ATTORNEY-CLIENT PRIVILEGE CONFIDENTIAL

Technical Memorandum

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File No: 17-2015-4019

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Date: October 13, 2016

Re: Initial Structural Stability Assessment [257.73(d)]
Coal Combustion Residuals (CCR) Rule Compliance
Apache Generating Station
Arizona Electric Power Cooperative, Inc.
Cochise County, Arizona

1.0 INTRODUCTION AND SCOPE

The Environmental Protection Agency (EPA) has finalized national regulations to provide a comprehensive set of requirements for the safe disposal of coal combustion residuals (CCRs), commonly known as coal ash, from coal-fired power plants. The rule establishes technical requirements for CCR landfills and surface impoundments under subtitle D of the Resource Conservation and Recovery Act, the nation's primary law for regulating solid waste. The final rule provides greater clarity on technical requirements in response to questions received during the comment period. Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler) presents herein the draft Initial Structural Stability Assessment for the Combustion Waste Disposal Facility at the Apache Generating Station in accordance with Section 257.73(d) of 40 CFR § 257 (2015)[1],: Hazardous and Solid Waste Management Systems; Disposal of Coal Combustion Residuals (CCR) from Electric Utilities. Section 257.73(d) states that an owner or operator of a CCR unit must conduct an initial structural stability assessment and document that the design, construction, operation, and maintenance of each CCR unit is consistent with recognized and generally accepted good engineering practices for the maximum volume of CCR and CCR wastewater which can be impounded therein.

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[1] Federal Register, 40 Code of Federal Regulations (CFR) Parts 257 and 261, Hazardous and Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities, Final Rule. Vol 80, No. 74, April 17, 2015.

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2.0 REVIEW OF EXISTING GEOTECHNICAL INFORMATION

Amec Foster Wheeler reviewed the following documents during preparation of this technical memorandum:

- AGRA Earth & Environmental, Inc. (AGRA), 2000. Scrubber Pond No. 2 Dike Sloughing Investigation, Apache Generating Station, Arizona Electric Power Cooperative, Inc. Cochise County, Arizona. AGRA Job No. 0-117-001043, Report No. 1, September 26.
- Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler), 2016a. Initial Safety Factor Assessment Report, Coal Combustion Residuals (CCR) Rule Compliance, Apache Generating Station, Arizona Electric Power Cooperative, Inc., Cochise County, Arizona. October 7.
- Amec Foster Wheeler, 2016b. 2015 Annual CCR Impoundments Inspection Report, Coal Combustion Residuals (CCR) Rule Compliance, Apache Generating Station, Arizona Electric Power Cooperative, Inc., Cochise County, Arizona. January 18.
- Amec Foster Wheeler, 2016c. Inflow Design Flood Control System Plan, Apache Generating Station, Arizona Electric Power Cooperative, Inc., Cochise County, Arizona. October 7.
- Amec Foster Wheeler, 2015. Autumn 2014 Annual Readings of Survey Monuments, Monitoring Points and Benchmarks Summary Report, Combustion Waste Disposal Facility, Apache Generating Station, Arizona Electric Power Cooperative, Inc, Cochise County, Arizona. Project No. 17-2014-4074. January 29.
- Burns & McDonnell, 1992. Arizona Electric Power Cooperative, Inc., Subsurface Investigation Report for Ash Pond Modifications at the Arizona 28 Apache Station, Cochise County, Arizona for the Arizona Electric Power Cooperative, Inc., August.
- Burns & McDonnell, 1993, Design Notes and Analysis for the Ash and Scrubber Sludge Disposal Ponds and Pond Dikes, Prepared for Arizona Electric Power Cooperative, January.
- Burns & McDonnell, 1994a, Response to ADWR Comments Regarding Dike Stability for the Ash Pond Modification Project, Prepared for Arizona Electric Power Cooperative, March.
- Burns & McDonnell, 1994b, Design Sheets Y4, Y6, Y12 and Y21, Revision 0, Waste Disposal Ponds and Appurtenances Construction, Prepared for Arizona Electric Power Cooperative Combustion Waste Disposal Facility, Issued to Owner March 10, Y4 and Y6 Issued for Bid September 20.
- Burns & McDonnell, 1995, Design Sheets Y3 Revision 1 and Y5 Revision 3, Waste Disposal Ponds and Appurtenances Construction, Prepared for Arizona Electric Power Cooperative Combustion Waste Disposal Facility, Revision to C.O. #2 January 27.
- GEI Consultant, 2009, Final Specific Site Assessment for Coal Combustion Waste Impoundments at Arizona Electric Power Cooperative (AEPCO) Apache Power Plant, Prepared for Arizona Electric Power Cooperative, December.

- Seed, R.B., Centin, K.O., Moss, R.E.S., Kammerer, A.M., Wu, J., Pestana, J.M., Riemer, M.F., Sancio, R.B., Bray, J.D., Kayen, R.E., and Faris, A. (2003). Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework. Earthquake Engineering Research Center (EERC), Report No. EERC 2003-06, College of Engineering, University of California, Berkeley.
- SHB AGRA, Inc. (SHB AGRA), 1993a. Combustion Waste Disposal Facility Fissure Investigation, Apache Generating Station, Arizona Electric Power Cooperative, Inc. Cochise County, Arizona, SHB Job No. E93-107, Communication No. 10, August 10.
- SHB AGRA, Inc. (SHB AGRA), 1993b. Preliminary Monitoring Plan, Combustion Waste Disposal Facility Fissure Investigation, Apache Generating Station, Arizona Electric Power Cooperative, Inc. Cochise County, Arizona, SHB Job No. E93-107, Communication No. 15, October 15.
- SHB AGRA, Inc. (SHB AGRA), 1994. Combustion Waste Disposal Facility Fissure Investigation, Refraction Seismic Investigation, Apache Generating Station, Cochise County, Arizona, for Arizona Electric Power Cooperative, Inc., SHB Job No. E94-125, October 14.
- U.S. Geological Survey (USGS). 2015. Design Maps Detailed Report. http://ehp3-earthquake.wr.usgs.gov/designmaps/us/report.php. July 21.
- U.S. Army Corps of Engineers (USACE). 2001- Design and Construction of Levees, EM 1110-2-1913, April.

Arizona Electric Power Cooperative, Inc. (AEPCO) owns and operates the Apache Generating Station (the Station). The seven electric generating units at the Station include two coal/natural gas-fired units. Ash waste from coal combustion and scrubber sludge from flue gas desulfurization systems (scrubbers) at the two coal/natural gas-fired units are discharged to the Station's Combustion Waste Disposal Facility (CWDF). The CWDF consists of four ash ponds, two scrubber sludge ponds and one evaporation pond. The floors of the impoundments are lined with 60-mil-thick, high-density polyethylene (HDPE) and the sides of the impoundments are lined with 80-mil-thick HDPE. Special liner designs were used in the scrubber ponds and in the evaporation pond to account for the presence of known earth fissures beneath the ponds. The CWDF was designed to hold 20 years of CCR; however, sales of fly ash have extended the anticipated life of the facility. Ash Pond Nos. 1 through 4 and Scrubber Pond No. 2 are subject to the CCR Rule. As of August 10, 2015, Scrubber Pond No. 1 is no longer receiving CCR containing materials and is not considered by AEPCO to be subject to the CCR Rule. The Evaporation Pond does not store CCR, and is not subject to the CCR Rule.

3.0 EPA REQUIREMENTS

Section 257.73(d) states that an owner or operator of a CCR unit must conduct an initial structural stability assessment and document that the design, construction, operation, and maintenance of each CCR unit is consistent with recognized and generally accepted good engineering practices for the maximum volume of CCR and CCR wastewater which can be impounded therein.

The initial structural stability assessment must be supported by appropriate engineering calculations and address the following sections of **257.73(d)(1)**:

(i) Stable foundations and abutments;

(ii) Adequate slope protection to protect against surface erosion, wave action, and adverse effects of sudden drawdown;

(iii) Dikes mechanically compacted to a density sufficient to withstand the range of loading conditions in the CCR unit;

(iv) Vegetated slopes of dikes and surrounding areas not to exceed a height of six inches above the slope of the dike, except for slopes which have an alternate form or forms of slope protection[2];

(v) A single spillway or a combination of spillways configured as specified in (d)(1)(v)(A). The combined capacity of all spillways must be designed, constructed, operated, and maintained to adequately manage flow during and following the peak discharge from the event specified in (d)(1)(v)(B).

(v)(A) All spillways must be either:

(1) Of non-erodible construction and designed to carry sustained flows; or

(2) Earth- or grass-lined and designed to carry short-term, infrequent flows at non-erosive velocities where sustained flows are not expected.

(v)(B) The combined capacity of all spillways must adequately manage flow during and following the peak discharge from a:

(1) Probable maximum flood (PMF) for a high hazard potential CCR surface impoundment; or

(2) 1000-year flood for a significant hazard potential CCR surface impoundment; or

(3) 100-year flood for a low hazard potential CCR surface impoundment.

(vi) Hydraulic structures underlying the base of the CCR unit or passing through the dike of the CCR unit that maintain structural integrity and are free of significant deterioration, deformation, distortion, bedding deficiencies, sedimentation, and debris which may negatively affect the operation of the hydraulic structure; and

(vii) Item (d)(1)(vii) is for CCR units with downstream slopes which can be inundated by the pool of an adjacent water body, such as a river, stream or lake, downstream slopes that maintain structural stability during low pool of the adjacent water body or sudden drawdown of the adjacent water body.

The following sections, 257.73 (d)(1)(i) through (vii) address the Initial Structural Stability Assessment for the CCR impoundments at AEPCO:

[2] Vegetation height vacated and remanded to the EPA for revision. Will review once EPA revises.

§ 257.73 (d)(1)(i)

Appropriate engineering calculations to assess structural stability for stable embankment foundations and abutments are presented in the Initial Safety Factor Assessment Report (Amec Foster Wheeler, 2016a). These include slope static and pseudo-static stability analyses for long-term storage pool and maximum storage pool conditions, and steady-state exit gradients for seepage analyses.

Geotechnical shear strength parameters at critical embankment cross sections for two different foundation conditions are developed and presented (Amec Foster Wheeler, 2016a) for the stability analyses. These parameters are based on field investigation results performed as part of the Initial Structural Stability Assessment and for the original CWDF design. Geotechnical parameters for the embankment materials are a unit weight of 125 pounds per cubic foot (pcf), a friction angle of 34 degrees, and cohesion of 200 pounds per square foot (psf). Two foundation material conditions are evaluated; a foundation material of clayey soils has a cohesion of 200 psf while a foundation material of sandier soils has a cohesion of 100 psf. Both foundation conditions have unit weight of 125 pcf and a friction angle of 34 degrees. Hydraulic conductivities of the clayey soils are assumed to range from 9.6×10^{-7} centimeters per second (cm/s) to 3.2×10^{-8} cm/s, and for the sandier soils to be 4.0×10^{-4} cm/s.

Steady-state seepage analyses for the critical sections were performed for two cases; long-term, maximum storage pool condition with a 3-foot freeboard, and maximum surcharge pool loading condition which represents the maximum storm event. The critical sections were analyzed for seepage, where seepage is allowed to pass through the entire cross section of the embankment. The assumed steady-state seepage condition is very conservative, as the HDPE lining system will not allow water through to develop full saturation in either case. The exit gradients ranged from 0.45 for the foundation consisting of clayey soils to 0.50 for the foundation consisting of sandier soils. The seepage analyses indicate that exit gradients at the toe of the critical sections of the embankments are less than or equal to the maximum permitted exit gradient (i) of 0.5 foot per foot as referenced in USACE Design Manual No. EM-1110-2-1913 (2001).

Conventional static and pseudostatic stability analyses of the critical embankment sections were performed for the downstream side only as it is the critical case. Cases analyzed were static long-term storage pool condition, static maximum surcharge pool condition, pseudo-static for long-term storage pool condition, and pseudo-static for maximum surcharge pool condition. Pseudo-static analyses assumed a peak ground acceleration of 0.165g, based upon a 2 percent probability of exceedance in 50 years (USGS, 2015). The stability analyses were performed on a 2-D representation of the critical cross sections using a conventional limit equilibrium method (Morgenstern and Price) to assess the minimum factor of safety for the critical sliding surface based on assumed shear strengths for each profile. The minimum acceptable factors of safety range from 1.40 to 1.50 for the static conditions and are 1.0 for the pseudo-static conditions for non-liquifable soils per 257.73 (e)(1)(i) through (iv). Calculated factors of safety range from 1.92 to 2.49 for the static stability analyses and 1.56 to 1.19 for the pseudo-static stability analyses.

Certain soil types and conditions are susceptible to liquefaction (Seed et al 2003). Soils with a PI of < 12 and an LL of < 37 are considered potentially susceptible to “classic cyclically induced liquefaction" if the water content is greater than 80 percent of the liquid limit. Soils with a PI of < 20 and a LL of < 47 are considered potentially liquefiable and detailed laboratory testing is recommended if the water content is greater than 85 percent of the liquid limit. Soils with a PI of > 20 or a LL of > 47 are generally not susceptible to classic cyclic liquefaction. Review of geotechnical data for the CWDF showed that, for soils with PI < 20, the water contents ranged from 13 to 41 percent of the liquid limit. Therefore, the site soils are not susceptible to liquefaction and additional liquefaction analyses are not required.

Earth Fissure EF2 passes through the Evaporation Pond at distances greater than 200 feet from the edges of nearby CCR regulated facilities (Scrubber Pond No. 2 to the west and Ash Pond Nos. 2 and 3 to the east). Relative displacement across that earth fissure due to differential subsidence could cause Earth Fissure EF2 to be defined as a 'fault' per § 257.53. The minimum allowable distance for a CCR regulated facility to the outermost damage zone of a fault that has moved in Holocene time is 200 feet per § 257.62(a). The closest approach of EF2 to Scrubber Pond No. 2 is about 300 feet east of the toe of the embankment near the north end of the pond. The closest approach of EF2 to Ash Pond No. 3 is 400 feet west of the toe of the embankment near the southern end of that pond. The closest approach of EF2 to Ash Pond No. 2 is about 400 feet west of the toe of the embankment near the northern end of that pond. These distances are greater than the 200-foot minimum offset required per § 257.62(a).

§ 257.73 (d)(1)(ii)

Design Sheet Y12 (Burns and McDonnell, 1992) specifies that 80-mil-thick HDPE liner be placed on the upstream face of interior embankments to protect the slopes where the slopes are in contact with impounded water or CCR fluids. At the top of exterior embankments, the HDPE liner crosses over the embankment crest, and is anchored by 0.5 feet of compacted soil fill at the top edge of the slope for a minimum lip distance of 3 feet, and then by a minimum of 2.5 feet of compacted soil fill across the embankment crest. At the top of interior embankments, the HDPE liner continues to the other interior slope with a minimum lip distance of 3 feet at the top of the slope. Embankment crests are protected with a 6-inch crushed rock surfacing that serves as access roadway. Exterior embankment slopes are protected by 8-inch thick granular slope protection.

During the Annual CCR Impoundment Inspection performed by Amec Foster Wheeler (2016b), it was observed that the crushed granular material, which has the consistency of rock rip-rap, is in place. There are no places on the exterior slopes where ponded water might come into contact with the exterior slopes. Potential for surface erosion of the exterior embankment slopes is limited to precipitation falling directly onto those exterior embankment slopes.

§ 257.73 (d)(1)(iii)

Construction Quality Assurance data obtained during construction is available and indicates that the embankments were mechanically compacted to meet the requirements of the design plans and specifications. Subsequent yearly inspections (such as Amec Foster Wheeler, 2016b) indicate that the embankments are generally performing as intended.

§ 257.73 (d)(1)(iv)

Alternative forms of slope protection rather than vegetation protect the embankment slopes. Interior slopes are protected with 80-mil-thick HDPE liner and exterior slopes are protected by crushed granular material. During the Annual CCR Impoundment Inspection (Amec Foster Wheeler, 2016b), vegetation was not observed on the slopes of the dikes.

§ 257.73 (d)(1)(v)

Design inflow is addressed by the Inflow Design Flood Control System Plan (Amec Foster Wheeler, 2016c). The CCR facilities are constructed of embankments that extend above existing grade approximately 20 feet with no access for surface water inflow, and thus have no spillways. Besides operational plant water and CCR fluids, the only inflow is from precipitation falling directly on the pond footprint area. The probable maximum precipitation (PMP) for the project site was analyzed using information for the State of Arizona (ADWR 2013). The local PMP for the project site varied from 9.8 to 15.4 inches depending on the storm type. The Tropical PMP (72-hour) of 15.4 inches was selected for design. The engineering calculations are included in the Inflow Design Flood Control System Plan (Amec Foster Wheeler, 2016c) as an attachment in accordance with § 257.82 (c)(1).

The PMP of 15.4 inches will be controlled by ensuring adequate freeboard within the ponds is available. Currently, the pond levels are maintained at least three feet below the crest in compliance with the Arizona Department of Environmental Quality and Arizona Department of Water Resources permits. Therefore, the existing ash and sludge ponds provide adequate storage to handle the rated inflow flood.

§ 257.73 (d)(1)(vi)

A visual inspection of the 24-inch HDPE pipes underlying CCR units connecting the intake towers to the Recycle Water Pump Structure at Ash Pond Nos. 1 through 4 was conducted on January 7, 2016. Charles S. Reece, IV, PE, Principal Engineer with AEPCO, Mr. Rucker, and Garrett Epstein and Steve Randall from Pro-Pipe, Inc., conducted the inspection. Four pipes, ranging from about 100 feet to 220 feet in length with welded joints at approximately 30-foot intervals, connect the intake towers at the ash ponds to the central pump structure. Mr. Reece entered the confined space and performed a visual inspection of the connection of the HDPE pipes into the pump structure. He observed that there were no cracks at the grouted pipe flange interfaces to the structure. The Pro-Pipe personnel then deployed an inspection robot into the pipes and conducted a visual inspection of the interiors of the pipes. No visible distortion or distress was observed in the video inspection. Images of the inspection, including screen grabs of video, are included in the 2015 Annual CCR Impoundments Inspection Report (Amec Foster Wheeler, 2016b).

§ 257.73 (d)(1)(vii)

The CCR unit is not subject to the requirements of this section since pools of adjacent water are not present to inundate downstream slopes.

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