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April 5, 2018
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Tennessee Valley Authority
1101 Market Street
Chattanooga, Tennessee 37402

**RE: Seismic Impact Zones
New CCR Landfill
TVA Shawnee Fossil Plant
Paducah, McCracken County, Kentucky**

1.0 PURPOSE

As described in 40 CFR § 257.63(a), an owner or operator of a new CCR landfill is required to demonstrate that the unit is not located in seismic impact zones unless the unit meets certain requirements. This letter documents Stantec's certification that the new CCR landfill at the TVA Shawnee Fossil Plant (SHF) complies with the location restrictions for seismic impact zones in the EPA Final CCR Rule at 40 CFR § 257.63(a).

2.0 SUMMARY OF FINDINGS

The attached demonstration documents that the new CCR landfill meets the requirements set forth in 40 CFR § 257.63(a).

3.0 QUALIFIED PROFESSIONAL ENGINEER CERTIFICATION

I, Michael J. Steele, being a Professional Engineer in good standing in the Commonwealth of Kentucky, do hereby certify, to the best of my knowledge, information, and belief:

1. that the information contained in this certification is prepared in accordance with the accepted practice of engineering;
2. that the information contained herein is accurate as of the date of my signature below; and
3. that the TVA Shawnee New CCR Landfill meets the requirements specified in 40 CFR § 257.63(a).

SIGNATURE



DATE

4/5/2018

ADDRESS: Stantec Consulting Services Inc.
3052 Beaumont Centre Circle
Lexington, Kentucky 40513

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ATTACHMENTS: Seismic Impact Zones Demonstration



Seismic Impact Zones Demonstration

New CCR Landfill
TVA Shawnee Fossil Plant
Paducah, McCracken County,
Kentucky



Prepared for:
Tennessee Valley Authority
Chattanooga Tennessee

Prepared by:
Stantec Consulting Services Inc.
Lexington, Kentucky

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**SEISMIC IMPACT ZONES DEMONSTRATION
TVA SHAWNEE NEW CCR LANDFILL**

April 5, 2018

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1.0 INTRODUCTION

On April 17, 2015, the "Disposal of Coal Combustion Residuals (CCR) from Electric Utilities" (EPA Final CCR Rule) was published in 40 CFR Parts 257 and 261 of the Federal Register. The Tennessee Valley Authority (TVA) retained Stantec Consulting Services Inc. (Stantec) to review the new coal combustion residual (CCR) landfill unit at the Shawnee Fossil Plant (SHF) for compliance with certain requirements of the EPA Final CCR Rule and, as appropriate, to provide a compliance demonstration report and certification of the seismic impact zones location requirements for this CCR unit pursuant to 40 CFR § 257.63.

1.1 OBJECTIVE

As required by § 257.63 of the EPA Final CCR Rule, an owner or operator of new CCR landfills is required to demonstrate that the unit is not located in seismic impact zones unless the unit meets certain requirements. The objective of this report is to document that the new CCR landfill complies with the location restriction for seismic impact zones.

1.2 UNIT DESCRIPTION

SHF is a coal-fired, electric-generating plant. The plant is located in McCracken County, Kentucky, along the south shore of the Ohio River near river mile 946, just east of the confluence of Little Bayou Creek with the Ohio River.

The new CCR landfill will be located on the Shawnee East Site, which consists of about 205 acres that TVA acquired in 2016 next to the eastern boundary of the SHF reservation. The new CCR landfill will be constructed in three stages over a total footprint of 88 acres. The embankment will be about 115 feet tall with maximum 4H:1V slopes and will accommodate about 8 million cubic yards of CCR material (fly ash, bottom ash, and gypsum) across an estimated 25-year operational life.

2.0 CRITERIA

The EPA Final CCR Rule § 257.63 requirements for seismic impact zones are:

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.*

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While the word “resist” in the above language is not defined in the EPA Final CCR Rule, the preamble to the CCR Rule provides this guidance:

For units located in seismic impact zones, as part of any demonstration, owners and operators should include: (1) A determination of the expected peak ground acceleration from a maximum strength earthquake that could occur in the area; (2) a determination of the site-specific seismic hazards such as soil settlement; and (3) a facility design that is capable of withstanding the peak ground acceleration. Seismic designs broadly should include a response analysis to quantify the demands of earthquake motion on facility structures (i.e., landfills, surface impoundments, liners, covers, leachate collection systems, surface water handling systems), liquefaction analyses of both waste and foundation soils to evaluate stability under seismic loading, and a slope stability and deformation analyses. Design modifications to accommodate seismic risks should include use of conservative design factors, use of ductile materials, built-in redundancy for critical system components, and other measures capable of mitigating the potential for seismic upset.

The facility should be capable of “withstanding the peak ground acceleration.” The preamble provides further guidance:

Following trends in earthquake engineering, seismic design criteria for new CCR landfills, new CCR surface impoundments and all lateral expansions should be based on a “withstand without discharge” standard. EPA interprets the performance standard in this criterion (“designed to resist the maximum horizontal acceleration in lithified earth material from a probable earthquake”) to require any new CCR unit located in a seismic impact zone to be designed to withstand seismic motion from a credible earthquake without damage to the foundation or to the structures that control leachate, surface drainage, or erosion. In other words, the CCR unit must be able to withstand an expected earthquake without discharging waste or contaminants.

The CCR Rule allows for a certain amount of damage to the CCR unit due to an earthquake, provided that the facility is designed not to release CCR, leachate, and contaminants.

In practice, the Agency recognizes that the CCR unit may sustain some limited damage during an earthquake, but ultimately, the CCR unit design must remain capable of preventing harmful release of CCR, leachate, and contaminants both during and after the seismic event.

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3.0 DEMONSTRATION

The new CCR landfill at SHF was evaluated with respect to the requirements outlined in Section 2.0. A summary of the relevant engineering analyses and results are provided in this section.

3.1 SUBSURFACE PROFILE (LANDFILL, FOUNDATION SOILS, AND PHREATIC SURFACE)

A vertical profile (stratigraphic column) through the new landfill and subsurface soils down to bedrock can be divided into three primary groups:

- Landfill Materials will consist of the bottom liner, stored CCR, and the final cover (cap). Planned CCR that will be stored in the landfill includes fly ash, bottom ash, and rejected gypsum (Flue Gas Desulfurization or FGD product).
- Foundation Soils extend down to approximately 60 feet (average) below the current ground surface. For the engineering analyses, the Foundation Soils were subdivided into four alternating layers of clay and silts/sands. Data on these materials were obtained from site explorations.
- Deep Soils are much older depositions below the Foundation Soils. Less data are available for these materials, which were characterized using published information from geology maps and historical, deep borings at the SHF site. The deep soil materials consist of dense gravels, sands, silts, and clays that are assumed to be about 285 feet thick beneath the site.

Published information (Harris et al. 1994) from deep boreholes in the vicinity indicates that the top of bedrock is at approximately elevation +20 feet, which is (on average) 345 feet below the current ground surface.

During the site explorations, multiple instruments (standpipe piezometers) were installed to monitor phreatic conditions. The resulting data were used to define a design piezometric surface for computing static porewater pressures in the subsurface soils.

3.2 DESIGN EARTHQUAKE

Site-specific seismic hazard analyses were performed to determine appropriate earthquake motions for the design. The landfill was designed to resist peak accelerations having a 2% probability of exceedance in 50 years (earthquake return period of about 2,500 years). At the site, this corresponds to a magnitude 7.53 event with a peak acceleration of 0.756 g in rock.

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For the stability analyses, seven acceleration time histories were developed to represent expected bedrock motions under the landfill during a design earthquake. Ground response analyses were used to predict the resulting seismic loads in the soil column and landfill. Maximum induced cyclic stresses were computed for use in the liquefaction triggering analyses. Acceleration time histories along potential failure surfaces were also estimated, as needed for the seismic deformation analyses.

3.3 LIQUEFACTION TRIGGERING ANALYSES

The potential for triggering soil liquefaction (sandy soils) and/or cyclic softening (clayey soils) was evaluated for the deposits beneath the landfill. Published, empirical methods were used with data from the site explorations.

The results showed that varying degrees of liquefaction can be expected in the Foundation Soil layers during the design earthquake. Data from cone penetration tests indicate that about 20% of the upper sands will liquefy during the design earthquake. Similar analyses predict widespread liquefaction in the deeper sand layer. Based on the plasticity and consistency of retrieved soil samples, the upper clays are not susceptible to cyclic softening. Cyclic softening is expected in the deeper clay layer, but only under the outer edges of the landfill. Softening of the deeper clays is not predicted under the interior of the landfill, where the overburden pressures are higher. Below that, the Deep Soil deposits appear to be too dense and well consolidated to liquefy.

These results were used to select liquefied soil strengths or apply appropriate strength reductions to model the impact of seismic loading on each layer within the Foundation Soils.

3.4 SEISMIC SLOPE STABILITY AND DEFORMATION ANALYSES

The seismic stability of the landfill was evaluated by selecting critical cross sections for analysis. Conventional, two-dimensional engineering analyses were used to evaluate post-earthquake and pseudostatic stability. Seismic displacement analyses were also completed.

The results indicate stable slopes for both the pseudostatic and post-earthquake conditions (computed safety factors are greater than unity). Seismic deformations are expected, but 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 (Kavazanjian, 1999).

Infinite-slope analyses were used to evaluate the seismic stability of various material interfaces within the designed cap system. Based on available manufacturer's data, the required interface strength between the geomembrane and soil cover is attainable. However, it will be challenging to achieve the required strength in other material interfaces in the cap system. Portions of the cap may slip during an earthquake and require repair. Because the bottom liner will not be impacted and the cap's geomembrane should remain intact, the CCR and associated leachate will be contained.

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High density polyethylene (HDPE) pipes are specified for construction of the leachate collection system under the landfill. HDPE is a ductile material and the pipe will be installed with fused joints, which are as strong as the parent material. The HDPE pipe can thus sustain the expected seismic deformations without rupture.

The leachate collection pond will be incised, with a normal pool surface below the adjacent ground surface. With no dikes or exterior slopes, the potential for release of pond contents during the design earthquake is mitigated.

4.0 CONCLUSION

Based on this assessment, the new CCR landfill located at SHF meets the requirements of § 257.63 of the EPA Final CCR Rule.

5.0 REFERENCES

- Harris, J. B., Street, R. L., Kiefer, J. D., Allen, D. L., Wang, Z. M. (1994). "Modeling Site Response in the Paducah, Kentucky Area." *Earthquake Spectra*, Vol 10, No. 3.
- Kavazanjian, E., Jr. (1999). "Seismic Design of Solid Waste Containment Facilities." *Proc. Eighth Canadian Conference on Earthquake Engineering*, Vancouver, BC, June, pp. 51-89.