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April 4, 2018

Tennessee Valley Authority
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Engineer's Certification of Seismic Impact Zone Demonstration
New CCR Landfill
EPA Final CCR Rule
TVA Paradise Fossil Plant
Drakesboro, Kentucky

1.0 PURPOSE

The purpose of this document is to certify that the Seismic Impact Zone Demonstration for the TVA Paradise Fossil Plant New CCR Landfill 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

TVA intends to construct a new CCR landfill at the PAF facility to provide long-term disposal capacity for CCR materials (fly ash, boiler slag, and gypsum) produced by the facility. Site reconnaissance was performed by AECOM prior to subsurface explorations performed across the landfill footprint in 2016, and within Cell 1A of the landfill in 2017.

In accordance with §257.63, the results of the engineering assessment performed on the landfill have determined that the unit meets the appropriate factors of safety and is structurally sound. These factors of safety indicate the landfill structural components have been designed to resist the maximum horizontal acceleration in lithified earth material for the site without discharge of waste or contaminants.

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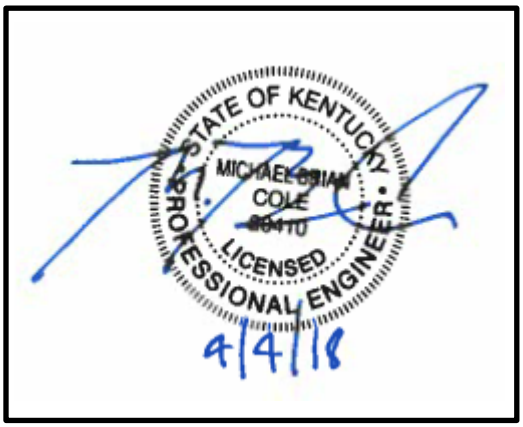
4.0 CERTIFICATION

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 within a seismic impact zone, as included in the Seismic Impact Zone Demonstration for CCR dated April 4, 2018 meets the requirements of 40 CFR § 257.63(a), as all structural components of the CCR Unit are designed to resist the maximum horizontal acceleration in lithified earth material for the site.

M. Brian Cole
Printed Name



4/4/18
Date

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ATTACHMENTS: Seismic Impact Zone Demonstration for CCR - New CCR Landfill

COAL COMBUSTION PRODUCT DISPOSAL PROGRAM

TENNESSEE VALLEY AUTHORITY – PARADISE FOSSIL PLANT
LANDFILL
DRAKESBORO, KENTUCKY

SEISMIC IMPACT ZONE DEMONSTRATION FOR CCR

NEW CCR LANDFILL

Prepared for

Tennessee Valley Authority
1101 Market Street
Chattanooga, TN 37402-2801

April 4, 2018 – Rev 0

Prepared by

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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, and any other pertinent data and/or investigations to support historic conditions and operations at the proposed new Landfill at the Tennessee Valley Authority (TVA) Paradise Fossil Plant (PAF).

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 in lithified earth material for the site.

1.3 SITE BACKGROUND

TVA owns and operates PAF in Drakesboro, Kentucky. The plant features three units, completed between 1963 and 1970, and three large natural-draft cooling towers. Units 1 and 2 were retired in 2017. The plant consumes about 20,000 tons of coal per day. Property of the PAF facility occupies more than 3,400 acres along the western side of the Green River. The plant is located along the west bank of the Green River along State Route 176 inside the eastern border of Muhlenberg County as depicted on the next page in **Figure 1**.

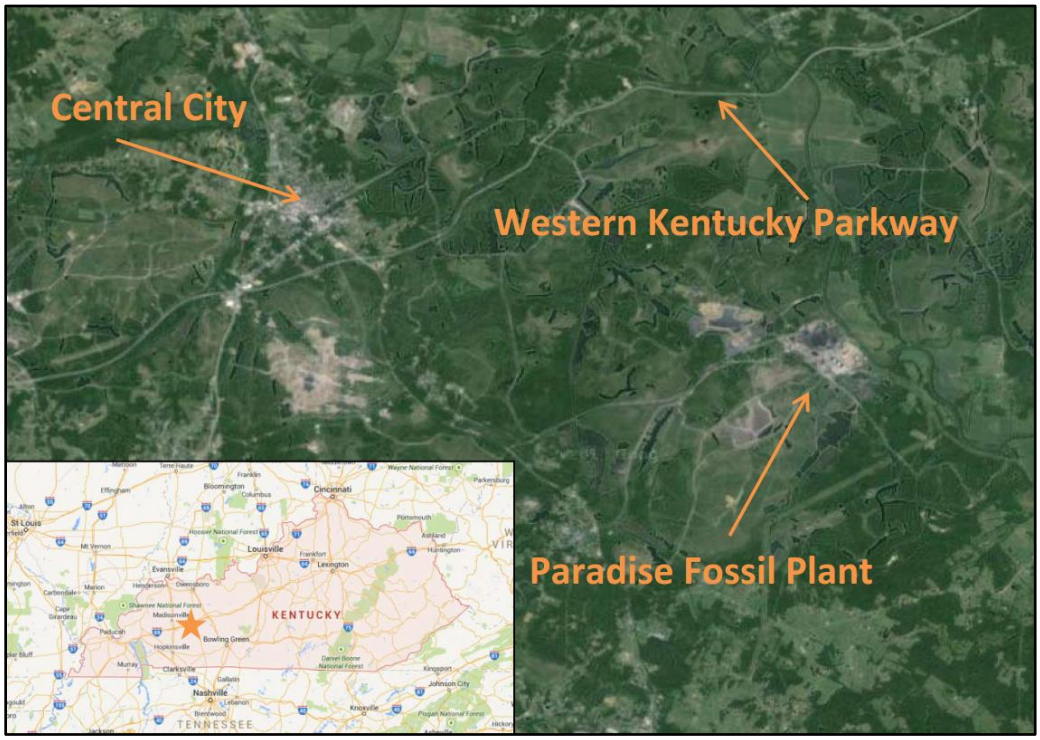

Figure 1: TVA PAF Site Location

TVA intends to construct a new CCR landfill at the PAF facility to provide long-term disposal capacity for CCR materials (fly ash, bottom ash, and gypsum) produced by the facility. Approximately ten percent boiler slag materials are anticipated to be landfilled whereas, the balance is anticipated to be reclaimed and marketed. The proposed landfill site (Site) covers approximately 116 acres, and planned construction will include a CCR landfill, two stormwater detention ponds, and corresponding leachate lagoons. The Site is presented in **Figure 2** on the next page.

Figure 2: PAF Landfill Site Location

The Site is bounded to the south by Jacobs Creek, a tributary that bisects the PAF property from Riverside Road; the Green River to the east, a PAF facility electrical transmission line easement to the west; and the PAF power station to the north. The Site was previously used as a storage area for boiler slag fines.

1.4 SITE HISTORY

Based on review of historical mining maps and observations during site investigations, much of the plant property and adjacent parcels has been mined using deep and surface methods from the 1960's through the 1980's. Some of the large surface impoundments located on the PAF facility are relics of previous mining operations.

Site reconnaissance was performed by AECOM prior to subsurface explorations performed across the landfill footprint in 2016, and within Cell 1A of the landfill in 2017. Based on observations during site reconnaissance in 2016, the Site includes cleared areas of historic mine reclamation, with slopes and sidewalls that are vegetated to varying degrees.

TVA performed grading within the proposed landfill site during 2016 as part of the Gypsum Stack Cover Soil project. Based on observations during site reconnaissance performed within Cell 1A of the landfill in August 2017 and topographic contours shown on Cell 1A construction drawings, it was observed that the north, west, and south boundaries of Cell 1A are located at

the top of a 3H:1V slope at elevation 450 ft. The slope grades downward toward the interior of the cell from elevation 450 ft to elevations ranging from 442 ft to 432 ft.

A gravel road is located around the north, west, and south boundaries of Cell 1A at about elevation 450 ft. Grass vegetation covers the ground surface outside of the gravel road. The road slopes downward along the south boundary of Cell 1A from elevation 450 ft to 432 ft. The northern portion of the eastern boundary of Cell 1A is the toe of a 3H:1V slope, and the southern portion of the eastern boundary of Cell 1A consists of gently sloping ground surface partially covered in grass vegetation. The ground surface within the interior of Cell 1A generally slopes downward from northwest to southeast from elevation 442 ft to 432 ft.

2.0 SEISMIC ANALYSIS

2.1 SITE STRATIGRAPHY AND GEOLOGIC SETTING

TVA PAF lies within the Shawnee Hills section of the Interior Low Plateau Physiographic Province in Northwestern Kentucky and Carbondale Formation. The region is underlain by coal rich Pennsylvanian age bedrock formations. Strip mining operations have significantly altered the topography and geology within the vicinity of the plant and, as such, portions of the site are likely underlain by mine spoils. Geologic mapping indicates the plant and surrounding areas are underlain by the Sturgis and Carbondale Formations in general order of descending geology. The Sturgis Formation is described as consisting of interlayered medium- to coarse-grained micaceous sandstone, silty and clayey shale, coal, and underclay. The Carbondale Formation generally consists of cyclic sequences of fine-grained sandstone, sandy shale, coal, and silty underclay. Although not depicted on the geologic mapping, alluvial deposits are likely present along the banks of the Green River. The geologic mapping indicates this alluvium generally consists of gravel, sand, silt, and clay and may be as much as 90 feet thick.

2.2 SEISMIC EVENTS

The US Geological Survey (USGS) information and geologic studies carried out by TVA indicate that PAF and the surrounding area may be subject to minor seismic events. Seismic events affecting the central portion of western Kentucky, thus the plant, primarily emanate from two zones of earthquake activity – the New Madrid Seismic Zone of the central Mississippi Valley and the Wabash Valley Seismic Zone located along the border between Illinois and southwestern Indiana. Although the majority of the events emanating from these zones are too small to be felt at the surface, the Wabash Valley Seismic Zone has produced three earthquakes within the last 20 years with magnitudes of 5 or greater and the New Madrid Seismic Zone produced a series of four earthquakes between December 1811 and early February 1812 each exhibiting estimated magnitudes on the order of 7.0 to 8.0 (Stantec 2009).

2.3 STRUCTURAL ANALYSIS

As part of the Phase 2 Site Investigation Report, a global slope stability analysis was performed on six cross sections based on the landfill design. The location of the section alignments were chosen based on strength of the subsurface soils, height and extent of CCR waste materials,

and final conditions of the landfill (including cap cover, stormwater ponds, and toe buttresses). The following cases were analyzed for each cross section and included for the purpose of the seismic impact zone certification:

- **Seismic Stability Condition**
- **Post-Earthquake Condition**

Stability analyses evaluation based on the six cross sections utilized specialized software, SLOPE/W, specifically designed for slope stability analysis. For this evaluation, SLOPE/W was programmed to utilize Spencer's Method to evaluate slope stability to determine Factors of Safety (FS) for circular and optimized circular deep seated global slip surfaces.

The factors of safety determined from each of these loading conditions will be utilized in design of the landfill in accordance with the EPA Final CCR Rule. However, the EPA Final CCR Rule does not prescribe slope stability criteria for minimum factor of safety for landfill design. For this evaluation, the minimum factors of safety used are based on values prescribed for impoundments in the EPA Final CCR Rule, and are considered consistent with standard geotechnical engineering practice.

Utilizing the United States Geological Survey online tool for site-specific Potential Seismic Hazard Deaggregation (for which site location and Seismic Site Class are inputs), the mean magnitude of a 2,475-year return event (2% chance of exceedance in 50 years, as per the EPA Final CCR Rule) was computed to be 7.0. The corresponding peak ground acceleration $(PGA)_{rock}$ was 0.19g. To determine the site-specific seismic acceleration for the pseudo-static stability analyses, the corresponding peak crest acceleration was determined from correlations provided by Harder (1993). The “maximum acceleration ratio” was then computed utilizing information from Idriss (2008). Correlations from Harder and Idriss were used to estimate the pseudostatic coefficient k_h value of 0.15g used for these analyses. The correlations are presented in detail in the Phase 2 Site Investigation Report.

Based on the analysis, the target factor of safety requirement for post-earthquake conditions of 1.2 was met for each cross section analyzed. Each cross section analyzed met the target factor of safety required for seismic conditions, with the exception of a condition analyzed beyond the toe at Section 1-1’. Analysis beyond the toe at Section 1-1’ under the pseudostatic condition resulted in a FS of 0.93, less than the target factor of safety of 1.0. A summary of slope stability analysis results is presented below in **Table 1**.

Table 1. Global Slope Stability Analysis Summary of Results

Loading Condition	Target FOS Criteria	Proposed PAF Landfill					
		Cross Section 1-1'	Cross Section 2-2'	Cross Section 3-3'	Cross Section 4-4'	Cross Section 5-5'	Cross Section 6-6'
Post-Earthquake	FS ≥ 1.2	1.62	1.81	1.84	1.76	1.72	1.64
Pseudostatic	FS ≥ 1.0	1.07 0.93[2]	1.34	1.28	1.23	1.18	1.22

Notes: 1 – Analysis performed to check stability for translational failure surface passing through the liner. A phi of 10.2 degrees was used for the liner and protective layer in this analysis.

2 – Analysis performed at existing slope beyond toe of landfill

The most critical scenario for global seismic conditions with the lowest factor of safety was encountered at Section 1-1' exhibiting a factor of safety of 1.07, during the seismic (pseudostatic) loading condition.

However, the slope beyond the toe of the landfill slope was analyzed for the pseudostatic condition at Section 1-1', resulting in a factor of safety of 0.93. A seismic displacement analysis was performed for Section 1-1' which indicated the displacement will likely occur in the mine spoil foundation soils and range from 1.2 to 4.6 inches in magnitude. While the EPA Final CCR Rule does not explicitly state a maximum allowable seismic displacement for landfill impoundments, a limited amount of predicted displacement of a landfill liner system is considered allowable due to the ductile nature of the liner components. As such, the predicted displacements that would impact the landfill's liner system are less than 12 inches, a design limit often used for lined, municipal waste facilities (Kavazanijan, 1999). It should be further noted that this area is beyond the toe of the landfill and any structures associated with the landfill construction, therefore further reducing the risk of impact to the landfill structural components. As such, based on these analyses, the structural components of the landfill are expected to withstand the impact from the design seismic loads without discharge of waste or contaminants.

3.0 CONCLUSIONS

In accordance with §257.63 the results of the engineering assessment performed on the proposed landfill have determined that the unit meets the appropriate factors of safety and is structurally sound. The landfill structural components have been designed to resist the impact from the maximum horizontal acceleration in lithified earth material for the site without discharge of waste or contaminants.

4.0 REFERENCES

- AECOM, 2017. Geotechnical Site Evaluation, Proposed CCR Landfill, Paradise Fossil Plant, Muhlenberg County, Kentucky, dated June 27, 2017.

- Stantec Consulting Services Inc. (2009). Report of Phase 1 Facility Assessment, Coal Combustion Product Impoundments and Disposal Facilities. Various Locations. Kentucky. Prepared for Tennessee Valley Authority, dated June 24, 2009.

- Kavazanijan, 1999. Seismic Design of Solid Waste Containment Facilities, Edward Kavazanijan, Jr. dated June 1999.