were visually compared with available design and construction records. During the field reconnaissance at the Green CCR Surface Impoundment, AECOM did not observe any dam safety conditions that required immediate action. AECOM noted the embankments and associated structures and conduits appeared to be well maintained and routinely inspected by Station staff. The inspection program includes scheduled formal, intermediate, and informal inspections as well as unscheduled special (emergency) inspections. Additionally, Big Rivers' plant personnel make daily observations and perform weekly reviews of the disposal areas.

Design drawings (Burns & Roe, 1977) were reviewed as part of this assessment. Historical geotechnical investigations and evaluations (Associated Engineers, 2016) were reviewed to evaluate subsurface conditions for this demonstration.

## 2.2 SUBSURFACE INVESTIGATIONS

The Report of Geotechnical Investigation and Stability Analysis, prepared by Associated Engineers, Inc., dated October 14, 2016, was provided to AECOM by Big Rivers as part of the data review for the surface impoundment. The assessment in the report was performed as part of the 40 CFR 257.73(e) requirements for CCR surface impoundments.

A geotechnical investigation and slope stability analysis was performed by Associated Engineers for the Green CCR Surface Impoundment in 2011, and boring logs were included in the 2016 geotechnical report (Associated Engineers, 2016). The investigation included five (5) borings drilled to depths ranging from about 20 to 59 feet below the existing ground surface (bgs). These borings were completed as standpipe piezometers.

An additional geotechnical evaluation was performed by Associated Engineers, Inc. in 2016. Additional subsurface investigation performed as part of this evaluation consisted of four (4) borings drilled with a Mobile B-48 ATV mounted drill rig equipped with hollow stem augers. The borings were located along two (2) cross sections in order to characterize variable conditions across the south embankment. Soil samples were obtained by Standard Penetration Test (SPT) in accordance with ASTM D-1586. Split spoon samples were obtained on continuous intervals

to further characterize the subsurface conditions. Undisturbed samples were obtained in borings offset about 5 feet from the original location.

Laboratory testing was performed on selected samples from the borings. Tests performed included moisture content, grain size analysis, Atterberg limits, unit weight, permeability, and consolidated-undrained triaxial compression tests.

### 2.3 SITE GEOLOGY

The USGS Geologic Map of the Robards Quadrangle indicates the site is underlain by bedrock consisting of units associated with the lower Lisman and upper Carbondale Formations. These units are comprised of interbedded shale and sandstone, with minor limestone, coal, and fireclay beds. The No. 11, 12, and 13 coal beds occurring in these units are thin to absent. No faults are mapped in the vicinity of the site.

Alluvial deposits associated with the Green River typically occur above bedrock in the lower topographical areas. Loess and residual soils typically occur above bedrock in the upland areas. Alluvial deposits are comprised of silt, clay, sand, and gravel. Silt and clay may be in part of lacustrine origin in lower valleys of large streams. Sand is very fine to coarse, well to poorly sorted and consisting mainly of subrounded to rounded quartz grains. Gravel is described as medium-brown to gray in color, comprised of iron-stained sandstone, quartz, coal, black shale and small amounts of pyrite. The alluvial deposits include slope wash along valley sides and at heads of tributary streams.

## 3.0 FOUNDATION CONDITIONS

The foundation conditions are summarized below based on the boring logs and laboratory data from the 2016 Associated Engineering exploration. As discussed in Section 1.3, the north side of the CCR unit is incised, the west dike is less than 5 feet in height, and the east dike is buttressed. The borings focused on the south embankment, which was 19.5 feet in height.

### 3.1 SITE SPECIFIC SOIL AND ROCK CONDITIONS

#### 3.1.1 EMBANKMENT MATERIALS

Based on the conditions encountered in the borings, the surface impoundment embankment is comprised of fill materials which extend from the crest of the embankment to depths of about 15 and 20 feet. This depth corresponds to elevations of about 377 to 382 feet. The fill materials were described as lean clay, lean clay with sand, and sandy lean clay (CL). SPT N-values recorded within the embankment material ranged from 9 to 32 blows per foot (bpf).

#### 3.1.2 NATIVE SOILS

Native soils were encountered in the borings below the embankment materials. Borings drilled along the west portion of the south embankment encountered native soils primarily consisting of sandy lean clay. Exceptions were noted at a depth of 29.0 feet below the crest and 19.5 feet

below the toe of the embankment, where a clayey sand (SC-SM) was encountered. Borings drilled along the east portion of the south embankment encountered native soils primarily comprised of lean clay and sandy lean clay. An interval of poorly graded sand with silt (SP-SM) was encountered from 52.5 feet to 57.2 feet below the crest, and 30.0 feet to 32.5 feet below the toe.

The SPT N-values recorded in the native soils typically ranged from 5 to 29 bpf, indicating medium stiff to very stiff consistency. Exceptions were noted at a depth of about 23 feet bgs at the embankment toe, where an SPT N-value of 3 bpf was recorded within the native clay, indicating soft consistency. An SPT N-value of 2 bpf was also recorded within the poorly graded sand layer discussed above, indicating very loose relative density.

### 3.1.3 BEDROCK

Weathered rock units consisting of highly weathered shale and weathered sandstone were encountered in borings below the embankment materials and native soils. Auger refusal was encountered in the borings at elevations ranging from 334 feet to 360 feet msl. Based on the results of the borings, auger refusal likely occurred on shale or sandstone bedrock. A summary of bedrock conditions is presented on the next page in **Table 1**.

**Table 1. Summary of Bedrock Conditions**

| Bedrock Condition | Embankment Location | Elevation Encountered (ft bgs) |
|---|---|---|
| Highly Weathered Shale | South | 362 |
| Weathered Sandstone | South | 343 to 361 |
| Auger Refusal | South | 334 to 360 |

### 3.1.4 SUBSURFACE WATER

The normal pool elevation for the Green Ash Pond is about 394 feet, based on available information. The piezometer data indicate the phreatic surface varies from approximately 13 to 14 feet below the crest of the embankment and about 1 foot below the downstream toe.

## 3.2 NATURAL UNSTABLE AREAS

Based on review of historical data and observations in the borings performed during the geotechnical exploration, native soil was encountered below the embankment materials. The native soils primarily consist of lean clay and sandy lean clay. Exceptions were noted at a depth of 29.0 feet below the crest and 19.5 feet below the toe of the embankment, where a clayey

sand (SC-SM) was encountered. An interval of poorly graded sand with silt (SP-SM) was encountered from 52.5 feet to 57.2 feet below the crest, and 30.0 feet to 32.5 feet below the toe. The native soils were underlain by shale and sandstone units. These rock units have a low risk of karst formation, and as such, karst conditions are not expected below the CCR unit.

As part of the geotechnical report, a preliminary screening analysis was performed to determine if the embankment materials and subgrade soils are subject to liquefaction. Liquefaction generally occurs primarily in clean fine sands, non-plastic silty sands, non-plastic silt, gravels, and has been observed in sensitive clays. The majority of the embankment and foundation soils are lean clay and clayey sand. Based on Atterberg Limits test results, the plasticity index values of these soils are greater than 7, and as such, the soils are generally not considered liquefiable.

A very loose, saturated interval of poorly graded sand with silt (SP-SM) was encountered in the borings about 52.5 feet below the crest of the embankment and 30 feet below the toe of the embankment. This sand layer was considered liquefiable for post-earthquake conditions.

Considering the typically medium-stiff to very stiff consistency of the native soils, and isolated very loose soils encountered, natural unstable areas were not encountered during the explorations performed at the site.

### 3.2.1 LIQUEFACTION POTENTIAL

Based on review of the Geotechnical Report (Associated Engineering, 2016), a localized portion of the foundation soils at the Green CCR Surface Impoundment are at a risk of liquefaction, consisting of a poorly graded sand with silt (SP-SM) interval occurring at 52.5 feet below the crest of the embankment and 30 feet below the toe of the embankment. This material was about 3 feet in thickness and, based on depth and location encountered in the borings, was interpreted as one seam.

The data suggests that a localized, limited seam of sandy material may be present and could be prone to liquefaction in a strong earthquake. However, similar seams are not likely to be continuous, as only one, thin layer of sand with potential for liquefaction was identified in the borings. Therefore AECOM anticipates that large-scale liquefaction and associated slope failures are unlikely. A post liquefaction slope stability analysis was performed at a critical cross section located along the south embankment (which included the liquefied material identified in the borings) and had a factor of safety of 1.80, well above the CCR Rule requirement of 1.2. Settlement analysis for liquefaction conditions indicated up to 2.7 inches of settlement may occur. This settlement is relatively small and would not affect serviceability of the embankment.

## 3.3 MAN MADE UNSTABLE AREAS

Based on review of mining maps available from the Kentucky Geological Survey, underground mines and surface mines are not present below the site. Based on the design drawings and previous geotechnical evaluations, the CCR unit was constructed on unmined area underlain by native soils.

As discussed in Section 3.1.1, the embankment is comprised of fill materials described as lean clay, lean clay with sand, and sandy lean clay (CL). SPT N-values recorded within the embankment material indicated medium stiff to very stiff consistency. The SPT values also indicate the embankment materials were well compacted during construction. Based on the SPT N-values and strength characteristics of the embankment materials, man-made unstable areas are not present at the Green CCR Surface Impoundment.

### 3.3.1 SETTLEMENT

Considering the age, type of construction and documented performance of the Green CCR Surface Impoundment embankment, traditional one-dimensional consolidation settlement is not a significant concern in the performance of the dikes. The CCR unit has been in place for over 40 years, and any primary settlement should have been completed. The embankments are also relatively low in height and as such significant settlement would not be expected under the corresponding loads and characteristics of the foundation materials. Observations by AECOM and others indicate that additional secondary consolidation-type settlement is not significant, and no significant distress appears to have been observed or reported along the any of the dikes at Green CCR Surface Impoundment.

## 4.0 REMEDIAL ACTION

No record or knowledge of historical structural instabilities has been identified for Green CCR Surface Impoundment. Based on the history of structural stability and ongoing observations of the CCR unit, no remedial actions are recommended for Green CCR Surface Impoundment.

## 5.0 CONCLUSIONS

Based upon our review of the available historical data and our engineering analyses, AECOM has concluded that the Green CCR Surface Impoundment meets the CCR Rule requirements for Unstable Areas found in 40 CFR §257.64 (a) and (b).

## 6.0 REFERENCES

- Burns & Roe. (1977) Plan Site Grading, Big Rivers Reid Station, September 15, 1977.

AECOM
500 W Jefferson St.
Suite 1600
Louisville, KY 40202
www.aecom.com

502-569-2301 tel
502-569-2304 fax

October 17, 2018

Big Rivers Electric Corporation
Sebree Generating Station
9000 Highway 2096
Robards, Kentucky 42452

**Engineer's Certification of Unstable Areas Demonstration**
**Existing Reid/HMPL CCR Surface Impoundment**
**EPA Final CCR Rule**
**Sebree Station**
**Robards, Kentucky**

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## 1.0 PURPOSE

The purpose of this document is to certify that the Unstable Areas Demonstration for the BREC Sebree existing Reid/HMPL CCR Surface Impoundment is in compliance with the Unstable Areas demonstration specified in the Final CCR Rule at 40 CFR §257.64 presented below is the project background, summary of findings, limitations and certification.

## 2.0 BACKGROUND

AECOM performed a site assessment to evaluate the current conditions of the existing surface impoundment in accordance with the unstable area requirements of location restrictions under the USEPA CCR Rule §257.64. As part of the site assessment, AECOM has reviewed available historical information and completed site reconnaissance visits and geotechnical explorations.

## 3.0 SUMMARY OF FINDINGS

Based upon our review of the available historical data and our engineering analyses, AECOM has concluded that the Reid/HMPL CCR Surface Impoundment meets the CCR Rule requirements for Unstable Areas found in 40 CFR §257.64 (a) and (b).

AECOM

## 4.0 CERTIFICATION

I, Michael Brian Cole, being a Registered Professional Engineer in good standing in the State of Kentucky, do hereby certify, to the best of my knowledge, information, and belief, that the information contained in this certification has been prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Unit, that the demonstration regarding the location of the CCR Unit in unstable areas as included in the Unstable Areas Demonstration for Coal Combustion Residuals dated October 17, 2018 meets the requirements of 40 CFR § 257.64(a) and § 257.64(b).


M. Brian Cole
*Printed Name*

October 17, 2018
*Date*

ADDRESS: AECOM
500 W Jefferson St Suite 1600
Louisville, KY 40202

TELEPHONE: (502)-569-2301

ATTACHMENTS: Unstable Area Demonstration for Coal Combustion Residuals

Big Rivers ELECTRIC CORPORATION

Your Touchstone Energy® Cooperative

# Reid/HMPL Existing CCR Surface Impoundment

## Disposal of Coal Combustion Residuals (CCR) from Electric Utilites Final Rule
## Unstable Areas Demonstration for Coal Combustion Residuals (CCR)

**October 17, 2018**

**Prepared by**

AECOM

**Project Number: 60571713**

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### FIGURES

# 1.0 BACKGROUND

## 1.1 OBJECTIVE

The purpose of this Unstable Areas Demonstration report is to document compliance with 40 CFR 257.64(a) of the Environmental Protection Agency Final Coal Combustion Residual Rule (EPA Final CCR Rule). This unstable areas demonstration is based on existing documentation such as construction drawings, record drawings, and any other pertinent data and/or investigations to support historic conditions and operations at Reid Henderson Municipal Power & Light (HMPL) CCR Surface Impoundment at the Big Rivers Electric Corporation (BREC) Sebree Generating Station.

## 1.2 RULE REQUIREMENT

According to *§257.64(a)* of the EPA Final CCR Rule, any new CCR landfills, existing, and new CCR surface impoundments, and all lateral expansions of CCR units must not be located in an unstable area unless the owner or operator demonstrates that recognized and generally good engineering practices have been incorporated into the design of the CCR unit to ensure that the integrity of the structural components of the CCR unit will not be disrupted.

In accordance with *§257.64(b)* the owner or operator must consider all of the following factors, at a minimum, when determining whether an area is unstable:

- §*257.64(b)(1*) – On-site or local soil conditions that may result in significant differential settling;
- *§257.64(b)(2)* – On-site or local geologic or geomorphic features, and
- *§257.64(b)(c)* – On-site or local human made features or events (both surface and subsurface).

## 1.3 SITE LOCATION

Big Rivers Electric Corporation (BREC) owns and operates the Sebree Station in Sebree, Kentucky. The Sebree Station is located in Webster County approximately 3.2 miles northeast of the town of Sebree, Kentucky situated immediately east of the Pennyrile Parkway approximately 1.5 miles north of the intersection of the Pennyrile Parkway and Kentucky Route 56. The site location is presented on the next page in **Figure 1**. Sebree Station is composed of Green Station and Reid/HMPL Station.

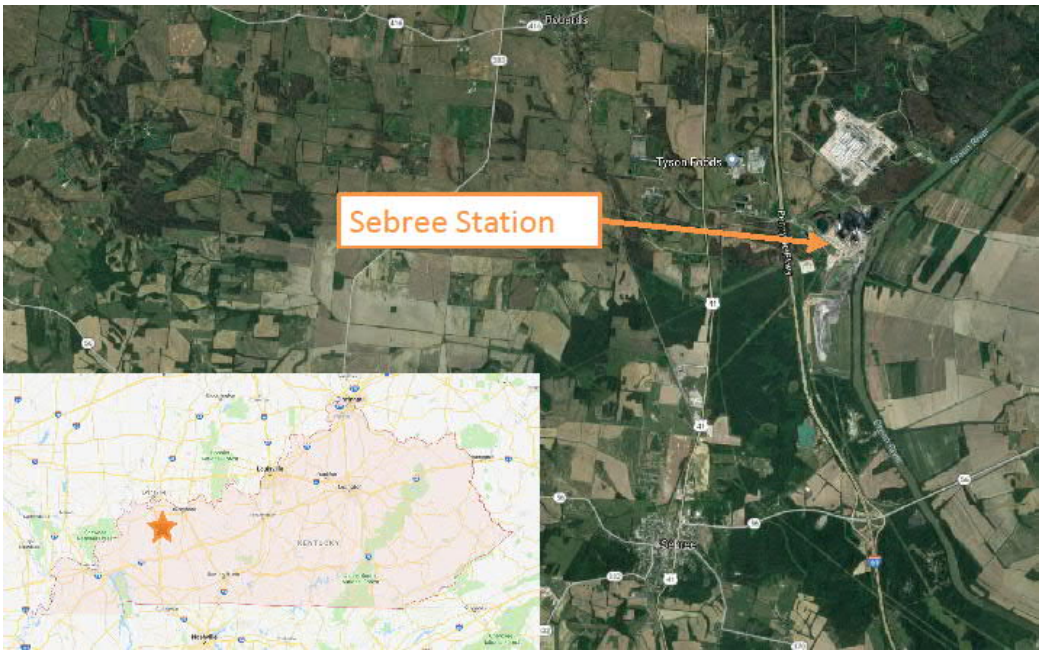


Figure 1: Big Rivers Sebree Site Location

The Reid/HMPL CCR Surface Impoundment (Reid/HMPL Pond) is located directly northwest of the Sebree Station. The CCR unit has been in existence for more than 40 years. The CCR unit operator has general maintenance and repair procedures in place as they determine necessity. There are no known occurrences of structural instability of the CCR unit.

The CCR unit is a combined incised/earthen embankment structure with a footprint area of approximately 25 acres. Embankments form the west, south and east sides of the impoundment and the north side is incised. The west dike is generally less 5 feet in height and the south dike reaches a maximum height of 19.5 feet. The east dike reaches a maximum height of approximately 8 feet and is buttressed with a secondary parallel embankment that serves as a 40 feet wide roadway. The site grading plans (Burns & McDonnell, 1971) show the original construction layout and ground contours for the impoundment site. Bottom ash has been placed above the normal pool along the inboard side, essentially creating reclaimed land.

The impoundment discharges through two 30-inch diameter corrugated metal pipes located on the south end of the facility. An aerial photograph of Reid/HMPL CCR Surface Impoundment is shown below in **Figure 2**.


**Figure 2:** Site Overview

## 2.0 SITE ASSESSMENT

### 2.1 SITE RECONNAISSANCE AND DATA REVIEW

An AECOM geotechnical engineer conducted detailed site reconnaissance as part of the site assessment to identify indications of unstable areas within or adjacent to the units, such as slope sloughing or settlement of the ground surface.. Where practical, existing conditions were visually compared with available design and construction records. During the field reconnaissance at the Reid/HMPL CCR Surface Impoundment, AECOM did not observe any dam safety conditions that required immediate action. AECOM noted the embankments and all associated structures and conduits appeared to be well maintained and routinely inspected by station staff.

Design drawings (Burns & McDonnell, 1971) were reviewed as part of this assessment. Historical geotechnical investigations and evaluations (Associated Engineers, 2016) were reviewed to evaluate subsurface conditions for this demonstration.

### 2.2 SUBSURFACE INVESTIGATIONS

The Report of Geotechnical Investigation and Stability Analysis, prepared by Associated Engineers, Inc., dated October 14, 2016, was provided to AECOM by Big Rivers as part of the data review for the surface impoundment. The assessment in the report was performed as part of the 40 CFR 257.73(e) requirements for CCR surface impoundments.

Associated Engineers performed a geotechnical investigation and slope stability analysis for the Reid/HMPL Pond in 2011. The investigation included five (5) borings drilled to depths ranging from about 20 to 59 feet below the existing ground surface (feet bgs). These borings were completed as standpipe piezometers. A geotechnical evaluation was performed by Associated Engineers, Inc. in 2016. Additional subsurface investigation performed as part of this evaluation consisted of eight (8) borings drilled with a Mobile B-48 ATV mounted drill rig equipped with hollow stem augers. The borings were located along four (4) cross sections in order to characterize conditions across the embankment. Soil samples were obtained by Standard Penetration Test (SPT) in accordance with ASTM D-1586. Split spoon samples were obtained on continuous intervals to further characterize the subsurface conditions. Undisturbed samples were obtained in borings offset about 5 feet from the original location.

Laboratory testing was performed on selected samples from the borings. Tests performed included moisture content, grain size analysis, Atterberg limits, unit weight, permeability, and consolidated-undrained triaxial compression tests.

### 2.3 SITE GEOLOGY

The USGS Geologic Map of the Robards Quadrangle indicates the site is underlain by bedrock consisting of units associated with the lower Lisman and upper Carbondale Formations. These units are comprised of interbedded shale and sandstone, with minor limestone, coal, and fireclay beds. The No. 11, 12, and 13 coal beds occurring in these units are thin to absent. No faults are mapped in the vicinity of the site.

Alluvial deposits associated with the Green River typically occur above bedrock in the lower topographical areas. Loess and residual soils typically occur above bedrock in the upland areas. Alluvial deposits are comprised of silt, clay, sand, and gravel. Silt and clay may be in part of lacustrine origin in lower valleys of large streams. Sand is very fine to coarse, well to poorly sorted, and consists mainly of subrounded to rounded quartz grains. Gravel is described as medium-brown to gray in color, comprised of iron-stained sandstone, quartz, coal, black shale and small amounts of pyrite. Unit includes slope wash along valley sides and at heads of tributary streams.

## 3.0 FOUNDATION CONDITIONS

### 3.1 SITE SPECIFIC SOIL AND ROCK CONDITIONS

#### 3.1.1 EMBANKMENT MATERIALS

Based on the conditions encountered in the borings, the surface impoundment embankment is comprised of fill materials which extend from the crest of the embankment elevation of about 429 feet to elevations ranging from about 400.7 to 391.4 feet. The fill materials were described as lean clay, lean clay with sand, and sandy lean clay (CL). SPT N-values recorded within the embankment material ranged from 7 to 30 blows per foot (bpf).

### 3.1.2 NATIVE SOILS

Native soils were encountered in the borings below the embankment and blanket drain materials primarily consisting of silty clay (CL-ML), lean clay (CL) and clayey sand (SC). Silty clay was encountered below the embankment materials. The SPT N-values recorded in the native soils typically ranged from 4 to 13 bpf, indicating medium stiff to stiff consistency. Exceptions were noted at a boring drilled at the crest of the southeast portion of the embankment at a depth of about 51 feet bgs, where soft, sandy lean clay with SPT N-value of 3 bpf was encountered, and at the toe of the southwest portion of the embankment at a depth of about 21 feet bgs, where very soft silty clay with SPT N-value of 1 bpf was encountered. Each of these layers were less than 2 feet in thickness.

### 3.1.3 BEDROCK

A highly weathered shale unit was encountered in borings drilled at the southwest and northwest portions of the embankment, below the embankment materials and native soils. A weathered sandstone unit was also encountered. Auger refusal was encountered in the borings at elevations ranging from 363 feet to 387 feet. Based on the results of the borings, auger refusal likely occurred on shale or sandstone bedrock. A summary of bedrock conditions is presented below in **Table 1**.

**Table 1. Summary of Bedrock Conditions**

| Bedrock Condition | Embankment Location | Elevation Encountered (ft bgs) |
|---|---|---|
| Highly Weathered Shale | South, West | 368 to 389 |
| Weathered Sandstone | South | 375 |
| Auger Refusal | South, West | 363 to 387 |

### 3.1.4 SUBSURFACE WATER

The normal pool elevation for the Reid/HMPL CCR Surface Impoundment is 426.28 feet, based on available information. The piezometer data indicate the phreatic surface varies from approximately 12 to 23 feet below the crest of the embankment and 4 to 9 feet below the downstream toe.

## 3.2 NATURAL UNSTABLE AREAS

Based on review of historical data and observations in the borings performed during the geotechnical exploration, native soil was encountered below the embankment materials. The alluvium was classified as moist to wet, primarily consisting of silty clay (CL-ML), lean clay (CL)

and clayey sand (SC). The SPT N-values recorded within the alluvium deposit typically ranged from 4 to 13 bpf, indicating medium stiff to stiff consistency. Isolated layers of very soft to soft silty clay and lean clay were encountered in borings drilled at the crest and toe of the south embankment at depths of about 51 and 21 feet bgs, respectively.

As part of the geotechnical report, a preliminary screening analysis was performed to determine if the embankment materials and subgrade soils are subject to liquefaction. Liquefaction generally occurs primarily in clean fine sands, non-plastic silty sands, non-plastic silt, gravels, and has been observed in sensitive clays. The majority of the embankment and foundation soils are lean clay and clayey sand, which are not considered liquefiable.

An interval of silt with sand encountered below the crest of the south embankment from depth of 45 to 48 feet bgs was considered liquefiable for post-earthquake conditions.

Considering the typically medium-stiff to stiff consistency of the native soils, and isolated very soft to soft soils encountered, natural unstable areas were not encountered during the explorations performed at the site.

### 3.2.1 LIQUEFACTION POTENTIAL

Based on review of the Geotechnical Report (Associated Engineering, 2016), embankment and foundation soils at the Reid/HMPL CCR Surface Impoundment at a risk of liquefaction include a silt with sand interval encountered in a boring drilled at the crest of the south embankment from depth of 45 to 48 feet bgs.

This silt interval is at a risk of liquefaction, where it is fully or partially saturated. The data suggests that localized, limited seams of sandy material may be present and could be prone to liquefaction in a strong earthquake. However, these zones are not likely to be continuous– only one, thin layer of sand with potential for liquefaction was identified in all the borings. Therefore we anticipate that largescale, liquefaction and associated slope failures are very unlikely. The factor of safety at a critical cross section located along the south embankment (which included the liquefied material identified in the borings) had a factor if safety of 1.58, well above the CCR Rule requirement of 1.2. Settlement analysis for liquefaction conditions indicated up to 1.2 inches of settlement may occur. The configuration of the embankment would render the effects of this settlement to be negligible.

## 3.3 MAN MADE UNSTABLE AREAS

Based on review of mining maps available from the Kentucky Geological Survey, underground mines and surface mines are not present below the site. Based on the design drawings and previous geotechnical evaluations, the CCR unit was constructed on undeveloped area underlain by native soils.

As discussed in Section 3.1.1, the embankment is comprised of fill materials described as lean clay, lean clay with sand, and sandy lean clay (CL). SPT N-values recorded within the embankment material indicated medium stiff to very stiff consistency. The SPT values also indicate the embankment materials were well compacted during construction. Based on the SPT

N-values and strength characteristics of the embankment materials, man-made unstable areas are not present at the Reid/HMPL CCR Surface Impoundment.

### 3.3.1 SETTLEMENT

Considering the age, type of construction and documented performance of the Reid/HMPL CCR Surface Impoundment embankment, traditional one-dimensional consolidation settlement is not a significant concern in the performance of the dikes at the Reid/HMPL site. The facilities have been in place for over 40 years, and any primary settlement should have been completed. Observations by AECOM and others indicate that additional secondary consolidation-type settlement is not significant, and no significant distress appears to have been observed or reported along any of the dikes at Reid/HMPL.

## 4.0 REMEDIAL ACTION

No record or knowledge of historical structural instabilities have been identified for Reid/HMPL CCR Surface Impoundment. Based on the history of structural stability and ongoing observations of the CCR unit, no remedial actions are recommended for Reid/HMPL CCR Surface Impoundment.

## 5.0 CONCLUSIONS

Based upon our review of the available historical data and our engineering analyses, AECOM has concluded that the Reid/HMPL CCR Surface Impoundment meets the CCR Rule requirements for 40 CFR §257.64(a) and §257.64(b).

## 6.0 REFERENCES

- Burns & McDonnell Engineering Co. (1971) Site Plan, Ash Pond and Cooling Tower Grading Plan, Cross Sections – Ash Pond Dike, Power Station Two – Units No. 1 and 2, October 8, 1971.