EPA Comments

SUBJECT: EPA Comments on “DRAFT REPORT - Dam Safety Assessment of CCW Impoundments: TVA Paradise Fossil Power Plant”

DATE: July 25, 2012

COMMENTS

1. Report is missing front signature page.
2. On page 8, section 3.1, under Slag Ponds 2A/2B, please provide the year in which these ponds were constructed and put into operation.
3. For section 3.1.2, can you please provide a table that includes the most recent structural stability analyses and the specific results for each study per unit?
4. In section 3.1.3, the report states: “The original construction of the Scrubber Sludge Complex was completed in 1986.” However, in section 3.1, the report states: “The Scrubber Sludge Complex was originally constructed in 1983.” Please clarify/rectify the discrepancy.
5. On page 11, under section3.1.3, under the Peabody Ash Pond section, the section “3.1.4 Instrumentation” is inserted at the end of the paragraph. Please remove the title from the current paragraph and reformat.
6. On Page 10, section 3.1.2, the report states: “the potential for liquefaction of the embankment materials was not assessed, which may be prudent for the Scrubber Sludge Complex given the presence of potentially liquefiable gypsum and fly ash material forming some of the upper slopes of this impoundment.” This ought to be addressed in the conclusions (section 5) as well.
7. Remove all other Appendix material not related to Paradise Fossil Plant.
8. There is a contradiction on whether in fact liquefaction analysis was performed. Section 6.2 requests the analysis to be performed and section 3.1.2 indicates the analysis has been done.
9. Appendix A, modify checklists to indicate “Significant” hazard potential rating to prevent confusion. Keep the comment on Page 4 that says the original hazard potential ratings given in the field were revised based on additional analysis and just say “checklists were updated to reflect the rating change”.

Stantec

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October 3, 2012 let_005_175551015_rev_0

Mr. John C. Kammeyer, PE
Vice President
Tennessee Valley Authority
1101 Market Street, LP 5G
Chattanooga, Tennessee 37402

Re: Response to Recommendations
USEPA Impoundment Assessment DRAFT Report
Paradise Fossil Plant (PAF)
Muhlenberg County, Kentucky

Dear Mr. Kammeyer:

As requested, Stantec has reviewed the DRAFT report *Dam Safety Assessment of CCW Impoundments, TVA Paradise Fossil Power Plant* dated July 10, 2012 prepared by O'Brien & Gere for the United States Environmental Protection Agency (USEPA). The purpose of this letter is to address O'Brien & Gere's conclusions and recommendations pertaining to structural stability, hydrologic/hydraulic (H&H) capacity, and technical documentation; and to provide additional supporting information relative to ongoing plant improvements, further analysis, and planned activities where applicable. O'Brien & Gere's recommendations and Stantec's corresponding responses are listed below.

O'Brien and Gere Report Section 6.2 – Scrubber Sludge Complex Heading:

- *Establish appropriate spillway design flood given the Hazard Classification of each unit.*
- *Design and construct an emergency overflow spillway to safely pass the appropriate spillway design flood.*
- *Raise low portion of Lower Stilling Pond dike as appropriate in conjunction with the design of the emergency overflow spillway.*

Stantec Response: The spillway design flood for all of TVA's Significant Hazard ash disposal impoundments has been established to be the 100% Probable Maximum Flood - PMF, in accordance with TVA's Coal Combustion Products Management Program Master Programmatic Document. Stantec's H&H Analysis for the Scrubber Sludge Complex demonstrated that the Upper Stilling Pond can safely contain and pass the 6-hour PMP storm under existing conditions. Therefore, no further actions are needed for this facility to be considered satisfactory. At the conceptual final closure phase; however, the Upper

Stilling Pond's spillway system and existing freeboard is not adequate to pass the spillway design flood. As part of the closure plan it will be necessary to either eliminate the Upper Stilling Pond, or to retro-fit with an emergency overflow spillway that can handle the 100% PMF.

The Lower Stilling Pond does not have sufficient spillway capacity or freeboard for the 100% PMF. It is currently capable of passing the 10-year 24-hour storm before the haul road that forms its southern boundary is overtopped. However, the Lower Stilling Pond is mostly incised below existing grade. It is therefore not envisioned that an overtopping event would cause loss of the impoundment, that ash would be released, or other unacceptable consequences would occur.

Stantec understands that TVA is planning to raise the low portion of the haul road and provide armoring of the haul road. This will be done so the combination of spillway capacity and freeboard will pass the 100-year 24-hour storm, and damage to the haul road embankment is minimized during an overtopping event for greater frequency storms.

O'Brien and Gere Report Section 6.2 – Scrubber Sludge Complex Heading: *Perform liquefaction potential analysis to determine if additional stability analyses are warranted.*

Stantec Response: Stantec performed a liquefaction potential assessment based on ground motion estimates for the 2,500-year earthquake scenarios, Standard Penetration Test borings, and corresponding laboratory test results. A description of the methodology and the results (ground response analysis and factor of safety against liquefaction versus elevation) are attached. Consistent with previously submitted seismic stability analyses, Section G was analyzed. The results show that liquefaction will not occur for the 2,500-year earthquake; therefore, additional stability analysis is not needed.

O'Brien and Gere Report Section 6.2 – Peabody Ash Pond Heading:

- *Establish appropriate spillway design flood given the Hazard Classification of each unit.*
- *Design and construct emergency overflow spillway to safely pass the appropriate spillway design flood.*

Stantec Response: The spillway design flood for all of TVA's Significant Hazard ash disposal impoundments has been established to be the 100% PMF, in accordance with TVA's Coal Combustion Products Management Program Master Programmatic Document. Stantec's H&H Analysis for the Peabody Ash Pond demonstrates that this facility safely passes the 100-year 24-hour storm, but it does not pass the PMP. Consequently, TVA plans to design and construct a new overflow spillway that will provide required freeboard and conveyance.

O'Brien and Gere Report Section 6.2 – Slag Ponds 2A/2B Heading:

- *Establish appropriate spillway design flood given the Hazard Classification of each unit.*
- *Design and construct emergency overflow spillway to safely pass the appropriate spillway design flood.*

Stantec Response: The spillway design flood for all of TVA's Significant Hazard ash disposal impoundments has been established to be the 100% PMF, in accordance with TVA's Coal Combustion Products Management Master Program Programmatic Document. Stantec's H&H Analysis for Slag Ponds 2A/2B demonstrates that these facilities safely pass the 100-year 24-hour storm, but they do not pass the PMP. Consequently, TVA plans to design and construct new overflow spillways that will provide required freeboard and conveyance at Slag Ponds 2A and 2B.

O'Brien and Gere Report Section 6.2 – Peabody Ash Pond (Maintenance):

- *Clear trees and vegetation on lower outboard slope of east dike.*
- *Armor lower outboard slope of east dike with riprap where steeper than 2.5H: 1V.*

Stantec Response: TVA plans to implement the above recommendations as part of an upcoming remediation project.

O'Brien and Gere Report Section 6.2 – Slag Ponds 2A/2B (Maintenance):

- *Clear trees and vegetation on lower outboard slope of east dike of Slag Pond 2B and Stilling Pond.*
- *Seal cracks in open channel spillway that conveys flow from Pond 2B to the Stilling Pond.*
- *Repair erosion along edge of crest at north end of divider dike.*

Stantec Response: TVA has cleared the referenced trees and vegetation and has repaired the erosion. TVA plans to seal the cracks in the spillway.

O'Brien and Gere Report Section 6.3 – Slag Ponds 2A/2B: *The small seep identified at the northeastern outboard toe of Pond 2B should be evaluated and monitored in accordance with TVA's Seepage Action Plan.*

Stantec Response: TVA will continue to monitor this small seep in accordance with the Seepage Action Plan.

Summary

Based on the results of O’Brien and Gere’s Report, and Stantec’s responses provided, there are no immediate, compelling or urgent actions necessary at the PAF CCP facilities. Considering that TVA plans to address identified H&H issues in the future, it is Stantec’s opinion that the appropriate rating for the Dam Safety Assessment for PAF facilities is currently “Fair”, and should be upgraded to “Satisfactory” after the H&H issues have been addressed.

We appreciate the opportunity to provide these responses. If you have any questions or need additional information, please call.

Sincerely,

STANTEC CONSULTING SERVICES INC.

Stephen H. Bickel

Stephen H. Bickel, PE
Senior Principal

Randy L. Roberts

Randy L. Roberts, PE
Principal

/db/cmw

Cc: Roberto L. Sanchez, PE
Michael S. Turnbow

Attachments

GENERAL METHODOLOGY
SEISMIC STABILITY ANALYSIS
TVA FOSSIL PLANTS

1. Seismic Hazards

1.1. Regional Seismic Sources

Seismicity in the TVA service area is attributed to the New Madrid fault and smaller, less concentrated crustal faults. Located in the western region, along the borders of Tennessee, Kentucky, Missouri, and Arkansas, the New Madrid source zone is capable of producing large magnitude earthquakes ($M > 7$). Events of this size would produce relatively long durations of strong ground shaking across the entire Tennessee River Valley. Fortunately, large magnitude New Madrid events are infrequent. Other source zones that may represent significant seismic risks for TVA facilities include those in eastern Tennessee, along the Wabash River Valley, and less significant sources throughout the region. While the maximum earthquake magnitudes associated with these other sources are smaller, compared to the New Madrid events, larger site accelerations can result from the closer proximity of TVA facilities.

These two earthquake scenarios generate significantly different seismic hazards at each locality and were considered independently in the analysis. To appropriately capture the influence of each, the assessments were completed independently for:

1. New Madrid events, and
2. events from “All Other Sources”.

1.2. Site-Specific Hazards

Site-specific seismic hazards were characterized for the seismic stability assessments. AMEC Geomatrix, Inc. (Oakland, California) used the 2004 TVA “Valley-wide” seismic hazard model (Geomatrix 2004) to generate seismic inputs for each of TVA’s fossil plants. Geomatrix documented their efforts in a report (AMEC Geomatrix Inc. 2011); excerpts are included herein.

The key data sets generated by Geomatrix and utilized by Stantec are:

1. Peak ground accelerations at top of hard rock (PGA_{rock}) for two different seismic sources (New Madrid Source and All Other Sources), for the 2,500-year return period, for each fossil plant location.
2. Seismic hazard deaggregation for PGA_{rock} for the 2,500-year return period. The hazards were deaggregated into appropriately sized bins of magnitude and epicentral distance.

1.3. PGA at Ground Surface

The peak horizontal accelerations obtained from the seismic hazard study represent accelerations at the top of hard bedrock (PGA_{rock}). For the assessment of liquefaction potential, the cyclic loads on natural soils and ash deposits were estimated using the simplified method described in Youd et al. (2001). This method requires estimates of the peak horizontal acceleration at the ground surface (PGA_{soil}).

Depending on the site and ground motion characteristics, peak accelerations may be amplified or attenuated (deamplified) as the energy propagates upward through the soil profile. Numerical ground response analyses can be used to model the propagation of ground motions and compute the cyclic stresses at various locations in the soil profile. One-dimensional, equivalent-linear elastic codes like ProShake can be used for this purpose if ground motion time histories are available.

To support sophisticated analyses at sites subject to higher seismic loads (i.e., large magnitudes and large accelerations), AMEC Geomatrix developed ground motion time histories for four TVA plants: Allen (ALF), Cumberland (CUF), Gallatin (GAF), and Shawnee (SHF). Relevant excerpts of the AMEC Geomatrix deliverable are provided herein. For these sites, Geocomp and Prof. Steve Kramer (University of Washington) performed ground response analyses using ProShake. These results, including profiles of acceleration and shear stress versus depth, were used for these four facilities. Compared to the more simplified method outlined below, the ProShake results allow for a more detailed representation of the ground response, particularly for facilities with extremely deep soils such as ALF and SHF.

Given the large portfolio of facilities that were considered, a simpler approach was used for the remaining facilities in this assessment. Developed for TVA by Dr. Gonzalo Castro and GEI Consultants, and implemented by Stantec in a spreadsheet, the method approximates what would be performed via one-dimensional, equivalent-linear elastic methods. For a representative soil profile, unit weights and groundwater conditions are applied to calculate total and effective stresses in the soil column. Soil stiffness (small-strain shear modulus or shear wave velocity), modulus reduction, and damping parameters are assigned based on estimated properties and published correlations. An iterative process is then used to estimate the PGA_{soil} at the top of ground, resulting from the PGA_{rock} for a given earthquake. The GEI method does not require a ground motion time history, but yields a result that appropriately considers the thickness and properties of the site-specific foundation soils. Instead of using acceleration time histories, this method utilizes response spectra for various levels of damping, which were generated by AMEC Geomatrix for use in these analyses. Relevant excerpts of the AMEC Geomatrix deliverable are provided herein. This method is more site-specific than using generic published correlations, and is judged to give reasonable results when compared to ProShake output.

2. Liquefaction Potential Assessment

2.1. Soil Loading from Earthquake Motions

The magnitude of the cyclic shear stresses induced by an earthquake is represented by the cyclic stress ratio (CSR). The simplified method proposed by Seed and Idriss (1971) and adopted by Youd et al. (2001) was used to estimate CSR. The cyclic stresses imparted to the soil were estimated from the earthquake parameters described above, representing earthquakes on the New Madrid fault and local crustal events.

2.2. Soil Resistance from Correlations with Penetration Resistance

The resistance to soil liquefaction, expressed in terms of the cyclic resistance ratio (CRR), was assessed using the empirical NCEER methodology (Youd et al. 2001). Updates to the procedure from recently published research were used where warranted. The analyses were based on the blowcount value (N) measured in the Standard Penetration Test (SPT) or the tip resistance (q_c) measured in the Cone Penetration Test (CPT).

The NCEER procedure involves a number of correction factors. Based on the site-specific conditions and soil characteristics, engineering judgment was used to select appropriate correction factors consistent with the consensus recommendations of the NCEER panel (Youd et al. 2001). To avoid inappropriately inflating the CRR, the NCEER fines content adjustment was not applied where zero blowcounts are recorded. The magnitude scaling factor (MSF) is used in the procedure to normalize the representative earthquake magnitude to a baseline 7.5M earthquake. The earthquake magnitude (M) most representative of the liquefaction risk was determined by applying the MSF to the de-aggregation data for the 2,500-year earthquakes (New Madrid and All Other Sources).

2.3. Factor of Safety Against Liquefaction

The factor of safety against liquefaction (FS_{liq}) is defined as the ratio of the liquefaction resistance (CRR) over the earthquake load (CSR). Following TVA design guidance and the precedent set by Seed and Harder (1990), FS_{liq} is interpreted as follows:

- Soil will liquefy where $FS_{liq} \leq 1.1$.
- Expect substantial soil softening where $1.1 < FS_{liq} \leq 1.4$.
- Soil does not liquefy where $FS_{liq} > 1.4$.

Using these criteria for guidance, values of FS_{liq} computed throughout a soil deposit or cross section (at specific CPT-q_c and SPT-N locations) were reviewed in aggregate. Occasional pockets of liquefied material in isolated locations are unlikely to induce a larger failure, and are typically considered tolerable. Instead, problems associated with soil liquefaction are indicated where continuous zones of significant lateral extent exhibit low values of FS_{liq}. Engineering judgment, including consideration for the likely performance in critical areas, was used in the overall assessment for each facility.

3. Post-Earthquake Slope Stability

3.1. Characterize Post-Earthquake Soil Strengths

The post-earthquake shearing resistance of each soil and coal combustion product (CCP) was estimated with consideration for the specific characteristics of that material. Specifically:

- Full static, undrained strength parameters were assigned to unsaturated soils, where significant excess pore pressures are not anticipated to develop under seismic loading.
- In saturated clays and soils with $FS_{liq} > 1.4$, 80% of the static undrained strength was assumed. These reduced strengths account for the softening effects of pore pressure buildup during an earthquake.
- In saturated, low-plasticity, granular soils with $1.1 < FS_{liq} \leq 1.4$, a reduced strength was assigned, based on the excess pore pressure ratio, r_u (Seed and Harder 1990). Typical relationships between FS_{liq} and r_u have been published by Marcuson and Hynes (1989).
- In saturated, low-plasticity, granular soils with $FS_{liq} \leq 1.1$, a residual (steady state) strength (S_r) was estimated for the liquefied soil.

Estimates of S_r can be obtained from empirical correlations published by various researchers. Typically, residual strength (or the ratio of residual strength over vertical effective stress) is correlated to corrected SPT blowcounts or corrected CPT tip resistance, based on back analysis of liquefaction case histories. For this evaluation, a new “hybrid” model developed by Kramer and Wang (in press) was used. Their hybrid model expresses mean residual strength as a function of both corrected SPT blowcounts and vertical effective stress:

$$\overline{\ln(S_r)} = -8.444 + 0.109(N_1)_{60} + 5.379(\sigma'_{vo})^{0.1}$$

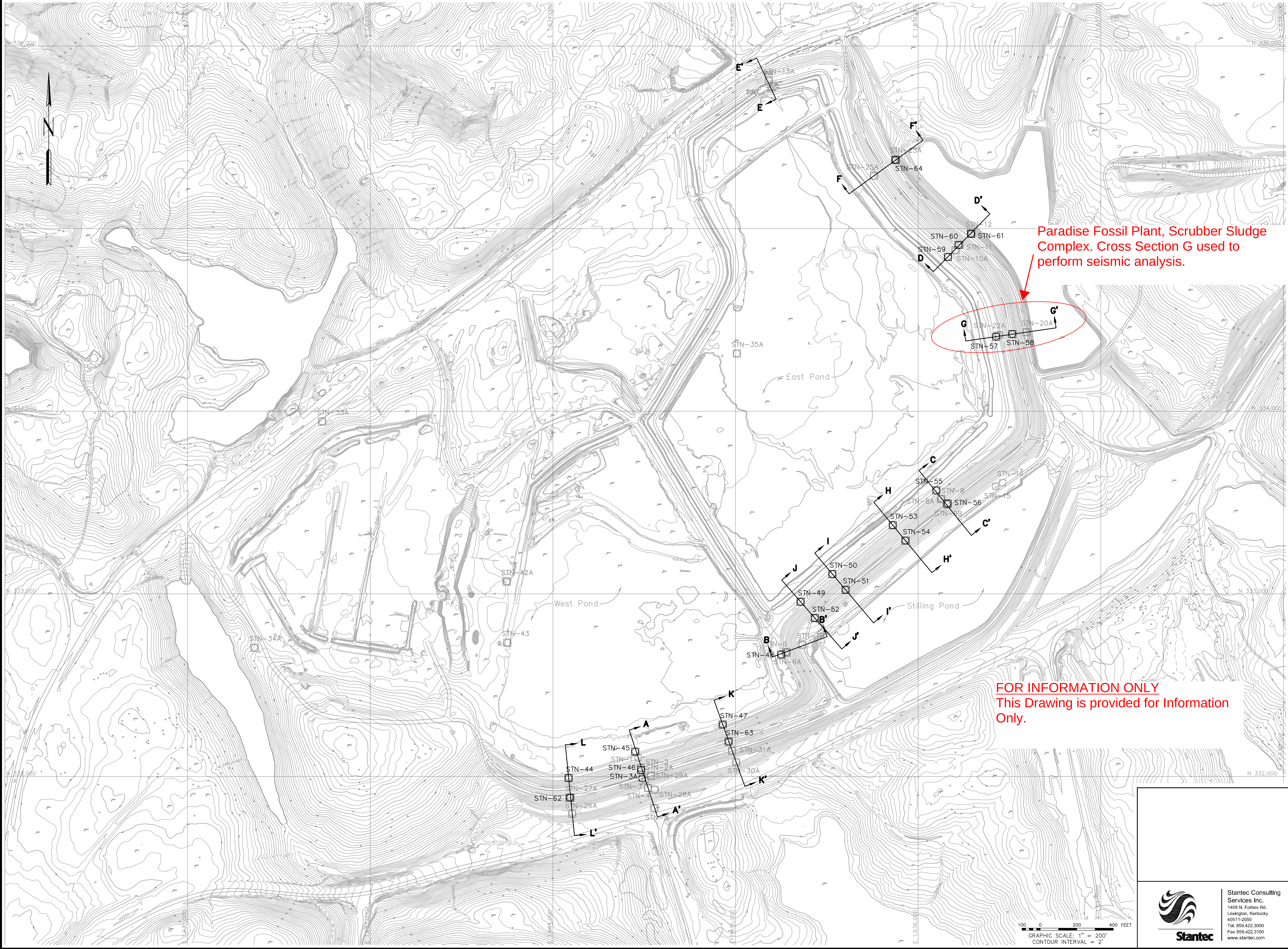
Where S_r = residual strength in atmospheres, $(N_1)_{60}$ = normalized and corrected SPT N-value, and σ_{vo}’ = initial vertical effective stress in atmospheres. A representative value of $(N_1)_{60}$ was selected for each liquefiable soil layer from a detailed review of the boring logs. SPT blowcounts judged to be erroneous or nonrepresentative of the in situ conditions were discarded. For example, excessively high blowcounts resulting from the SPT sampler hitting a cobble or boulder and excessively low blowcounts associated with borehole heave were discarded. The remaining blowcounts (in terms of $(N_1)_{60}$) were then averaged to arrive at the representative value.

3.2. Analyze Slope Stability

The next step in the evaluation considered slope stability for post-earthquake conditions, including liquefied strengths where appropriate. Slope stability was evaluated using two-dimensional, limit equilibrium, slope stability methods and reduced soil strengths (from above), representing the loss of shearing resistance due to cyclic pore pressure generation during the earthquake. The analyses were accomplished using Spencer’s method of analysis, as implemented in the SLOPE/W software, considering both circular and translational slip mechanisms. The analyses represent current operating conditions (geometry and phreatic levels).

If extensive liquefaction is indicated, stability was evaluated for the static conditions immediately following the cessation of the earthquake motions. Residual or steady state strengths were assigned in zones of liquefied soil, with reduced strengths that account for cyclic softening and pore pressure build up assumed in unliquefied soil. Failure (large, unacceptable displacements) is indicated if the safety factor (FS_{slope}) computed in this step is less than one. Slopes exhibiting $FS_{slope} \geq 1$ with liquefaction are assumed stable with tolerable deformations.

Within SLOPE/W, the residual strength model described previously was implemented with a cohesion (equal to S_r) that varies spatially. Based on the representative $(N_1)_{60}$ value and the initial vertical effective stress, S_r was calculated and assigned at key locations within the liquefied soil layer. The strength at any other point in the deposit was interpolated in SLOPE/W, thereby recognizing the increasing strength at higher vertical effective stress.



Paradise Fossil Plant, Scrubber Sludge Complex. Cross Section G used to perform seismic analysis.

FOR INFORMATION ONLY

This Drawing is provided for Information Only.

NOTES:

1. THE TOPOGRAPHIC BASEMAP SHOWN ON THIS DRAWING WAS DEVELOPED BY STANTEC USING AN ELECTRONIC DRAWING PROVIDED BY TVA IN MARCH, 2010. THE INFORMATION IS BELIEVED TO BE APPROXIMATE AND SHOULD NOT BE USED FOR CONSTRUCTION PURPOSES.
2. THE GEOTECHNICAL INFORMATION AND DATA FURNISHED HEREIN ARE NOT INTENDED AS REPRESENTATION OR WARRANTIES BUT ARE FURNISHED FOR INFORMATION ONLY. IT SHALL BE DISTINCTLY UNDERSTOOD THAT THE OWNER OR ENGINEER WILL NOT BE RESPONSIBLE FOR ANY DEDUCTION, INTERPRETATION OR CONCLUSION DRAWN THERE FROM. THE INFORMATION IS MADE AVAILABLE IN ORDER THAT THE CONTRACTOR MAY HAVE READY ACCESS TO THE SAME INFORMATION AVAILABLE TO THE OWNER AND THE ENGINEER AND IS NOT PART OF THIS CONTRACT.

INSTRUMENTATION LOCATION TABLE

INSTRUMENT	NORTHING	EASTING	GROUND SURFACE ELEVATION (FEET)	PIEZOMETER TIP ELEVATION (FEET)
STN-1*	332,102.89	1,634,466.78	509.9	NA
STN-2	332,046.91	1,634,482.61	494.3	437.1
STN-2A	332,046.91	1,634,482.61	494.3	468.9
STN-3*	331,980.02	1,634,505.77	483.5	NA
STN-3A*	331,989.56	1,634,489.16	489.8	NA
STN-4	331,937.06	1,634,520.16	467.6	420.7
STN-5	331,826.79	1,634,555.94	452.0	399.3
STN-6	332,682.25	1,635,277.08	510.9	413.1
STN-6A	332,677.36	1,635,279.66	511.0	472.6
STN-7B	332,721.84	1,635,366.07	486.8	474.4
STN-8*	333,522.45	1,636,128.32	510.2	NA
STN-8A	333,519.21	1,636,124.51	510.2	452.3
STN-9B	333,490.39	1,636,156.12	497.5	455.5
STN-10A	334,881.85	1,636,204.33	514.0	465.7
STN-11*	334,909.50	1,636,230.61	504.5	NA
STN-12	334,974.78	1,636,288.23	494.4	464.4
STN-13A	335,811.89	1,635,182.62	525.1	504.0
STN-15*	333,588.73	1,636,423.97	480.9	NA
STN-16*	333,609.25	1,636,462.16	481.1	NA
STN-20A	334,433.28	1,636,592.28	489.7	470.7
STN-22A	334,417.64	1,636,443.36	519.4	490.4
STN-23A	335,379.92	1,635,873.53	501.8	470.0
STN-25A	335,289.98	1,635,757.90	523.3	489.5
STN-26A	331,796.20	1,634,106.29	471.4	454.1
STN-27A	331,884.74	1,634,097.38	492.2	470.3
STN-28A	331,927.41	1,634,557.82	470.2	454.2
STN-29A	332,004.37	1,634,537.00	489.1	470.9
STN-30A	332,077.28	1,635,004.16	470.5	455.6
STN-31A	332,141.29	1,634,981.22	487.0	468.9
STN-33A	333,944.10	1,632,737.00	527.2	478.3
STN-34A	332,705.10	1,632,367.00	510.9	485.6
STN-35A	334,316.70	1,635,007.00	520.4	496.6
STN-42	333,067.40	1,633,747.00	515.5	470.7
STN-42A	333,067.40	1,633,747.00	515.7	500.7
STN-43	332,733.20	1,633,751.00	513.5	487.9
STN-44	331,991.72	1,634,086.60	510.0	498.1
STN-45	332,136.33	1,634,450.96	517.0	501.0
STN-46	332,034.92	1,634,483.72	496.1	486.1
STN-47	332,284.56	1,634,929.95	516.5	490.5
STN-48	332,667.56	1,635,250.39	519.9	485.1
STN-49	332,956.89	1,635,356.31	523.9	501.0
STN-50	333,108.69	1,635,530.13	524.0	502.0
STN-51	333,022.54	1,635,602.72	498.9	486.9
STN-52	332,867.62	1,635,433.99	495.9	481.5
STN-53	333,376.37	1,635,860.86	523.5	504.1
STN-54	333,291.99	1,635,930.41	500.6	487.1
STN-55	333,566.60	1,636,099.43	523.7	514.7
STN-56	333,494.76	1,636,161.26	500.0	482.0
STN-57	334,409.01	1,636,426.68	524.9	511.9
STN-58	334,422.92	1,636,515.29	506.7	480.1
STN-59	334,845.21	1,636,162.73	525.6	512.0
STN-60	334,911.36	1,636,220.95	508.0	496.7
STN-61	334,971.36	1,636,290.43	494.4	485.4
STN-62	331,883.99	1,634,092.50	491.9	480.1
STN-63	332,191.18	1,634,962.04	494.5	487.0
STN-64	335,375.88	1,635,876.57	502.0	485.4

* DENOTES SLOPE INCLINOMETER

LEGEND

⊠	EXISTING PIEZOMETER (INSTALLED SEPT. 2010)
○	EXISTING SLOPE INCLINOMETER (INSTALLED SEPT. 2010)
⊠	EXISTING PIEZOMETER (PREVIOUSLY INSTALLED)
○	EXISTING SLOPE INCLINOMETER (PREVIOUSLY INSTALLED)

PLOT DATE: 08/25/2011 USER: FLYNN, RENEE
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REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R –	–	–	–	–	–	–	–	–	–	–	–
R –	–	–	–	–	–	–	–	–	–	–	–

DISCIPLINE INTERFACE
1
2
3
4

SCALE: 1"=200' EXCEPT AS NOTED

YARD
SCRUBBER SLUDGE COMPLEX

GEOTECHNICAL EXPLORATION INSTRUMENTATION PLAN

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
–	–	–	–	–	–	–

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PARADISE FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R 2000	DATE –	64	C	XXWXXX–01	R 0

STANTEC	0
TASK COMPLETED BY:	REV NO.

PLOT FACTOR:200
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

Top of Hard Rock Accelerations (from AMEC Geomatrix 2011a)

TABLE 10

HAZARD RESULTS FOR THE PARADISE FOSSIL PLANT

Seismic Sources	**Return Period (years)[1]**	**Annual Probability of Exceedance**	**PGA[1] (g)**	**S_a(0.2)[2] (g)**	**S_a(0.4) (g)**	**S_a(1.0) (g)**	**S_a(2.0) (g)**	**S_a(4.0) (g)**
New Madrid Seismic Zone	2,500	0.0004	0.1156	0.2052	0.156	0.0778	0.0522	0.0245
	1,500	0.00067	0.0859	0.1484	0.1171	0.0577	0.0355	0.0155
	1,000	0.001	0.0632	0.1137	0.0877	0.0429	0.0229	0.0108
	500	0.002	0.0243	0.0427	0.0326	0.0123	0.0064	0.0025
	250	0.004	0	0	0	0	0	0
	100	0.01	0	0	0	0	0	0
All Other Seismic Sources	2,500	0.0004	0.1126	0.1670	0.1133	0.0513	0.0316	0.0136
	1,500	0.00067	0.0863	0.1287	0.0863	0.0380	0.0222	0.0097
	1,000	0.001	0.0690	0.1046	0.0681	0.0298	0.0165	0.0069
	500	0.002	0.0464	0.0690	0.0447	0.0179	0.0100	0.0039
	250	0.004	0.0295	0.0442	0.0274	0.0107	0.0055	0.0021
	100	0.01	0.0140	0.0211	0.0129	0.0046	0.0022	0.0008

Notes
1. Peak ground acceleration
2. S_a(0.2) refers to the 5% damped spectral acceleration at a spectral period of 0.2 seconds (spectral frequency of 5 cycles/sec).

Response Spectra Used in Ground Response Analysis (from AMEC Geomatrix 2011b)
Hazard Results for the Paradise Fossil Plant

Seismic Sources	Return Period (years)[1]	Annual Probability of Exceedance	PGA[1] (g)	$S_a(0.2)$[2] (g)	$S_a(0.4)$ (g)	$S_a(1.0)$ (g)	$S_a(2.0)$ (g)	$S_a(4.0)$ (g)
New Madrid Seismic Zone	2,500	0.0004	0.1156	0.3347	0.2418	0.1148	0.0741	0.0337
	1,500	0.00067	0.0859	0.2420	0.1815	0.0851	0.0504	0.0213
	1,000	0.001	0.0632	0.1854	0.1360	0.0633	0.0325	0.0148
	500	0.002	0.0243	0.0696	0.0505	0.0181	0.0091	0.0034
	250	0.004	0	0.0000	0.0000	0.0000	0.0000	0.0000
	100	0.01	0	0.0000	0.0000	0.0000	0.0000	0.0000
All Other Seismic Sources	2,500	0.0004	0.1126	0.2724	0.1756	0.0754	0.0444	0.0184
	1,500	0.00067	0.0863	0.2099	0.1338	0.0558	0.0311	0.0130
	1,000	0.001	0.069	0.1706	0.1056	0.0437	0.0230	0.0092
	500	0.002	0.0464	0.1125	0.0693	0.0262	0.0139	0.0052
	250	0.004	0.0295	0.0721	0.0425	0.0156	0.0076	0.0027
	100	0.01	0.014	0.0344	0.0200	0.0067	0.0030	0.0010

Notes

1. Peak ground acceleration.
2. $S_a(0.2)$ refers to the 1% damped spectral acceleration at a spectral period of 0.2 seconds (spectral frequency of 5 cycles/sec).

Response Spectra Used in Ground Response Analysis (from AMEC Geomatrix 2011b)
Hazard Results for the Paradise Fossil Plant

Seismic Sources	Return Period (years)[1]	Annual Probability of Exceedance	PGA[1] (g)	$S_a(0.2)$[2] (g)	$S_a(0.4)$ (g)	$S_a(1.0)$ (g)	$S_a(2.0)$ (g)	$S_a(4.0)$ (g)
New Madrid Seismic Zone	2,500	0.0004	0.1156	0.2435	0.1827	0.0900	0.0598	0.0278
	1,500	0.00067	0.0859	0.1761	0.1372	0.0667	0.0407	0.0176
	1,000	0.001	0.0632	0.1349	0.1027	0.0496	0.0262	0.0123
	500	0.002	0.0243	0.0507	0.0382	0.0142	0.0073	0.0028
	250	0.004	0	0.0000	0.0000	0.0000	0.0000	0.0000
	100	0.01	0	0.0000	0.0000	0.0000	0.0000	0.0000
All Other Seismic Sources	2,500	0.0004	0.1126	0.1982	0.1327	0.0592	0.0361	0.0154
	1,500	0.00067	0.0863	0.1527	0.1011	0.0439	0.0253	0.0109
	1,000	0.001	0.069	0.1241	0.0798	0.0344	0.0188	0.0078
	500	0.002	0.0464	0.0819	0.0524	0.0206	0.0114	0.0044
	250	0.004	0.0295	0.0525	0.0321	0.0123	0.0062	0.0023
	100	0.01	0.014	0.0250	0.0151	0.0053	0.0025	0.0009

Notes

1. Peak ground acceleration.
2. $S_a(0.2)$ refers to the 3% damped spectral acceleration at a spectral period of 0.2 seconds (spectral frequency of 5 cycles/sec).

Response Spectra Used in Ground Response Analysis (from AMEC Geomatrix 2011b)
Hazard Results for the Paradise Fossil Plant

Seismic Sources	Return Period (years)[1]	Annual Probability of Exceedance	PGA[1] (g)	$S_a(0.2)$[2] (g)	$S_a(0.4)$ (g)	$S_a(1.0)$ (g)	$S_a(2.0)$ (g)	$S_a(4.0)$ (g)
New Madrid Seismic Zone	2,500	0.0004	0.1156	0.2052	0.156	0.0778	0.0522	0.0245
	1,500	0.00067	0.0859	0.1484	0.1171	0.0577	0.0355	0.0155
	1,000	0.001	0.0632	0.1137	0.0877	0.0429	0.0229	0.0108
	500	0.002	0.0243	0.0427	0.0326	0.0123	0.0064	0.0025
	250	0.004	0	0	0	0	0	0
	100	0.01	0	0	0	0	0	0
All Other Seismic Sources	2,500	0.0004	0.1126	0.167	0.1133	0.0513	0.0316	0.0136
	1,500	0.00067	0.0863	0.1287	0.0863	0.038	0.0222	0.0097
	1,000	0.001	0.069	0.1046	0.0681	0.0298	0.0165	0.0069
	500	0.002	0.0464	0.069	0.0447	0.0179	0.01	0.0039
	250	0.004	0.0295	0.0442	0.0274	0.0107	0.0055	0.0021
	100	0.01	0.014	0.0211	0.0129	0.0046	0.0022	0.0008

Notes

1. Peak ground acceleration
2. $S_a(0.2)$ refers to the 5% damped spectral acceleration at a spectral period of 0.2 seconds (spectral frequency of 5 cycles/sec).

Response Spectra Used in Ground Response Analysis (from AMEC Geomatrix 2011b)
Hazard Results for the Paradise Fossil Plant

Seismic Sources	Return Period (years)[1]	Annual Probability of Exceedance	PGA[1] (g)	$S_a(0.2)$[2] (g)	$S_a(0.4)$ (g)	$S_a(1.0)$ (g)	$S_a(2.0)$ (g)	$S_a(4.0)$ (g)
New Madrid Seismic Zone	2,500	0.0004	0.1156	0.1820	0.1392	0.0699	0.0470	0.0221
	1,500	0.00067	0.0859	0.1316	0.1045	0.0518	0.0320	0.0140
	1,000	0.001	0.0632	0.1009	0.0782	0.0385	0.0206	0.0097
	500	0.002	0.0243	0.0379	0.0291	0.0110	0.0058	0.0023
	250	0.004	0	0.0000	0.0000	0.0000	0.0000	0.0000
	100	0.01	0	0.0000	0.0000	0.0000	0.0000	0.0000
All Other Seismic Sources	2,500	0.0004	0.1126	0.1481	0.1011	0.0461	0.0286	0.0124
	1,500	0.00067	0.0863	0.1142	0.0770	0.0342	0.0201	0.0088
	1,000	0.001	0.069	0.0928	0.0608	0.0268	0.0150	0.0063
	500	0.002	0.0464	0.0612	0.0399	0.0161	0.0091	0.0036
	250	0.004	0.0295	0.0392	0.0244	0.0096	0.0050	0.0019
	100	0.01	0.014	0.0187	0.0115	0.0041	0.0020	0.0007

Notes

1. Peak ground acceleration.
2. $S_a(0.2)$ refers to the 7% damped spectral acceleration at a spectral period of 0.2 seconds (spectral frequency of 5 cycles/sec).

Response Spectra Used in Ground Response Analysis (from AMEC Geomatrix 2011b)
Hazard Results for the Paradise Fossil Plant

Seismic Sources	**Return Period (years)**[1]	**Annual Probability of Exceedance**	**PGA**[1] **(g)**	**$S_a(0.2)$**[2] **(g)**	**$S_a(0.4)$ (g)**	**$S_a(1.0)$ (g)**	**$S_a(2.0)$ (g)**	**$S_a(4.0)$ (g)**
New Madrid Seismic Zone	2,500	0.0004	0.1156	0.1595	0.1223	0.0616	0.0416	0.0196
	1,500	0.00067	0.0859	0.1153	0.0918	0.0457	0.0283	0.0124
	1,000	0.001	0.0632	0.0884	0.0688	0.0340	0.0183	0.0087
	500	0.002	0.0243	0.0332	0.0256	0.0097	0.0051	0.0020
	250	0.004	0	0.0000	0.0000	0.0000	0.0000	0.0000
	100	0.01	0	0.0000	0.0000	0.0000	0.0000	0.0000
All Other Seismic Sources	2,500	0.0004	0.1126	0.1298	0.0888	0.0407	0.0254	0.0110
	1,500	0.00067	0.0863	0.1000	0.0677	0.0302	0.0179	0.0079
	1,000	0.001	0.069	0.0813	0.0534	0.0237	0.0133	0.0056
	500	0.002	0.0464	0.0536	0.0350	0.0142	0.0081	0.0032
	250	0.004	0.0295	0.0344	0.0215	0.0085	0.0045	0.0017
	100	0.01	0.014	0.0164	0.0101	0.0037	0.0018	0.0007

Notes

1. Peak ground acceleration.
2. $S_a(0.2)$ refers to the 10% damped spectral acceleration at a spectral period of 0.2 seconds (spectral frequency of 5 cycles/sec).

Seismic Risk Assessment

Plant:	Paradise Fossil Plant	🟩	User Input
Facility:	Scrubber Sludge Complex	🟩	Drop-down selection
Section:	G	🟦	Default value, user can modify
Seismic Zone:	New Madrid	⬜	Calculated value
# of Layers	13	🟥	Calculated value, unoptimized
Total Thickness	122.36	feet	

Global Inputs:

PGA_{SOIL}	0.1075	
Groundwater Elevation (Z_{GW})	505.07	feet
Additional Vert. Stress	0	psf
Pa	2116.8	psf
k	0	
Ko	0.5	
g	32.2	ft/s2
Yw	62.4	pcf
$G/G_{MAX,TOL}$	0.20%	
$G/G_{MAX,ACTUAL}$	0.18%	

Calculation Checks:

PGA_{SOIL} ---> ~2500 Year Return Period	OK
$G/G_{MAX,ACTUAL}$ Ratio	OK

(19) Composite Shear Wave Velocity $\overline{V}_S$	(20) Natural Period T	(22) Composite Damping Ratio $\overline{\xi}$ %	Interpolated Return Period (years)
693.5	0.7057	6.401	2498.3

Layer	Material	Elevations Z_{TOP} (feet)	Z_{BOTTOM} (feet)	Z_{MID} (feet)	Overburden (feet)	Specific Gravity G_s	Moist Unit Weight γ_{DRY} (pcf)	Saturated Unit Weight γ_{SAT} (pcf)	Over-consolidation Ratio OCR	Plasticity Index PI
1	Gypsum	512.36	505.07	508.7	3.6	2.7	115	115	1	0
2	Gypsum	505.07	495.07	500.1	12.3	2.7	115	115	1	0
3	Gypsum	495.07	485.07	490.1	22.3	2.7	115	115	1	0
4	Gypsum	485.07	475.07	480.1	32.3	2.7	120	120	1	0
5	Gypsum	475.07	468.19	471.6	40.7	2.7	120	120	1	0
6	Clay	468.19	458.19	463.2	49.2	2.7	135	135	1	0
7	Clay	458.19	448.19	453.2	59.2	2.7	135	135	1	0
8	Clay	448.19	438.19	443.2	69.2	2.7	135	135	1	0
9	Clay	438.19	428.19	433.2	79.2	2.7	135	135	1	0
10	Clay	428.19	418.19	423.2	89.2	2.7	135	135	1	0
11	Clay	418.19	408.19	413.2	99.2	2.7	135	135	1	0
12	Clay	408.19	400	404.1	108.3	2.7	135	135	1	0
13	Clay	400	390	395.0	117.4	2.7	135	135	1	0
14										
15										
16										
17										
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19										
20										
21										
22										
23										
24										
25										

Seismic Risk Assessment

Plant:	Paradise Fossil Plant	
Facility:	Scrubber Sludge Complex	
Section:	G	
Seismic Zone:	All Other Zones	
# of Layers	13	
Total Thickness	122.36	feet

🟩	User Input
🟩	Drop-down selection
🟦	Default value, user can modify
⬜	Calculated value
🟥	Calculated value, unoptimized

Global Inputs:

PGA_{SOIL}	0.0823	
Groundwater Elevation (Z_{GW})	505.07	feet
Additional Vert. Stress	0	psf
Pa	2116.8	psf
k	0	
Ko	0.5	
g	32.2	ft/s2
Yw	62.4	pcf
$G/G_{MAX,TOL}$	0.20%	
$G/G_{MAX,ACTUAL}$	0.18%	

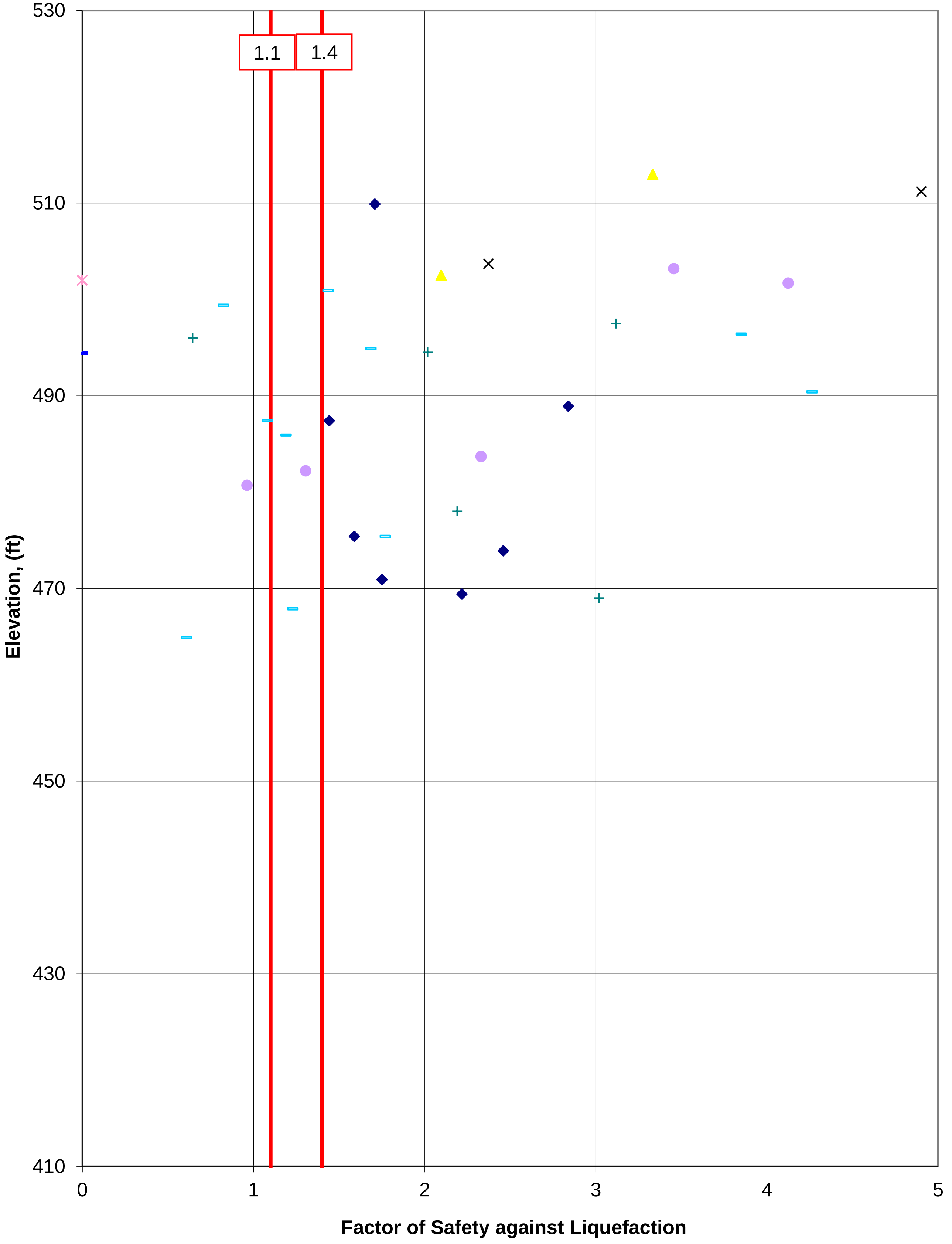
Calculation Checks:

PGA_{SOIL} ---> ~2500 Year Return Period	OK
$G/G_{MAX,ACTUAL}$ Ratio	OK

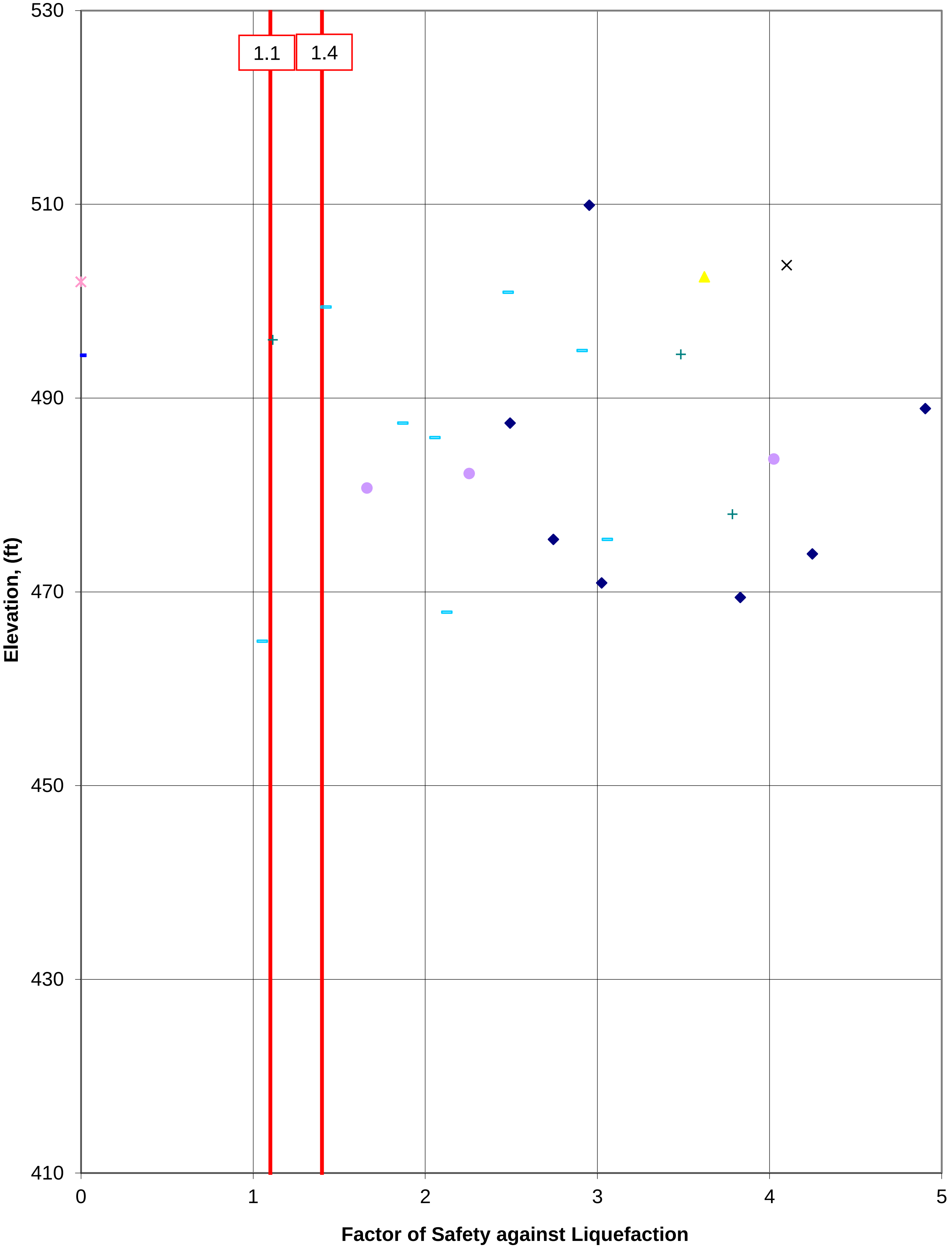
(19) Composite Shear Wave Velocity	(20) Natural Period	(22) Composite Damping Ratio	Interpolated Return Period
$\overline{V}_S$	T	$\overline{\xi}$ %	(years)
714.3	0.6852	5.333	2497.3

Layer	Material	Elevations Z_{TOP} (feet)	Z_{BOTTOM} (feet)	Z_{MID} (feet)	Overburden (feet)	Specific Gravity G_S	Moist Unit Weight Y_{DRY} (pcf)	Saturated Unit Weight Y_{SAT} (pcf)	Over-consolidation Ratio OCR	Plasticity Index PI
1	Gypsum	512.36	505.07	508.7	3.6	2.7	115	115	1	0
2	Gypsum	505.07	495.07	500.1	12.3	2.7	115	115	1	0
3	Gypsum	495.07	485.07	490.1	22.3	2.7	115	115	1	0
4	Gypsum	485.07	475.07	480.1	32.3	2.7	120	120	1	0
5	Gypsum	475.07	468.19	471.6	40.7	2.7	120	120	1	0
6	Clay	468.19	458.19	463.2	49.2	2.7	135	135	1	0
7	Clay	458.19	448.19	453.2	59.2	2.7	135	135	1	0
8	Clay	448.19	438.19	443.2	69.2	2.7	135	135	1	0
9	Clay	438.19	428.19	433.2	79.2	2.7	135	135	1	0
10	Clay	428.19	418.19	423.2	89.2	2.7	135	135	1	0
11	Clay	418.19	408.19	413.2	99.2	2.7	135	135	1	0
12	Clay	408.19	400	404.1	108.3	2.7	135	135	1	0
13	Clay	400	390	395.0	117.4	2.7	135	135	1	0
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

TVA PAF Scrubber Sludge Complex, Source = New Madrid, Mw = 7.64, PGAsoil = 0.1075 g, Return Period = 2500 years, SPT Data, NCEER Simplified Method, No Fines Correction if Zero Blowcounts



TVA PAF Scrubber Sludge Complex, Source = All Other Zones, Mw = 6.85, PGAsoil = 0.0823 g, Return Period = 2500 years, SPT Data, NCEER Simplified Method, No Fines Correction if Zero Blowcounts



Tennessee Valley Authority, 1101 Market Street, BR4A, Chattanooga, Tennessee 37402

October 19, 2012

Mr. Stephen Hoffman
US Environmental Protection Agency (EPA) (5304P)
1200 Pennsylvania Avenue, NW
Washington, DC 20460

TENNESSEE VALLEY AUTHORITY (TVA) – COMMENTS ON COAL ASH SITE ASSESSMENT ROUND 11 DRAFT REPORTS FOR ALLEN (ALF), BULL RUN, (BRF) COLBERT (COF), CUMBERLAND (CUF), GALLATIN (GAF), JOHN SEVIER (JSF), JOHNSONVILLE, (JOF) KINGSTON (KIF), PARADISE (PAF), SHAWNEE (SHF), WATTS BAR (WBF), AND WIDOWS CREEK (WOF) FOSSIL PLANTS

Dear Mr. Hoffman:

Tennessee Valley Authority (TVA) appreciates the opportunity to provide responses to the recommendations outlined in the Draft Coal Ash Site Assessment Round 11 Draft Reports for TVA's fossil plants. The Draft Reports were attached to EPA's September 5, 2012 email from Jana Englander to TVA's Susan Kelly. This EPA review process has provided TVA a public forum to confirm that our coal ash facilities meet current state requirements.

TVA has contracted with Stantec Consulting Services Inc., to assist in the technical review and responses to the EPA draft reports. The draft report responses are attached for your consideration in finalizing the Coal Ash Site Assessment Round 11 Reports. The following is a summary of our responses;

Allen: A seismic stability analysis and liquefaction analysis have been completed indicating acceptable performance under seismic loading. TVA recommends the Allen East Ash Pond be upgraded from Poor to Satisfactory.

Bull Run: TVA has no additional comments to EPA's analysis.

Colbert: TVA has no additional comments to EPA's analysis.

Cumberland: The operating pool level for the Ash Pond has been lowered 6.2 feet and the seepage analysis has been revised. Piping factors of safety are now satisfactory. TVA recommends the final rating for the Ash Pond be upgraded from Fair to Satisfactory.

A liquefaction potential assessment was performed for the Gypsum Disposal Area and showed the saturated ash materials are anticipated to undergo liquefaction for the 2,500-year earthquake. Therefore, a higher level of slope stability analysis was completed demonstrating that the factor of safety is satisfactory. TVA recommends the final rating for the Gypsum Disposal Area be upgraded from Poor to Satisfactory.

Additional seismic analysis and field investigation is underway for the Dry Fly Ash Stack. The results are indicating the possibility of a favorable response. However, the analysis is not complete. We anticipate its completion during EPA's review of these comments.

Gallatin: A seismic stability analysis for Ponds A and E has been completed with acceptable results. TVA recommends the final rating be upgraded from Fair to Satisfactory.

An additional stability and seepage analysis for the saddle dikes on the stilling ponds has been completed and a project to increase the hydrologic/hydraulic capacity of the ponds is underway. Based on the analysis and improvement plans underway, TVA recommends the Gallatin Stilling Ponds rating be upgraded from Poor to Fair and from Fair to Satisfactory once the project is completed.

John Sevier: The static and seismic slope stability analysis were reviewed and deemed to be appropriate for the soil materials present.

Johnsonville: A quantitative liquefaction analysis and a post-earthquake static slope stability analysis were performed. Results showed the slope to remain stable. As a result, TVA recommends that final rating for Ash Disposal Area 2 be upgraded from Fair to Satisfactory.

Kingston: TVA has no additional comments to EPA's analysis.

Paradise: A liquefaction analysis was performed and the hydrologic/hydraulic capacity was evaluated. The liquefaction analysis indicated that the materials would remain stable and not liquefy during a 2,500 year event. The H&H analysis confirmed that the ponds safely pass the 100-year 24-hour storm. However, they do not pass the Probable Maximum Flood. TVA has plans to design and construct features to correct this issue at the ponds. TVA recommends that the facilities at Paradise be upgraded from Fair to Satisfactory once the H&H issues have been addressed.

Shawnee: A liquefaction analysis and post-earthquake static stability analysis were performed with acceptable results. TVA recommends that the rating for Ash Pond No. 2 be upgraded from Poor to Satisfactory.

Watts Bar: A hydrologic/hydraulic analysis was performed for the design storm and the new spillway system currently under design and in construction. Based on the satisfactory outcome of the analysis; TVA recommends the final rating be upgraded from Fair to Satisfactory.

Widows Creek: TVA has no additional comments to EPA's analysis.

The following is a summary of the draft facility ratings and TVA's proposed final ratings.

EPA Draft Report Results

Plant	Facility	Draft Rating	Driver for Rating	Stantec Proposed Final Rating
ALF	East Pond	**Poor**	Seismic	**Sat**
BRF	FA Pond	**Sat**		**Sat**
	BA Pond	**Fair**	Liquefaction	**Fair**
	Gyp Pond	**Fair**	Liquefaction	**Fair**
COF	Dry Stack	**Sat**		**Sat**
	BA Pond	**Fair**	Liquefaction	**Fair**
CUF	Ash Pond	**Fair**	Piping	**Sat**
	Dry Stack	**Poor**	Seismic	**Poor**
	Gyp	**Poor**	Seismic	**Sat**
GAF	Ash Ponds	**Fair**	Liquefaction	**Sat**
	Stilling Ponds	**Poor**	H&H and static	**Fair**
JSF	Dry Stack	**Sat**		**Sat**
	Ash pond	**Sat**		**Sat**
JOF	Island	**Fair**	Liquefaction	**Sat**
KIF	Ash/stilling	**Fair**	Liquefaction	**Fair**
	GDA	**Sat**		**Sat**
PAF	Scrubber sludge	**Fair**	H&H - overtopping	**Fair**
	Ash Pond	**Fair**	H&H - overtopping	**Fair**
	Slag Ponds	**Fair**	H&H - overtopping	**Fair**
SHF	Ash Pond	**Poor**	Seismic	**Sat**
WBF	Pond	**Fair**	H&H	**Sat**
WCF	Gyp stack	**Sat**		**Sat**
	Ash Pond	**Fair**	Liquefaction	**Fair**

TVA takes its environmental responsibilities very seriously and appreciates EPA's efforts to verify the quality of our impoundments. We would like to arrange a conference call once your staff has received this letter and briefly reviewed the attached reports so we can answer any immediate questions or concerns. Please contact Susan Kelly at (423)-751-2058 or sjkelly0@tva.gov to arrange this conference call.

Sincerely,

Cynthia M. Anderson
for
Brenda E. Brickhouse
Vice President
Compliance Interface and Permits

Enclosures

SJK:LMB
Enclosures
cc (electronic distribution with enclosures):

- C. M. Anderson, BR 4A-C
- D. L. Bowling, Jr., WT 7D-K
- B. E. Brickhouse, BR 4A-C
- A. S. Cooper, OMA 1A-WDC
- D. M. Hastings, WT 6A-K
- J. C. Kammeyer, LP 5D-C
- G.A. Kelley, LP 3D-C
- S.J. Kelly, BR 4A-C
- A.A. Ray, LP3K-C
- M. S. Turnbow, LP 5G-C
- EDMS (Leslie Bailey), BR 4A-C