



October 15, 2018

Tennessee Valley Authority
1101 Market Street
Chattanooga, Tennessee 37402

**Engineer's Certification of Seismic Impact Zone Demonstration
Gypsum Disposal Area, Gypsum Disposal Area Stilling Pond 1, and Gypsum Disposal Area
Stilling Pond 2
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 Gypsum Disposal Area, Gypsum Disposal Area Stilling Pond 1, and Gypsum Disposal Area Stilling Pond 2 are in compliance with the Seismic Impact Zone Location Restriction Demonstration specified in the EPA Final CCR Rule at 40 CFR §257.63. Presented below are the project background, summary of findings, limitations and certification.

2.0 BACKGROUND

As required by 40 CFR §257.63 of the EPA Final CCR Rule, by October 17, 2018, the owner or operator of an existing surface impoundment must demonstrate either that the unit is not located in a seismic impact zone or that the unit's structural components are designed to resist the maximum horizontal acceleration in lithified earth material for the site.

3.0 SUMMARY OF FINDINGS

In support of the above demonstration, AECOM has determined that the Gypsum Disposal Area, Gypsum Disposal Area Stilling Pond 1, and Gypsum Disposal Area Stilling Pond 2 at the Paradise Fossil Plant (PAF) in Drakesboro, Kentucky, are located within a Seismic Impact Zone, (defined as an area with a Maximum Horizontal Acceleration of 0.1g). A report detailing the demonstration procedure of the Seismic Impact Zone Demonstration is attached to this document.

In accordance with 40 CFR §257.63; the results of the engineering assessment performed on the surface impoundment have determined that the unit meets the appropriate factors of safety and is structurally sound. These factors of safety indicate the impoundments' structural components have been designed to resist the maximum horizontal acceleration in lithified earth material.

Rest of Page Left Blank Intentionally



AECOM
564 White Pond Drive
Akron, OH 44320-1100
www.aecom.com

330-836-9111 tel
330-836-9115 fax

4.0 CERTIFICATION

I, Nicholas Golden, being a 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 generally accepted engineering practices; that the information contained herein is accurate as of the date of my signature below; and that Gypsum Disposal Area, Gypsum Disposal Area Stilling Pond 1, and Gypsum Disposal Area Stilling Pond 2 meet the requirements of 40 CFR § 257.63(a).

SIGNATURE  _____

DATE 10/15/18

ADDRESS: AECOM
564 White Pond Drive,
Akron, Ohio 44320

TELEPHONE: (330)-836-9111

ATTACHMENTS: Engineer's Certification of Seismic Impact Zone Demonstration (40 CFR §257.63) for Coal Combustion Residuals (CCR) Existing Surface Impoundments - Gypsum Disposal Area, Gypsum Disposal Area Stilling Pond 1, and Gypsum Disposal Area Stilling Pond 2



COAL COMBUSTION PRODUCT DISPOSAL PROGRAM

TENNESSEE VALLEY AUTHORITY – PARADISE FOSSIL PLANT
GYPSUM DISPOSAL AREA, GYPSUM DISPOSAL AREA STILLING POND 1, AND
GYPSUM DISPOSAL AREA STILLING POND 2
DRAKESBORO, KENTUCKY

ENGINEER'S CERTIFICATION SEISMIC IMPACT ZONE DEMONSTRATION (40 CFR § 257.63) FOR COAL COMBUSTION RESIDUALS (CCR) EXISTING SURFACE IMPOUNDMENTS

Prepared for



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

October 15, 2018 – Rev 0

Prepared by





TABLE OF CONTENTS

1.0	INTRODUCTION.....	1
1.1	Objective.....	1
1.2	Rule Requirements	1
1.3	Site Description.....	1
2.0	DEMONSTRATION	3
2.1	Site Stratigraphy and Geologic Setting.....	3
2.2	Seismic Events	3
2.3	Structural Analysis	4
	2.3.1 Spillway Structural Integrity	4
	2.3.2 Seismic Factor of Safety.....	4
3.0	CONCLUSIONS	7
4.0	REFERENCES.....	7

FIGURES

Figure 1: TVA PAF Site Location

Figure 2: Site Overview

Figure 3: GEI Critical Cross-Sections

Figure 4: Gypsum Disposal Area Critical Cross-Sections

TABLES

Table 1: Gypsum Disposal Area Seismic Safety Factors for Critical Cross Sections

Table 2: Gypsum Disposal Area Stilling Pond 1 and Stilling Pond 2 Seismic Safety Factors for Critical Cross Sections



1.0 INTRODUCTION

1.1 OBJECTIVE

The purpose of this demonstration is to evaluate 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 Gypsum Disposal Area, Gypsum Disposal Area Stilling Pond 1 and Gypsum Disposal Area Stilling Pond 2 at the Tennessee Valley Authority (TVA) Paradise Fossil Plant (PAF).

1.2 RULE REQUIREMENTS

40 CFR §257.63(a) *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 by the dates specified in paragraph (c) of this section 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.*

40 CFR §257.63(b) *The owner or operator of the CCR unit must obtain a certification from a qualified professional engineer stating that the demonstration meets the requirements of paragraph (a) of this section.*

40 CFR §257.63(c) *The owner or operator of the CCR unit must complete the demonstration required by paragraph (a) of this section by the date specified in either (c)(1) or (2) of this section*

40 CFR §257.63(c)(1) *For an existing surface impoundment, the owner or operator must complete the demonstration on later than October 17, 2018.*

1.3 SITE DESCRIPTION

PAF is located in Drakesboro, Kentucky along the southwestern side of the Green River and State Route 176. The plant sits inside the eastern border of Muhlenberg County as depicted below in **Figure 1**. The Gypsum Disposal Area manages process water flows and CCR waste during power generation. The Gypsum Disposal Area has two stilling ponds called Stilling Ponds 1 & 2. These ponds receive process water and stormwater drainage from the Gypsum Disposal Area and the surrounding drainage area. This area is located west of the PAF plant. It is bordered by hilly and grassy areas on all four sides. Stilling Pond 1 drains to Stilling Pond 2, which discharges to a surface water channel that eventually leads to the Peabody Ash Pond, which is located on the southeast side of the site.

The collective Gypsum Disposal Area is approximately 225 acres in area and partially enclosed by a 1.4 mile long dike with a maximum height of approximately 62 feet.

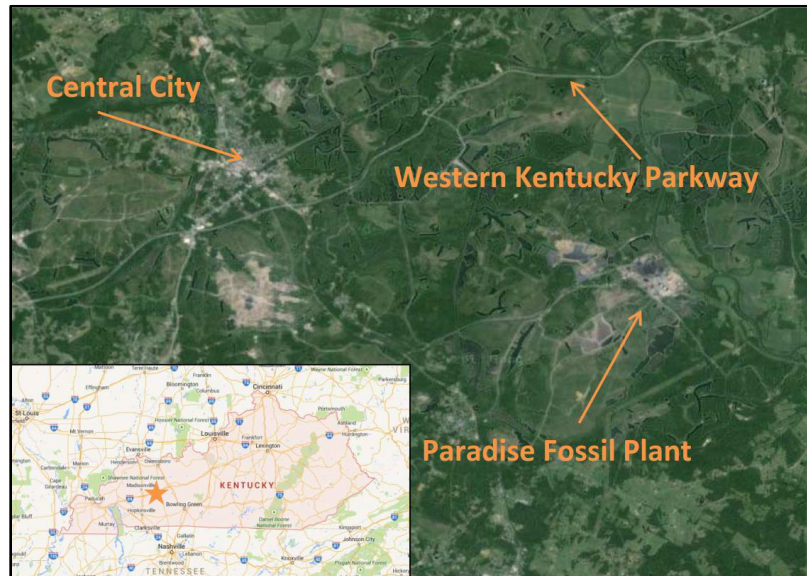


Figure 1. TVA PAF Site Location

In 1985, TVA issued the initial drawings for the original embankment and Gypsum Stack Ash Pond. TVA put the Gypsum Disposal Area (previously named Gypsum Stack Ash Pond) into service in 1986 as a conventional pond but then converted the pond to a disposal stack for co-mingled gypsum and fly ash in 1996.

Foundation soils for the original embankment were prepared by dewatering the area, clearing the vegetation, compacting the subgrade and scarification of the surficial soils in preparation for the earth fill placement. The embankment was constructed by placing earth fill material in 6" lifts and compacting them to a minimum 95% of maximum dry density within a moisture range of -3% to +3% of optimum moisture as determined by ASTM D698 (Standard Proctor Method).

The Gypsum Stack Ash Pond was comprised of two adjoining ponds identified as the East Pond and the West Pond. The construction drawings for the original embankment included the installation of an internal drain system consisting of chimney drains, perforated collector pipes and finger drains.

Construction documents from 1993 show additional construction activities at the Gypsum Disposal Area. Construction included raising the southern dike, construction of eastern and western perimeter dikes, and an internal divider dike. By 1996, the expansion was completed, and TVA switched to gypsum-fly ash stacking. Co-mingled gypsum and fly ash sludge from Units 1 and 2 sluiced to the gypsum stack at the north end of the East Pond. When the units were in operation the West Pond portion of the facility received gypsum from Unit 3's wet FGD scrubber system. The facility is being operated utilizing the upstream method of construction and rim-ditch mode of operation, which allows for achieving proper compaction along rim areas of dikes. **Figure 2** provides a current aerial of the site.

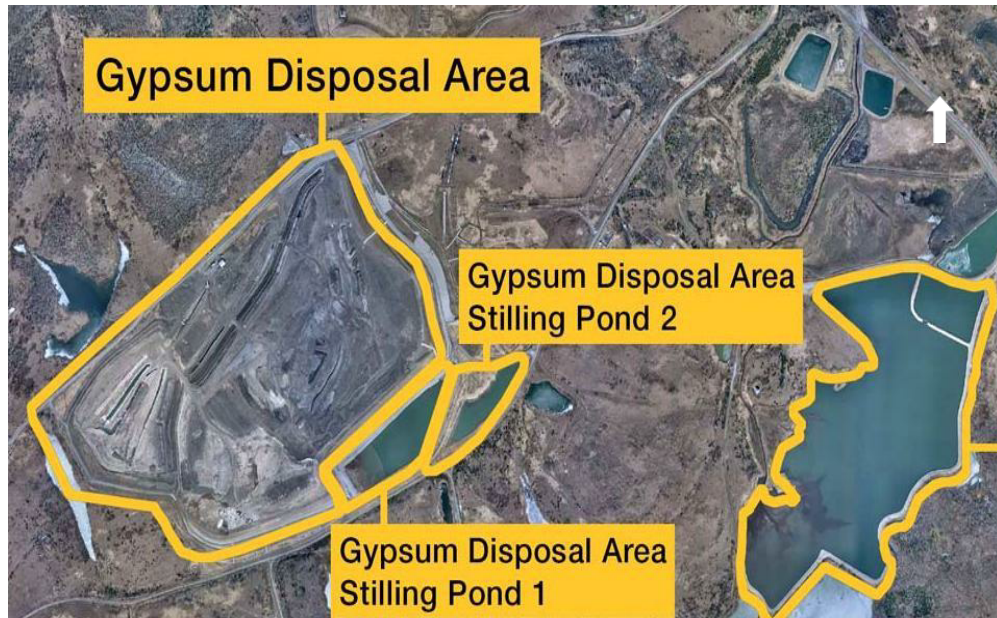


Figure 2. Site Overview

2.0 DEMONSTRATION

2.1 SITE STRATIGRAPHY AND GEOLOGIC SETTING

PAF lies within the Shawnee Hills section of the Interior Low Plateau Physiographic Province in Northwestern Kentucky and Carbondale Formation (TVA, Paradise CCR Management Operations Environmental Assessment).

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

2.3.1 SPILLWAY STRUCTURAL INTEGRITY

In 2016, the spillway structure within the Gypsum Disposal Area was replaced. The replacement spillway consists of a concrete weir structure which leads to three (3) 24-inch discharge pipes and a concrete impact basin for erosion control.

An analysis of the existing spillway structure was performed using the design earthquake for 2% exceedance in 50 years. The existing spillway is designed to resist the loading caused by the design seismic event. Therefore, the spillway structure at Gypsum Stack meets the requirement of 40 CFR §257.63(a).

2.3.2 SEISMIC FACTOR OF SAFETY

GEI Consultants performed a safety factor assessment for the Gypsum Disposal Area in 2016. These analyses included both static and seismic slope stability analyses. GEI compiled geotechnical data previously collected by GEI in 2014 and data collected by Stantec in 2010 for the completion of this assessment. Through the course of their assessment, GEI identified H-H' and K-K' as critical cross sections for seismic and K-K' as the critical cross section for liquefaction using a design earthquake loading of approximately 0.16g. The critical cross sections are shown below in **Figure 3**.



Figure 3. GEI Critical Cross-Sections K'-K' and H'-H'

A design earthquake event was simulated for the pseudo static analysis performed has a probability of exceedance of 2% in 50 years, corresponding to a return period of approximately 2,475 years per the Final CCR Rule requirements. The results pertinent to the seismic factor of safety for the stilling ponds are summarized below in **Table 1**. The evaluation was performed in accordance with 40 CFR §257.73(e) of the CCR Rule.

Table 1. Gypsum Disposal Area Safety Factors for Critical Cross Sections		
Critical Cross Section	EPA Criteria	Calculated FOS
H-H' and K-K'	Seismic Factor of Safety (Pseudo-static stability)	1.0
K-K'	Liquefaction Factor of Safety (Post-earthquake stability)	1.3

AECOM performed a static and seismic safety evaluation for the Gypsum Disposal Area Stilling Ponds 1 and 2. Slope stability analyses were performed for normal pool, flood pool, temporary loading, pseudo-static, and post-earthquake conditions at two critical cross sections which were selected during the stability analysis as representative of the most critical areas, such as, the maximum embankment height, the steepest embankment slope and the least resisting force at and beyond the downstream toe. The critical cross sections are shown below in **Figure 4**. The design earthquake event that was simulated for the pseudo-static analysis has a probability of exceedance of 2% in 50 years, corresponding to a return period of approximately 2,475 years per the EPA Final CCR Rule requirements. For this analysis a peak ground acceleration value of 0.192 g was determined.



Figure 4. Gypsum Disposal Area Critical Cross-Sections

The results pertinent to the seismic factor of safety for the stilling ponds are summarized below in **Table 2**. The evaluation was performed in accordance with 40 CFR §257.73(e) of the CCR Rule.

Table 2. Gypsum Disposal Area Stilling Pond 1 and Stilling Pond 2 Seismic Safety Factors for Critical Cross Sections

Critical Cross Section	EPA Criteria	Calculated FOS
A-A'	Seismic Factor of Safety (Pseudo-static stability)	1.13
	Liquefaction Factor of Safety (Post-earthquake stability)	1.74
B-B'	Seismic Factor of Safety (Pseudo-static stability)	1.14



	Liquefaction Factor of Safety (Post-earthquake stability)	1.77
--	--	------

The seismic assessment at PAF resulted in a seismic factor of safety of 1.13 [40 CFR §257.73(e)(1)(iii)] and a liquefaction factor of safety of 1.74 [40 CFR §257.73(e)(1)(iv)]. These results meet or exceed the minimum required seismic factor of safety of 1.00 and liquefaction factor of safety of 1.20.

3.0 CONCLUSIONS

In accordance with 40 CFR §257.63, the Gypsum Disposal Area, Gypsum Disposal Area Stilling Pond 1 and Gypsum Disposal Area Stilling Pond 2 exceed the minimum Factors of Safety for seismic stability of the dikes, and the existing surface water control systems have adequate stability to resist the maximum horizontal acceleration in lithified earth material for the site. Therefore, the existing surface impoundments that create the collective Gypsum Disposal Area meet the requirements of 40 CFR §257.63.

4.0 REFERENCES

- Geotechnical Exploration and Analysis at Paradise Fossil Plant. AECOM, 2016.
- Paradise CCR Management Operations Environmental Assessment, Tennessee Valley Authority, 2017.
- 257-73(c) History of Construction at Paradise Fossil Plant Gypsum Disposal Area. AECOM. 2016.
- 257-73(d) Structural Stability Assessment at Paradise Fossil Plant Gypsum Disposal Area. AECOM. 2016.
- 257-73(e) Safety Factor Assessment at Paradise Fossil Plant Gypsum Disposal Area. AECOM. 2016.
- Engineer's Certification of Initial Safety Factor Assessment for Coal Combustion Residuals, Gypsum Stack, Paradise Fossil Plant, GEI Consultants, 2016.