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October 17, 2018

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

Engineer's Certification of Seismic Impact Zone Demonstration
Existing Green CCR Surface Impoundment
EPA Final CCR Rule
Sebree Station
Robards, Kentucky

1.0 PURPOSE

The purpose of this document is to certify that the Seismic Impact Zone Demonstration for the BREC Sebree Station "Green" Existing CCR Surface Impoundment is in compliance with the Seismic Impact Zone demonstration specified in the Final CCR Rule at 40 CFR §257.63 presented below is the project background, summary of findings, limitations and certification.

2.0 BACKGROUND

According to 40 CFR 257.63(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 seismic impact zones unless the owner the owner or operator demonstrates that all structural components including liners, leachate collection and removal systems, and surface water control systems, are designed to resist the maximum horizontal acceleration in lithified earth material for the site.

3.0 SUMMARY OF FINDINGS

In accordance with §257.63, the results of the engineering assessment have determined that the Green CCR Surface Impoundment is located within a seismic impact zone. Detailed engineering analysis demonstrates that the structural components of the impoundment dike embankment and foundation are configured to resist the maximum horizontal acceleration in lithified earth material for the site. The spillway does not include a riser structure to evaluate.

Pursuant to 40 C.F.R. § 257.63(b) and (c)(1), for an existing Surface Impoundment, the owner or operator must obtain a certification from a qualified professional engineer stating that the owner or operator has demonstrated that the CCR unit meets the requirements for seismic impact zones no later than October 17, 2018.

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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 a seismic impact zone as included in the Seismic Impact Zone Demonstration for Coal Combustion Residuals dated October 17, 2018 meets the requirements of 40 CFR § 257.63(a).

M. Brian Cole
Printed Name

October 17, 2018
Date

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ATTACHMENTS: Seismic Impact Zone Demonstration for Coal Combustion Residuals

Exisitng Green Surface Impoundment

Seismic Impact Zone Demonstration for Coal Combustion Residuals (CCR)
Disposal of Coal Combustion Residuals (CCR) from Electric Utilites Final Rule

October 17, 2018

Prepared by:

AECOM

Project Number: 60571713

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1.0 INTRODUCTION

1.1 OBJECTIVE

The purpose of this demonstration is to document compliance with 40 CFR 257.63 of the Environmental Protection Agency Final Coal Combustion Residual Rule (EPA Final CCR Rule). This Seismic Impact Zone Demonstration is based on existing documentation such as construction drawings, record drawings, geotechnical information, and any other pertinent data and/or investigations to support historic conditions and operations at the Green Surface Impoundment at the Big Rivers Electric Corporation (BREC) Sebree Station. All supporting documentation is located in the attached appendices.

1.2 RULE REQUIREMENTS

According to *40 CFR 257.63(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 seismic impact zones unless the owner or operator demonstrates that all structural components including liners, leachate collection and removal systems, and surface water control systems, are designed to resist the maximum horizontal acceleration (MHA) in lithified earth material for the site.

The MHA in lithified earth material means the maximum expected horizontal acceleration at the ground surface as depicted on a seismic hazard map, with a 98% or greater probability that the acceleration will not be exceeded in 50 years, or the maximum expected horizontal acceleration based on a site specific seismic risk assessment. This requirement translates to a 10% probability of exceeding the MHA in 250 years. Note that MHA is equivalent to the Peak Ground Acceleration (PGA) at the B-C boundary (firm rock) in the USGS maps.

Lithified earth material means all rock, including all naturally occurring and naturally formed aggregates or masses of mineral or small particles of older rock that formed by crystallization of magma or by induration of loose sediments. This term does not include man-made materials, such as fill, concrete, and asphalt, or unconsolidated earth materials, soil, or regolith lying at or near the earth surface.

A seismic Impact zone means an area having a 2% or greater probability that the maximum expected horizontal acceleration, expressed as a percentage of the earth's gravitational pull (g), will exceed 0.10 g in 50 years.

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.

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. 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.

The unit embankment is highest along the south dike, reaching a height of 19.5 feet. Depth of impoundment water and CCR is 16 feet and 46 feet (at respective locations of maximum impounded water and CCR depths). Elevation of impound water and CCR is 394 feet. and 408 feet., respectively, above mean sea level.

The impoundment discharges through two 30-inch diameter corrugated metal pipes located on the south end of the facility.

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

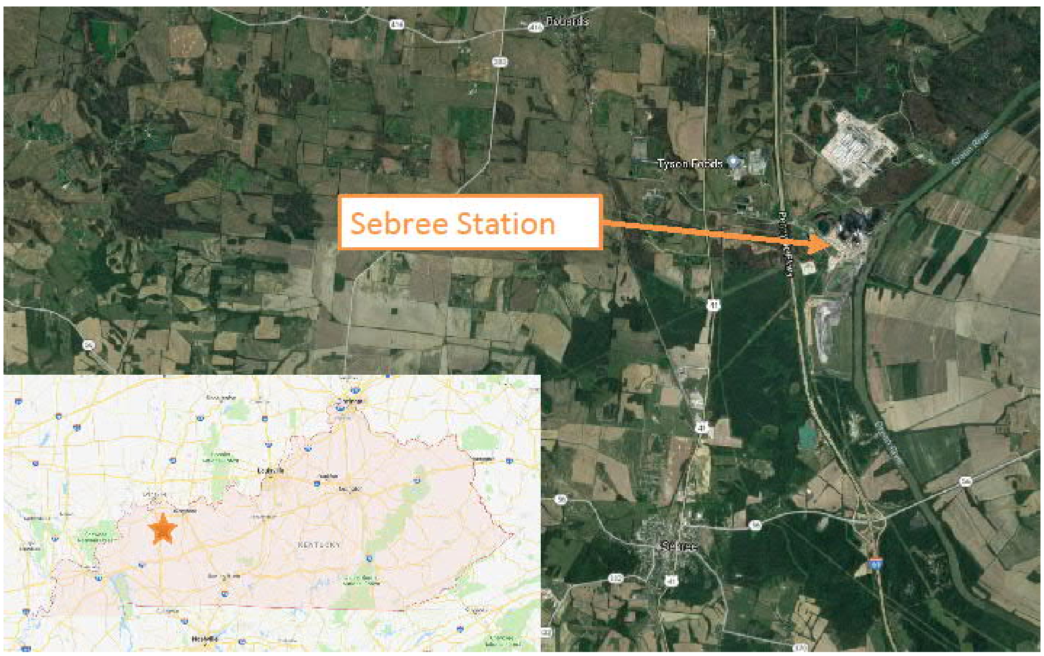


Figure 1: Site Location/Vicinity Map

Figure 2: CCR Unit Site Overview

2.0 Seismic Analysis

2.1 Site Stratigraphy and Geologic Setting

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. 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 sub-rounded 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. Loess and residual soils typically occur above bedrock in the upland areas and are less than 20 feet in thickness.

The embankment and foundation of the Green Surface Impoundment has been explored in the past utilizing soil borings and laboratory testing. Standard Penetration Testing, Natural Moisture

Content testing, Atterberg Limits, Sieve Analysis, Hydraulic Conductivity, and Consolidated Undrained Triaxial testing were performed on the embankment and foundation materials. Subsurface data indicates the embankment materials extend to depths of about 14 feet to 22 feet below the ground surface and generally consist of stiff consistency (N-values of 9 or greater) lean clay (CL based on the United Soil Classification System). The foundation materials consist of medium stiff to stiff (N-values for 5 to 9) lean clay or clayey sand (CL or SC based on the USCS) to depths of 10 to 24 feet below the bottom of the embankment. Bedrock consisting of sandstone or weathered shale was encountered at elevations varying from approximately 360-feet to 330-feet.

2.2 HISTORICAL SEISMIC EVENTS

The Sebree Station is located in northwestern Kentucky, just south of the Wabash Valley Seismic Zone and about 140-km north and east of the New Madrid Seismic Zone (NMSZ) (**Figure 3**). Although the site is located within the continental interior and far from active plate boundaries, the preexisting structures formed in earlier tectonic settings are still capable of generating seismicity that can pose a hazard to the region. This seismicity has included several large historical earthquakes in the area (M > 7), e.g., the 1811 and 1812 New Madrid earthquakes.

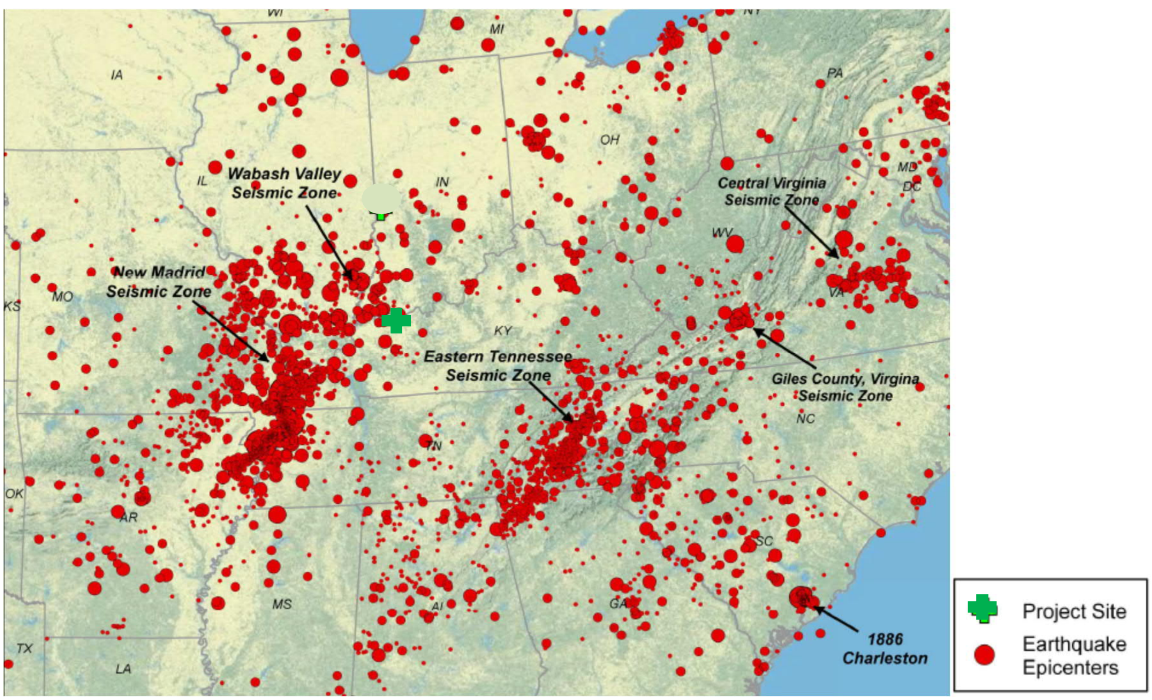


Figure 3: Historical seismicity and seismic zones in the Central and Eastern U.S.

The Wabash Valley Seismic Zone is a region of southwestern Indiana and southeastern Illinois that contains the Wabash Valley fault system (WVFS), see **Figure 3**. Numerous Holocene (less than 11,700 years ago) paleoliquefaction features have been mapped along river valleys within the Wabash Valley Seismic Zone and have been interpreted as having been caused by paleoearthquakes (e.g., Obermeier et al., 1993). However, the faults of the WVFS have been mapped as pre-Quaternary (before 2.6 million years ago), and no fault has been identified as the causative structure for the paleoliquefaction features nor been explicitly correlated with historic or paleoseismicity.

2.3 SEISMIC IMPACT ZONE

Seismic zones, which represent areas of the United States with the greatest seismic risk, are mapped by the U.S. Geological Survey (USGS) and readily available for all the U.S. (http://earthquake.usgs.gov/hazards/apps/). Based on the United States Geological Survey (USGS) on line Unified Hazard Tool, the peak ground acceleration (PGA) in lithified earth having a 2% or greater probability of occurring in 50 years is 0.279-g at the Green CCR Surface Impoundment at the Sebree Station site. Output from the tool is provided in **Appendix A**. A generalized view of the location of the site with respect to seismic hazards in the United States is provided below in **Figure 4.**

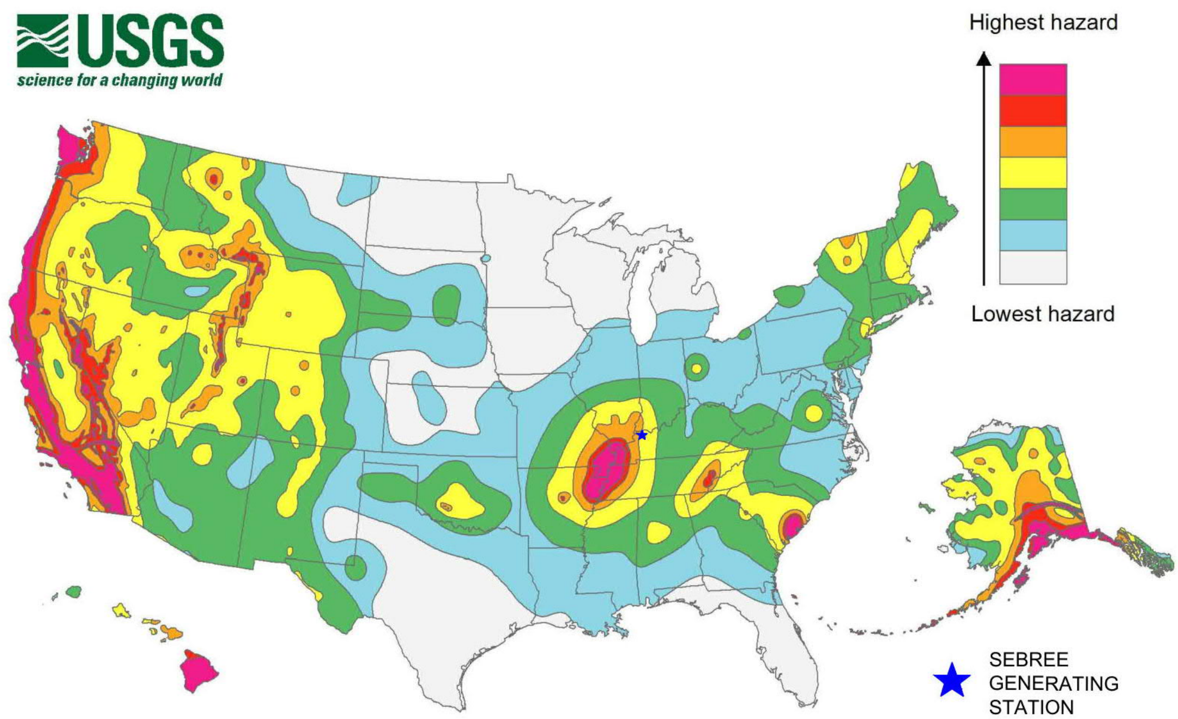


Figure 4: General View of Location of Seismic Hazards Relative to Project Site

As the site's PGA exceeds 0.10g, the CCR Rule requires a demonstration that all structural components including liners, leachate collection and removal systems, and surface water control systems are designed to resist the maximum horizontal acceleration in lithified earth material for the site.

2.4 STRUCTURAL ANALYSIS

Leachate Collection and Removal Systems

No leachate collection systems are present at the Green CCR Surface Impoundment.

Dike and Foundation Stability

Global slope stability analysis under seismic loading conditions was performed in 2016 by Associated Engineers, Inc. at two selected embankment cross sections, GR-1 and GR-2 at the Green CCR Surface Impoundment. The location of the section alignments were chosen based on strength of the subsurface soils, critical embankment cross sections, such as at the maximum embankment height, or at the steepest embankment slopes. Each section was analyzed for the following seismic load cases:

- Pseudo-Static (Seismic) Stability Condition
- Post-Earthquake (Liquefaction) Condition

The design seismic coefficient for the seismic stability condition was determined by Associated Engineers, Inc. using USGS seismic hazard maps. An SPT based liquefaction triggering analysis was performed to determine if liquefiable materials were present within the embankment or foundation. Liquefaction triggering was found to occur only at cross section GR-2, at a depth of 30 feet to 32.5 feet at boring GR-T2 and 52 feet to 57 feet at boring GR-C2. As a result, this layer was assigned a shear strength of 0 for the post-earthquake condition slope stability analysis. No other liquefiable zones were observed at the remaining three cross sections.

The results of these analyses were incorporated into the slope stability analyses, which were performed using limit equilibrium methods through the computer software SLIDE (Version 6.0). The stability analyses were performed using two dimensional limit equilibrium analysis based on the Bishop Simplified Method. Potential failure surface geometries analyzed included primarily failures extending from the crest of the embankment to its toe and basal geometries passing through the impoundment foundation. Circular failure geometries were evaluated for each cross section.

The critical (lowest) factor of safety values resulting from the analysis at each cross section are presented in **Table 1**. Cross Section GR-2 was determined to be the critical section based on demonstrating the lowest factor of safety.

Table 1. Global Seismic Slope Stability Analysis Summary of Results

Loading Condition	Cross Section GR-1	Cross Section GR-2
Psuedo-static (Seismic)	1.148	1.002
Post-Earthquake (Liquefaction)	N/A	1.800

The CCR Rule's factor of safety requirement is 1.0 and 1.2, for pseudostatic (seismic) and post-earthquake (liquefaction) conditions, respectively. Therefore, each cross section analyzed meets the required factor of safety targets.

3.0 CONCLUSIONS

In accordance with §257.63, the results of the engineering assessment have determined that the Green CCR Surface Impoundment is located within a seismic impact zone. Detailed engineering analysis demonstrates that the structural components of the impoundment dike embankment and foundation are configured to resist the maximum horizontal acceleration in lithified earth material for the site. The spillway does not include a riser structure to evaluate.

Pursuant to 40 C.F.R. § 257.63(b) and (c)(1), for an existing Surface Impoundment, the owner or operator must obtain a certification from a qualified professional engineer stating that the owner or operator has demonstrated that the CCR unit meets the requirements for seismic impact zones no later than October 17, 2018.

4.0 REFERENCES

- Associated Engineers, Inc. Green Station Surface Impoundment-Disposal of Coal Combustion Residuals (CCR) from Electric Utilities Final Rule Structural Integrity Criteria for Existing CCR Surface Impoundments Report of Geotechnical Investigation and Stability Analysis. October 14, 2016.
- USGS interactive Web Site, Unified Hazard Tool, April 3, 2018, https://earthquake.usgs.gov/hazards/interactive/

APPENDIX A - UNIFIED HAZARD TOOL OUTPUT

U.S. Geological Survey - Earthquake Hazards Program

Unified Hazard Tool

Please do not use this tool to obtain ground motion parameter values for the design code reference documents covered by the U.S. Seismic Design Maps web tools (e.g., the International Building Code and the ASCE 7 or 41 Standard). The values returned by the two applications are not identical.

Input

Edition

Conterminous U.S. 2014 (v4.0.x)

Spectral Period

Peak ground acceleration

Latitude

Decimal degrees

37.64096

Time Horizon

Return period in years

2475

Longitude

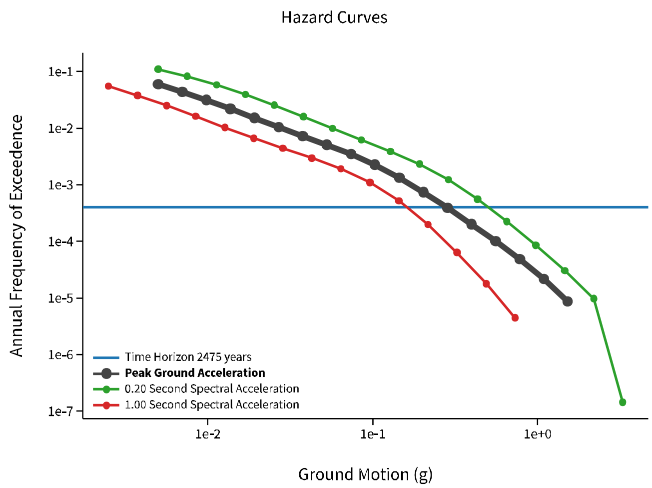
Decimal degrees, negative values for western longitudes

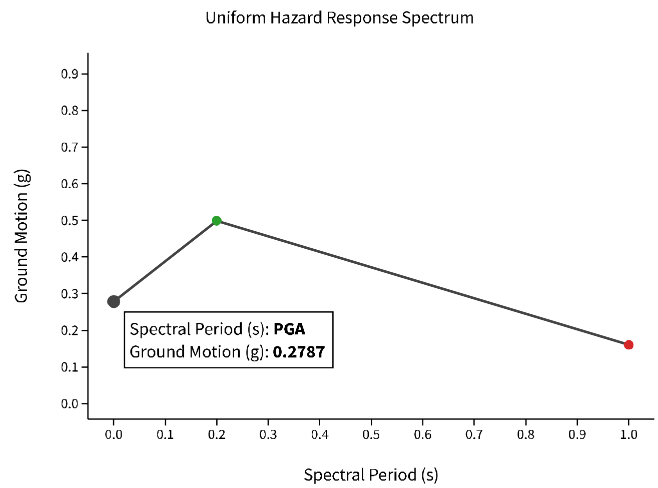
-87.503171

Site Class

760 m/s (B/C boundary)

Hazard Curve





View Raw Data

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October 17, 2018

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Engineer's Certification of Seismic Impact Zone Demonstration
Existing CCR Surface Impoundment
EPA Final CCR Rule
Sebree Station
Robards, Kentucky

1.0 PURPOSE

The purpose of this document is to certify that the Seismic Impact Zone Demonstration for the BREC Sebree "Reid/HMPL" Existing CCR Surface Impoundment is in compliance with the Seismic Impact Zone demonstration specified in the Final CCR Rule at 40 CFR §257.63 presented below is the project background, summary of findings, limitations and certification.

2.0 BACKGROUND

According to 40 CFR 257.63(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 seismic impact zones unless the owner the owner or operator demonstrates that all structural components including liners, leachate collection and removal systems, and surface water control systems, are designed to resist the maximum horizontal acceleration in lithified earth material for the site.

3.0 SUMMARY OF FINDINGS

In accordance with §257.63, the results of the engineering assessment have determined that the Reid/HMPL CCR Surface Impoundment is located within a seismic impact zone. Detailed engineering analysis demonstrates that the structural components of the impoundment dike embankment and foundation are configured to resist the maximum horizontal acceleration in lithified earth material for the site. However, seismic analysis indicates the existing riser structure does not meet the requirements of the CCR rule.

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 dikes of the CCR unit are designed to resist the maximum horizontal acceleration in lithified earth material for the site, which is located in the Seismic Impact Zone, as summarized in the Seismic Impact Zone Demonstration for Coal Combustion Residuals dated October 17, 2018, meeting the requirements of 40 CFR § 257.63(a). However, the riser structure for the CCR unit's spillway does not meet these requirements.

M. Brian Cole
Printed Name

October 17, 2018
Date

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ATTACHMENTS: Seismic Impact Zone Demonstration for Coal Combustion Residuals

Your Touchstone Energy® Cooperative

Existing Reid/HMPL CCR Surface Impoundment

Seismic Impact Zone Demonstration for Coal Combustion Residuals (CCR)
Disposal of Coal Combustion Residuals (CCR) from Electric Utilites Final Rule

October 17, 2018

Prepared by:

Project Number: 60571713

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1.0 INTRODUCTION

1.1 OBJECTIVE

The purpose of this demonstration is to document compliance with 40 CFR 257.63 of the Environmental Protection Agency Final Coal Combustion Residual Rule (EPA Final CCR Rule). This Seismic Impact Zone Demonstration is based on existing documentation such as construction drawings, record drawings, geotechnical information, and any other pertinent data and/or investigations to support historic conditions and operations at the Reid/HMPL CCR Surface Impoundment at the Big Rivers Electric Corporation (BREC) Sebree Station. All supporting documentation is located in the attached appendices.

1.2 RULE REQUIREMENTS

According to *40 CFR 257.63(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 seismic impact zones unless the owner or operator demonstrates that all structural components including liners, leachate collection and removal systems, and surface water control systems, are designed to resist the maximum horizontal acceleration (MHA) in lithified earth material for the site.

The MHA in lithified earth material means the maximum expected horizontal acceleration at the ground surface as depicted on a seismic hazard map, with a 98% or greater probability that the acceleration will not be exceeded in 50 years, or the maximum expected horizontal acceleration based on a site specific seismic risk assessment. This requirement translates to a 10% probability of exceeding the MHA in 250 years. Note that MHA is equivalent to the Peak Ground Acceleration (PGA) at the B-C boundary (firm rock) in the USGS maps.

Lithified earth material means all rock, including all naturally occurring and naturally formed aggregates or masses of mineral or small particles of older rock that formed by crystallization of magma or by induration of loose sediments. This term does not include man-made materials, such as fill, concrete, and asphalt, or unconsolidated earth materials, soil, or regolith lying at or near the earth surface.

A seismic Impact zone means an area having a 2% or greater probability that the maximum expected horizontal acceleration, expressed as a percentage of the earth's gravitational pull (g), will exceed 0.10 g in 50 years.

Pursuant to 40 C.F.R. § 257.63(b) and (c)(1), for an existing surface impoundment, the owner or operator must obtain a certification from a qualified professional engineer stating that the owner or operator has demonstrated that the CCR unit meets the requirements for seismic impact zones no later than October 17, 2018.

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.

The CCR unit is a combined incised/earthen embankment structure with a footprint area of approximately 24 acres. Embankments form the west, south and east sides of the impoundment, and the north side is incised. The Green River is located approximately 1/2 mile east of the structure. Prior to construction, the original site topography sloped toward the west. 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.

The unit embankment is highest along the west dike, reaching a height of 42 feet, with a crest elevation of approximately 429-feet. The dike has been constructed with 3H:1V downstream slopes and 2.5H:1V upstream slopes. The dike consists of a clay core featuring CL and CH materials (low and high plasticity clay based on the United Soil Classification System) and an outer shell consisting of SW, SM and SP (well graded, silty, and poorly graded sand). A sand or limestone blanket drain is present at the base of the downstream toe of the structure.

Depth of impoundment water and CCR is 16 feet and 39 feet (at respective locations of maximum impounded water and CCR depths). Elevation of impound water and CCR is 426 feet. and 440 feet, respectively, above mean sea level. These approximate depths and respective elevations are based on the most recent (December 2015) flight topographic contours and bathymetric survey data.

The impoundment discharges through a rectangular concrete riser spillway structure with stop logs for pool level control. The discharge structure flows into a 24-inch diameter smooth-walled spillway pipe. The riser structure was evaluated by a structural engineer as a key component of the “surface water control systems” for the CCR unit.

A site location plan of the Sebree Station is supplied as **Figure 1**. An aerial photograph of the Reid/HMPL Pond is shown on the next page in **Figure 2**.

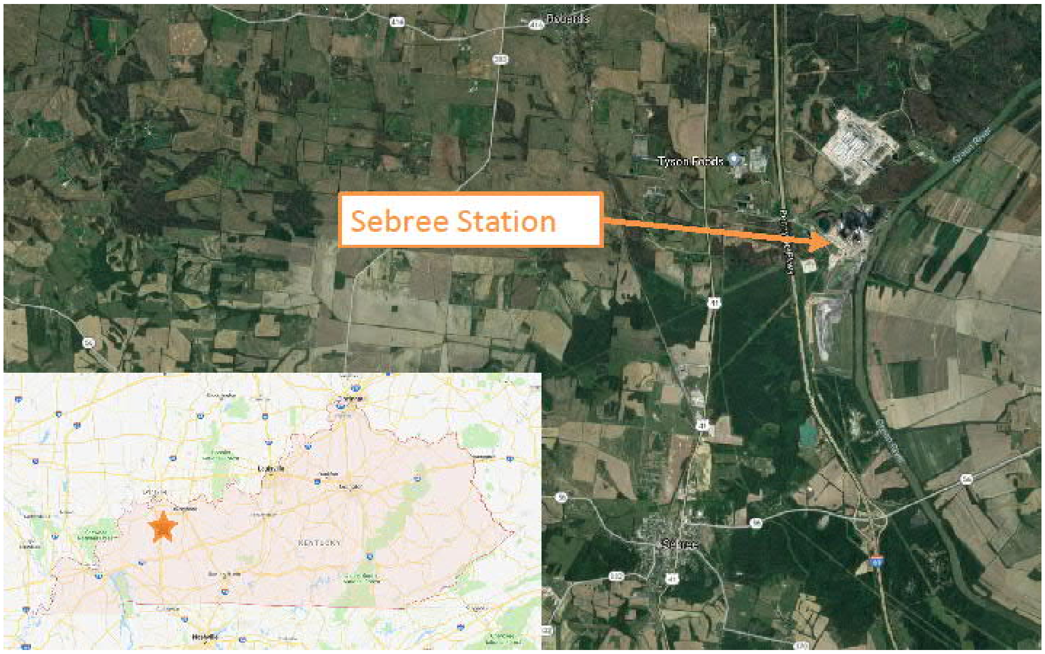


Figure 1: Site Location/Vicinity Map

Figure 2: CCR Unit Site Overview

2.0 SEISMIC ANALYSIS

2.1 SITE STRATIGRAPHY AND GEOLOGIC SETTING

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 sub-rounded 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.

The embankment and foundation of the Reid\HMPL Surface Impoundment has been explored in the past utilizing soil borings and laboratory testing. Subsurface data indicates the embankment materials extend to depths of about 28 feet to 42 feet below the ground surface and are underlain by natural materials consisting of CL or SC materials to depths of 14 to 22 feet below the bottom of the embankment. Standard Penetration Testing, Natural Moisture Content testing, Atterberg Limits, Sieve Analysis, Hydraulic Conductivity, and Consolidated Undrained Triaxial testing were performed on the embankment and foundation materials. Bedrock was encountered at elevations varying from approximately 390-feet to 365-feet.

2.2 HISTORICAL SEISMIC EVENTS

The Sebree Station is located in northwestern Kentucky, just south of the Wabash Valley Seismic Zone and about 140-km north and east of the New Madrid Seismic Zone (NMSZ) (**Figure 3**). Although the site is located within the continental interior and far from active plate boundaries, the preexisting structures formed in earlier tectonic settings are still capable of generating seismicity that can pose a hazard to the region. This seismicity has included several large historical earthquakes in the area ($M > 7$), e.g., the 1811 and 1812 New Madrid earthquakes.

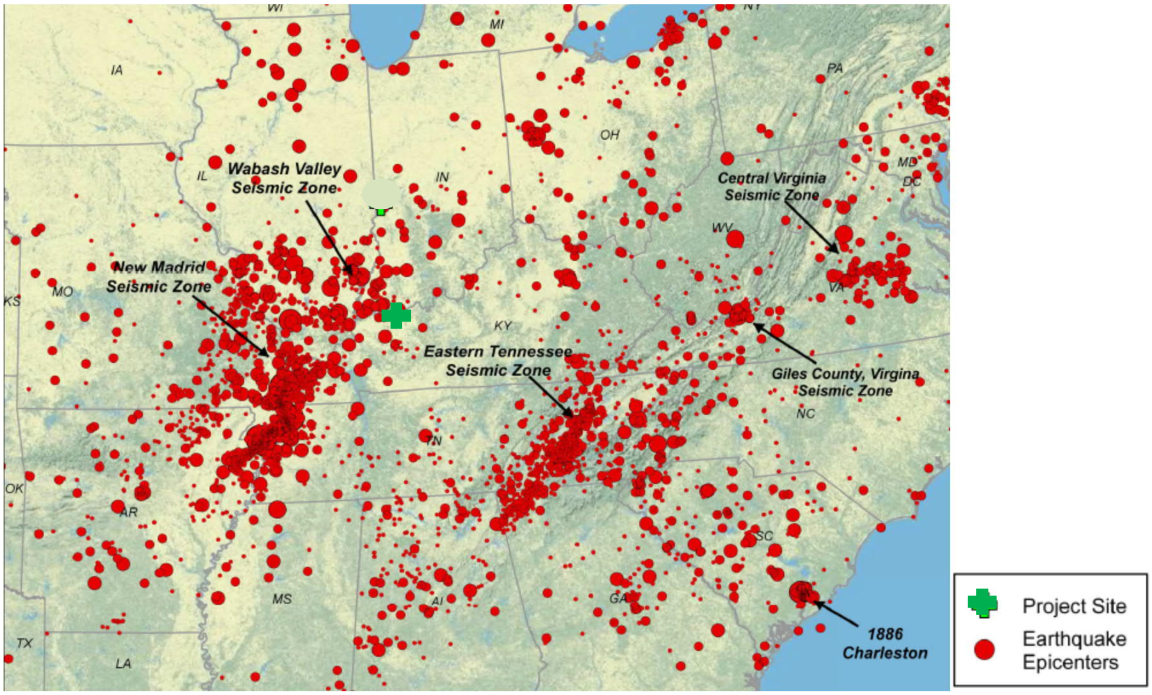


Figure 3: Historical seismicity and seismic zones in the Central and Eastern U.S.

The Wabash Valley Seismic Zone is a region of southwestern Indiana and southeastern Illinois that contains the Wabash Valley fault system (WVFS), see **Figure 3**. Numerous Holocene (less than 11,700 years ago) paleoliquefaction features have been mapped along river valleys within the Wabash Valley Seismic Zone and have been interpreted as having been caused by paleoearthquakes (e.g., Obermeier et al., 1993). However, the faults of the WVFS have been mapped as pre-Quaternary (before 2.6 million years ago), and no fault has been identified as the causative structure for the paleoliquefaction features nor been explicitly correlated with historic or paleoseismicity.

2.3 SEISMIC IMPACT ZONE

Seismic zones, which represent areas of the United States with the greatest seismic risk, are mapped by the U.S. Geological Survey (USGS) and readily available for all the U.S. (http://earthquake.usgs.gov/hazards/apps/). Based on the United States Geological Survey (USGS) on line Unified Hazard Tool, the peak ground acceleration (PGA) in lithified earth having a 2% or greater probability of occurring in 50 years is 0.282-g at the HMPL Surface Impoundment at the Sebree Station site. Output from the tool is provided in **Appendix A**. A generalized view of the location of the site with respect to seismic hazards in the United States is provided below in **Figure 4.**

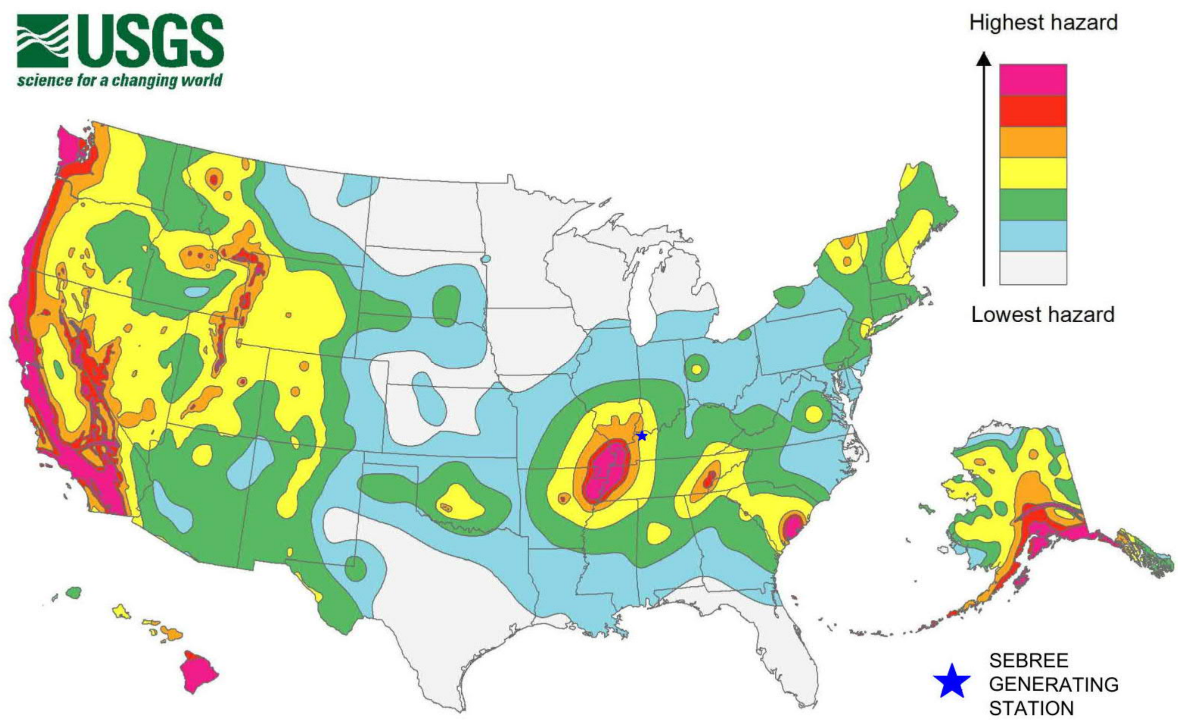


Figure 4: General View of Location of Seismic Hazards Relative to Project Site

As the site's PGA exceeds 0.10g, the CCR Rule requires a demonstration that all structural components including liners, leachate collection and removal systems, and surface water control systems are designed to resist the maximum horizontal acceleration in lithified earth material for the site.

2.4 STRUCTURAL ANALYSIS

<u>Surface Water Control Structure (Outlet Structure) Stability</u>

There is one active outlet structure at the Reid/HMPL CCR Surface Impoundment. It consists of a reinforced concrete riser tower founded on native soil with an approximate height of 45' – 6". The riser tower is 8' x 5' in plan dimension (6' x 3' inside clear dimension) with 3 of the sides consisting of 12" thick concrete walls and the 4th side consisting of stop logs. The bottom 5'-6" height of the riser tower consists of four sided, 12" thick concrete. There is a 27" diameter outlet pipe at the base of the riser tower supported on a concrete saddle. The foundation for the riser tower is reinforced concrete 12' x 15' in plan dimensions and 1'-6" thick. The riser tower was originally designed in 1971. A 1981 modification shows that a 24" diameter corrugated metal riser pipe was to have been installed within the concrete riser tower with the remaining inside clear space between the CMP and inside face of concrete walls filled in with concrete.

The riser structure was analyzed for seismic stability underground motions corresponding to an earthquake event with 2% probability of exceedance in 50 years. The design process for hydrodynamic load outlined in EM 1100-2-2400 was used to evaluate the riser against seismic load. A finite element model (FEM) of the structure was produced using the STAAD Pro. 8i computer program, and external stability (overturning) and stresses in the structures were calculated. The riser tower is assumed to be surrounded by liquefied ash for purposes of this evaluation. The results of the calculation were as follows:

- The concrete riser tower is not structurally adequate for seismic loading. The foundation has a factor of safety of 0.41 against overturning during the design seismic event.
- Strength evaluation of the structure indicated that the riser does not have adequate flexural capacity.
- The shear capacity of the riser was found to meet the minimum criteria.

These results indicate a lack of structural stability under the design earthquake ground motions. The inadequacy can be attributed to the tall, slender riser, minimal vertical reinforcing, as well as a location with relatively high mapped seismicity and adjacent liquefiable ash.

Leachate Collection and Removal Systems

No leachate collection systems are present at the Reid\HMPL CCR Surface Impoundment.

Dike and Foundation Stability

Global slope stability analysis under seismic loading conditions was performed in 2016 by Associated Engineers, Inc. at four selected embankment cross sections at the Reid\HMPL CCR Surface Impoundment. The location of the section alignments were chosen based on strength of the subsurface soils, critical embankment cross sections, such as at the maximum embankment height, or at the steepest embankment slopes. Each section was analyzed for the following seismic load cases:

- Pseudo-Static (Seismic) Stability Condition
- Post-Earthquake (Liquefaction) Condition

The design seismic coefficient for the seismic stability condition was determined by Associated Engineers, Inc. using USGS seismic hazard maps. An SPT based liquefaction triggering analysis was performed to determine if liquefiable materials were present within the embankment or foundation. Liquefaction was found to occur only at cross section RH-1, at a depth of 45-feet to 48-feet, which is 13 feet below the base of the embankment. As a result, this layer was assumed to liquefy for the post-earthquake condition. No other liquefiable zones were observed at the remaining three cross sections. .

The results of these analyses were incorporated into the slope stability analyses, which were performed using limit equilibrium methods through the computer software SLIDE. The stability analyses were performed using two dimensional limit equilibrium analysis based on the Bishop Simplified Method. Potential failure surface geometries analyzed included primarily failures extending from the crest of the embankment to its toe and basal geometries passing through the impoundment foundation. Circular failure geometries were evaluated for each cross section.

The critical (lowest) factor of safety values resulting from the analysis at each cross section are presented in **Table 1**. Cross Section RH-2 was determined to be the critical section based on demonstrating the lowest factor of safety.

Table 1. Global Seismic Slope Stability Analysis Summary of Results

Loading Condition	Cross Section RH-1	Cross Section RH-2	Cross Section RH-3	Cross Section RH-4
Pseudo-static (Seismic)	1.126	1.075	1.147	1.106
Post-Earthquake (Liquefaction)	1.585	N/A	N/A	N/A

The CCR Rule's factor of safety requirement is 1.0 and 1.2, for pseudostatic (seismic) and post-earthquake (liquefaction) conditions, respectively. Therefore, each cross section analyzed meets the required factor of safety targets.

3.0 Conclusions

In accordance with §257.63, the results of the engineering assessment have determined that the Reid/HMPL CCR Surface Impoundment is located within a seismic impact zone. Detailed engineering analysis demonstrates that the structural components of the impoundment dike embankment and foundation are configured to resist the maximum horizontal acceleration in lithified earth material for the site. However, seismic analysis indicates the existing riser structure does not meet the requirements of the CCR rule.

4.0 References

- Associated Engineers, Inc. Reid/HMPL Station Surface Impoundment-Disposal of Coal Combustion Residuals (CCR) from Electric Utilities Final Rule Structural Integrity Criteria for Existing CCR Surface Impoundments Report of Geotechnical Investigation and Stability Analysis. October 14, 2016.
- USGS interactive Web Site, Unified Hazard Tool, April 3, 2018, https://earthquake.usgs.gov/hazards/interactive/

APPENDIX A - UNIFIED HAZARD TOOL OUTPUT

U.S. Geological Survey - Earthquake Hazards Program

Unified Hazard Tool

Please do not use this tool to obtain ground motion parameter values for the design code reference documents covered by the U.S. Seismic Design Maps web tools (e.g., the International Building Code and the ASCE 7 or 41 Standard). The values returned by the two applications are not identical.

Input

Edition

Conterminous U.S. 2014 (v4.0.x)

Spectral Period

Peak ground acceleration

Latitude

Decimal degrees

37.648951

Time Horizon

Return period in years

2475

Longitude

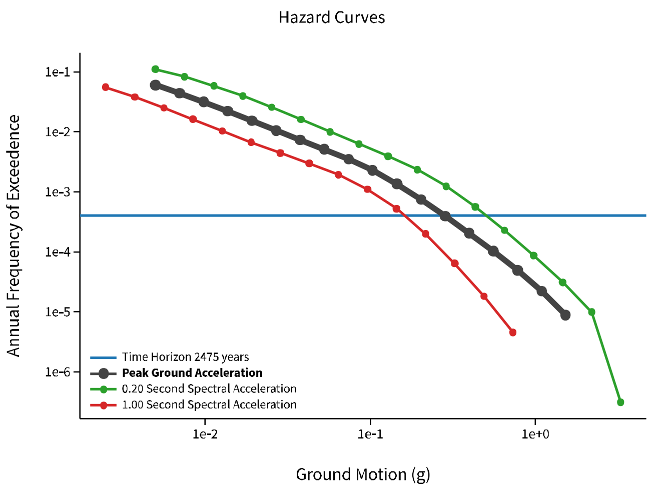
Decimal degrees, negative values for western longitudes

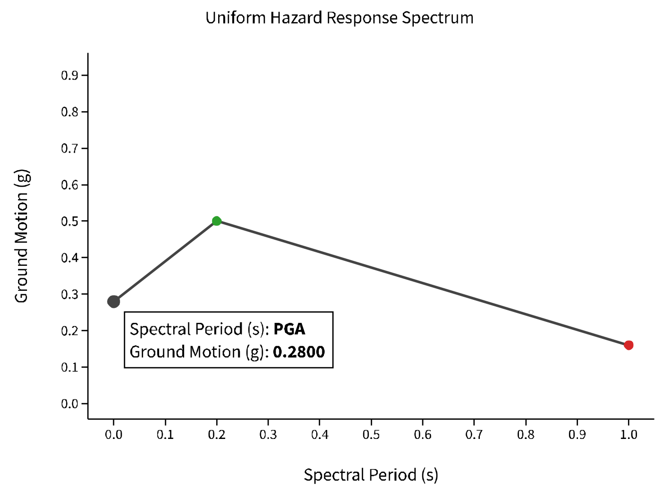
-87.505714

Site Class

760 m/s (B/C boundary)

Hazard Curve





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