Stantec Consulting Services Inc.
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October 17, 2018
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Revision 0

Tennessee Valley Authority
1101 Market Street
Chattanooga, Tennessee 37402

RE: Fault Areas
Active Ash Pond 2
EPA Final Coal Combustion Residuals (CCR) Rule
TVA Johnsonville Fossil Plant
New Johnsonville, Tennessee

1.0 PURPOSE

As described in 40 CFR § 257.62(a), an owner or operator of an existing CCR surface impoundment is required to demonstrate that the unit is not located in fault areas unless the unit meets certain requirements. This letter documents Stantec's certification that Active Ash Pond 2 at the TVA Johnsonville Fossil Plant (JOF) complies with the location restrictions for fault areas in the EPA Final CCR Rule at 40 CFR § 257.62(a).

2.0 SUMMARY OF FINDINGS

The attached demonstration documents that Active Ash Pond 2 meets the requirements set forth in 40 CFR § 257.62(a).

3.0 QUALIFIED PROFESSIONAL ENGINEER CERTIFICATION

I, Stephen H. Bickel, being a Professional Engineer in good standing in the State of Tennessee, 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 Johnsonville Active Ash Pond 2 meets the requirements specified in 40 CFR § 257.62(a).

RE: Fault Areas
Active Ash Pond 2
EPA Final Coal Combustion Residuals (CCR) Rule
TVA Johnsonville Fossil Plant
New Johnsonville, Tennessee

SIGNATURE [signature] DATE 10/16/2018

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ATTACHMENTS: Fault Areas Demonstration

Fault Areas Demonstration

Active Ash Pond 2
Johnsonville Fossil Plant
New Johnsonville, Tennessee

Prepared for:
Tennessee Valley Authority
Chattanooga, Tennessee

Prepared by:
Stantec Consulting Services Inc.
Lexington, Kentucky

October 16, 2018
Revision 0

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1.0 BACKGROUND

On April 17, 2015, EPA Published the "Disposal of Coal Combustion Residuals (CCR) from Electric Utilities" final rule in the Federal Register. The Tennessee Valley Authority (TVA) contracted Stantec Consulting Services Inc. (Stantec) to evaluate the Active Ash Pond 2 at Johnsonville Fossil Plant (JOF) regarding the requirements for the Fault Areas Location Restriction as required by the EPA Final CCR Rule §257.62.

As required by §257.62 of the EPA Final CCR Rule, an owner or operator of an existing or new CCR landfill, existing or new CCR surface impoundment, or any lateral expansion of a CCR unit is required by October 17, 2018 to demonstrate that the unit is not located within 60 meters (200 feet) of the outermost damage zone of a fault that has had displacement in the Holocene time period unless the owner or operator demonstrates that measures are in place to prevent damage to the structural integrity of the CCR unit under an alternative setback distance of less than 60 meters (200 feet).

Johnsonville Fossil Plant (JOF) is located on a 685-acre reservation in New Johnsonville, Humphreys County, Tennessee. The plant is on the east bank of Kentucky Lake reservoir, approximately 12 miles west from Waverly, Tennessee, and approximately 70 miles west from Nashville, Tennessee. The plant is located in the Western Highland Rim and Gulf Coastal Plain of Tennessee. The site is underlain by bedrock primarily of Devonian age.

Active Ash Pond 2 is centered approximately 2,000 feet west from the plant's powerhouse. It was created by placing fill and then building an approximate two-mile-long perimeter dike, on an area within the former Tennessee River floodplain (now inundated by Kentucky Lake), to enclose approximately 90 acres. The perimeter dike varies from 25 to 35 feet in height.

Active Ash Pond 2 has been in operation since 1970. It formerly received sluiced fly ash and bottom ash and plant process water. It also received stormwater runoff pumped from the Coal Yard Drainage Basin. The last coal fired generating units were shut down in December 2017, therefore Active Ash Pond 2 no longer receives fly ash or bottom ash.

TVA has determined that Active Ash Pond 2 is a CCR Surface Impoundment and therefore subject to the final rule.

2.0 ASSESSMENT

This compliance demonstration was developed by conducting two tasks.

The first task was a review of available literature and published data related to the potential for faulting in the project vicinity. The results of that study, which does not identify faults within the established minimum horizontal buffer, is titled "Literature Survey and Discussion of the Geology and Seismicity of the Tennessee Valley Authority Johnsonville Fossil Plant West-Central Tennessee", and it is presented in Appendix A.

The second task was a site specific neotectonics analysis. This study evaluates existing landforms for indications of past fault activity through a compilation of lineaments and surface drainage analysis within the project vicinity. The results of this study do not identify the presence of lineaments or drainage characteristics indicative of faults within the established minimum horizontal buffer distance. The results of the study are presented in a report titled "CCR Unit Location Restrictions Demonstrations - TVA, Johnsonville Fossil Plant, New Johnsonville, Tennessee, Neotectonics Analysis," and it is presented in Appendix B.

3.0 CONCLUSIONS

Based on the assessment outlined herein, the Active Ash Pond 2 at Johnsonville Fossil Plant meet all requirements of §257.62 of the final rule for separation distance from fault areas.

APPENDIX A
LITERATURE SURVEY AND DISCUSSION OF THE GEOLOGY AND SEISMICITY OF THE TENNESSEE VALLEY AUTHORITY JOHNSONVILLE FOSSIL PLANT WEST-CENTRAL TENNESSEE

Literature Survey and Discussion of the Geology and Seismicity of the Tennessee Valley Authority Johnsonville Fossil Plant West-Central Tennessee

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University of Tennessee–Knoxville

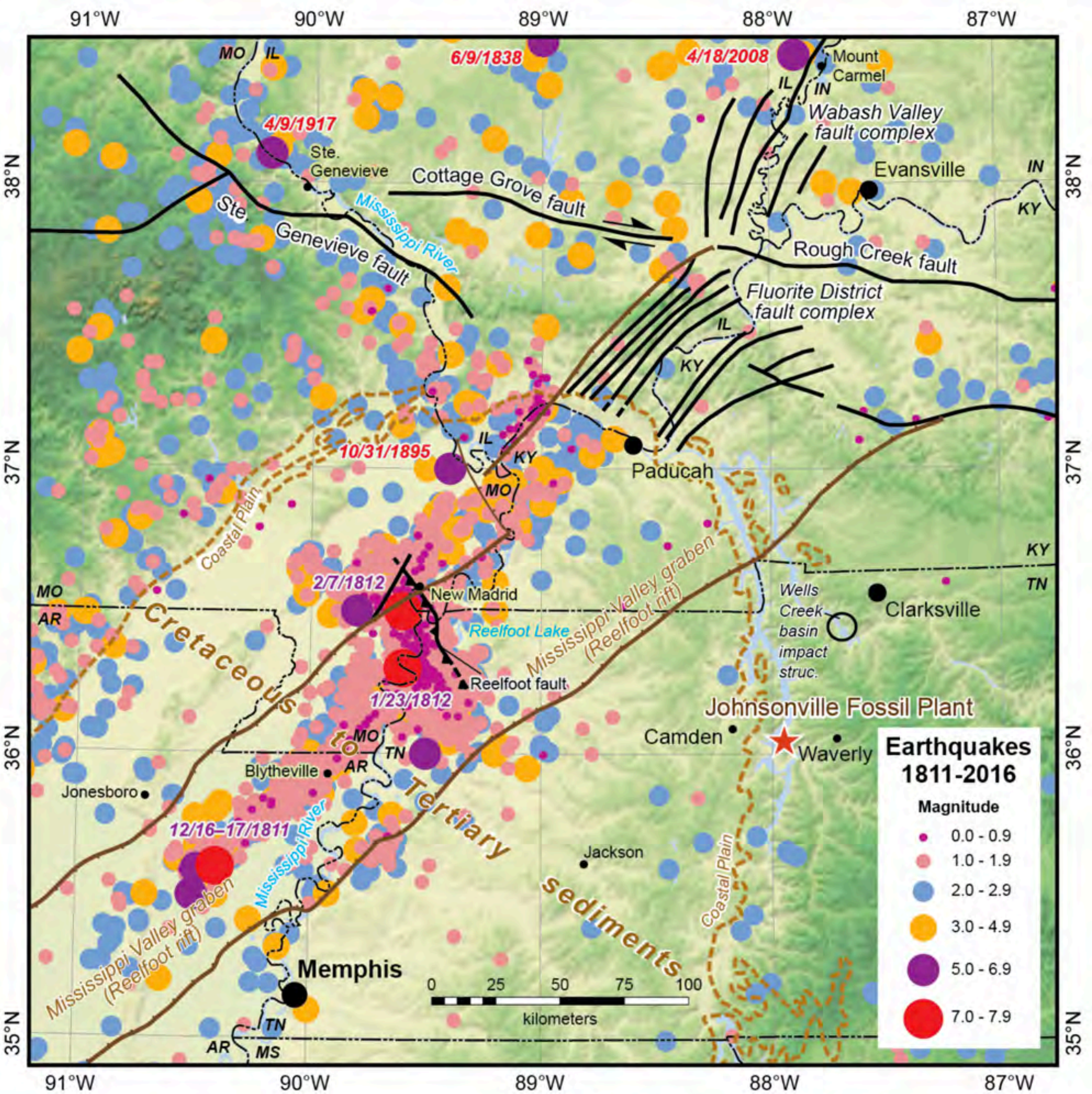
July 30, 2018

Introduction

The purpose of this report is to provide a literature survey and discussion of known active (surface displacement during the last 11,000 years—Holocene time) or potentially active (evidence of surface displacement during the last 1.6 m.y.—Quaternary time) faults (Bryant and Hart, 2007) near the Tennessee Valley Authority Johnsonville Fossil Plant and associated ash ponds at New Johnsonville in west-central Tennessee. The plant is located in Humphreys County, Tennessee, along Kentucky Lake (Tennessee River), some 12 miles west of Waverly and ~7 miles east of Camden (Fig. 1). The plant was originally commissioned in 1951 as a coal-fired plant that produced 1,500 megawatts, but was later converted to a gas turbine facility that produced 1,133 megawatts of electricity; it was decommissioned in 2017.

The references cited in this report are considered critical for understanding the geology, paleoseismology, and modern seismicity of the region, and in the vicinity of the Johnsonville Fossil Plant ash ponds. Many of the papers, maps, and reports cited herein contain additional citations that provide much greater detail about the surface and subsurface geology and seismicity of the region. Several of these reports and publications include Kellberg (1948, 1949), Marcher and Stearns (1962), Stearns and Marcher (1962), Lounsbury and Finlayson (1965), Barnes (1967), Wilson and Russell (1969), Wilson (1987), Johnston and Schweig (1996), McBride and Nelson (2001), McBride et al. (2002), Tavakoli et al. (2010), Pratt (2012), and Van Arsdale et al. (2013).

This summary is intended to summarize the available geologic and seismicity literature near and in the region surrounding the Johnsonville Fossil Plant and associated ash ponds. In particular, it is important to note any active faults within a 2-mi radius of the plant, and to chronicle the seismicity of the region that might affect the plant. The definitions below are from California Geological Survey Special Report (2007 revision); this report defines a rigorous set of criteria for evaluating seismically active faults in the state that has the greatest earthquake hazard (and population) in the U.S. *An active fault (or earthquake fault) is one that has been demonstrated to have moved during the Holocene (last 11,000 years).* This would include the zone of deformation (damage zone) on either side of the fault, which would encompass geologic structures (folds, subsidiary faults, joints and shear fractures, etc.) that would have been produced as coseismic features during movement on the fault that produced seismicity (Bryant and Hart, 2007). The California Geological Survey defined the boundaries of “Earthquake Fault Zones” to be located ~500 ft (150 m) from a major active fault and 200 to 300 ft (60-90 m) from well-defined minor faults (Bryant and Hart, 2007, p. 42).



Sources: Linework - Natl. Atlas Data; EQs - USGS/NEIC, CERI, & Stover, C. W. and Coffman, J. L., 1993; Faults - McBride & Nelson (2001), Hough et al. (2000), and Johnston & Schweig (1996)

Figure 1. Location map for the Tennesee Valley Authority Johnsonville Fossil Plant (red star), regional seismicity, major tectonic features and faults, the Wells Creek basin impact structure circle, and major population centers. Dates of earthquakes of M_w > 5 are shown in red and purple letters. Magnitudes of earthquakes before ~1925 are estimated qualitiatvely.

Regional Geology and Seismicity

The Johnsonville Steam Plant and ash ponds are located ~12 miles west of Waverly and ~7 miles east of Camden, Tennessee, in the Western Highland Rim along the east side of the Tennessee River (Fig. 1). Surface geology in this region consists of late Paleozoic carbonate and clastic sedimentary rocks of the Western Highland Rim exposed east of the Tennessee River and Paleozoic sedimentary rocks overlain by unconsolidated Gulf Coastal Plain sediments west of the river, the latter principally along ridgetops near the river. Coastal Plain sediments form a continuous blanket west of Camden, Tennessee. These rocks and sediments are unconformably overlain in river bottoms by thin unconsolidated Quaternary terrace, floodplain, and other river deposits. The Johnsonville Plant rests directly on Devonian Camden Chert, while some of the support structures, including the ash ponds, are located on Quaternary Tennessee River terraces.

West and southwest of the Johnsonville site is the large subsurface early Paleozoic Mississippi Valley graben, identified by aeromagnetic data (frequently referred to as the Reelfoot rift; e.g., Hildenbrand and Hendricks, 1995; Johnston and Schweig, 1996; Van Arsdale et al., 2013). Deposition of the Paleozoic section was uninterrupted above the graben and was not affected by any of the faults associated with it. The Paleozoic section was folded into the Pascola arch, which connects the Nashville dome to the east with the Ozark dome to the northwest. The crest of the arch was beveled by pre-Cretaceous erosion exposing rocks as old as Lower Ordovician Knox Group (Stearns and Marcher, 1962). The Johnsonville Plant is located along the present-day hinge between the Nashville dome to the east, the subsurface Pascola arch to the west, and the Mississippi Embayment syncline to the west (Fig. 1).

Numerous small faults and folds occur in the area near the Johnsonville site. White (1960) attributed the folds to solution collapse of carbonate rocks, a phenomenon that I have observed directly with folded chert layers in Knox Group saprolite along the shores of Tellico Lake in East Tennessee. As further evidence of the solution origin of these folds, White indicated that the underlying rocks are not folded. Barnes (1967) mapped numerous small-displacement normal faults in the Hurtsburg quadrangle located south of the Johnsonville area. These also could easily be related to solution collapse of carbonate rocks. The other published quadrangle maps in this area, e.g., Camden (to the west; Wilson and Russell, 1969), Waverly (to the east; Lounsbury and Finlayson, 1965), and Harmon Creek (north of Johnsonville; Wilson, 1987), either have no mapped faults at the scale of mapping or contain one fault (Waverly). None of these faults are thought to have a tectonic origin. Ross (1946), however, reported reverse (thrust) faults in the Camden, Tennessee, area, although none were mapped in the Camden quadrangle (Wilson and Russell, 1969). Unfortunately, the geology of the Johnsonville quadrangle is not published, but Kellberg (1948) described northwest-striking, southwest-dipping thrust faults in the region around and in the Johnsonville site. He also attributed these faults to Paleozoic processes related to the northwest-trending Pascola arch connecting the Nashville and Ozark domes.

Most of the seismicity of the New Madrid seismic zone is contained within the Mississippi Valley graben (Fig. 1), and some have suggested that the seismic activity in this and other eastern U.S. intraplate seismic zones is related to early Paleozoic faults (e.g., Johnston and Schweig, 1996; Wheeler, 1996).

The active seismicity, however, only roughly parallels the graben boundaries, and is located in a northeast-trending zone of earthquakes that is truncated (or displaced) by a northwest-trending zone of seismicity, a thrust now called the Reelfoot fault in northwestern Tennessee and southeastern Missouri (Chiu et al., 1992; Johnston and Schweig, 1996; Cox et al., 2006). The history of the New Madrid seismic zone and the 1811-1812 earthquakes is chronicled by Johnson and Schweig (1996) and Hough et al. (2000).

A major zone of seismicity continues to the northeast from near the northwest tip of the Reelfoot fault that diminish in frequency and magnitude of earthquakes northeastward to the region in Kentucky near Paducah (Fig. 1). The northeast-trending faults that are defined by the seismicity in the New Madrid seismic zone have recently been interpreted as dextral strike-slip faults that are truncated by the Reelfoot fault (Cox et al., 2006; Tavakoli et al., 2010; Pratt, 2012). The zone of greatest frequency and magnitude of historic earthquakes continues northwestward across southernmost Illinois into southeastern Missouri in a zone that parallels the strike of the Paleozoic Ste. Genevieve fault (Fig. 1). The northeastern limit of historical New Madrid earthquakes, which ends immediately southwest of Paducah, Kentucky, bounds a region of very low to no historic seismicity in southern Illinois and adjacent Kentucky to an area near the N70°W-trending Paleozoic Cottage Grove dextral fault in southern Illinois where a group of historical earthquakes mostly of $M_w < 5.0$ occurs on both sides of the Cottage Grove fault (Fig. 1).

The current interpretation of the New Madrid seismic zone is that it is related to a crustal-scale dextral strike-slip fault system and flower structure (Tavakoli, et al., 2010; Pratt, 2012). This interpretation is based on earthquake, seismic reflection, and surface geologic data (Tavakoli et al., 2010), as well as computer modeling of the structure (Pratt, 2012). This fits the available data better than any previous interpretation. Despite the density of earthquakes near the Johnsonville Plant being low, and a few earthquakes of M_w between 2 and 3 have occurred here is historic times (Fig. 1), the USGS seismic hazard map derived from probabilistic risk assessment ranks this area in the moderate hazard range (Petersen et al., 2014). The plant is located >25 mi (40 km) from any of these earthquakes, and >50 mi from the eastern boundary of the Reelfoot rift, the commonly accepted boundary of the seismic zone. A more detailed assessment of the earthquake hazard for the Johnsonville Plant might place it in a much lower hazard category.

McBride and Nelson (2001) and McBride et al. (2002, their Figure 2) identified a young fault suite in southern Illinois in both seismic reflection profiles and surface exposures, which displace Cretaceous and Tertiary deposits, and early Pleistocene sediments, but not the late Pleistocene sediments, and overlying Pleistocene loess and Quaternary stream deposits. These young faults (inactive for at least 55 ka) may or may not be related to the complex of Paleozoic faults in that area (McBride et al., 2002, their Fig. 2) (Fig. 1). A similar group of faults was imaged in seismic-reflection data by LuziettI et al. (1995) in the Crittenden fault zone in eastern Arkansas. This fault system similarly displaces Paleozoic, Cretaceous, and Tertiary sediments, but could not be demonstrated to have displaced the younger Pleistocene sediments, although the sediments may have been folded.

Johnsonville Site Geology and Potentially Active Faults Within Two Miles of the Site

The geology at the Johnsonville site consists of Devonian Camden Chert, Devonian-Mississippian Chattanooga Shale, Mississippian Ridgetop Formation [now considered part of the Ft. Payne Formation], and Mississippian Ft. Payne Formation (Kellberg, 1948, 1949). Limestone probably belonging to one or more of the underlying Silurian formations was encountered in boreholes, but no attempt was made to determine to which formation(s) these limestones belong (Kellberg (1948). Kellberg's isometric projection (fence diagram) and cross sections, constructed primarily from borehole data (Exhibits 2, 3, and 4), depict a northwest-striking, southwest-dipping thrust fault, and a few subparallel subsidiary faults that cross part of the site. These faults have a displacement of <50 ft. Kellberg (1948) recommended that the thin stratigraphic section of overlying Chattanooga Shale be stripped and that the power plant foundation be located in the Camden Chert.

Ash ponds for the Johnsonville Plant are located in Quaternary river sediments, either terraces or alluvium on an island in the river, or on the east side of the river near the plant. There were no faults that displaced any of the Quaternary sediments indicated in any of the available reports, so it is assumed that any geologic structures present in bedrock formed either during the Paleozoic or Mesozoic, or are very localized and related to modern solution collapse of underlying carbonate bedrock, as White (1960) suggested.

The Johnsonville Steam Plant is located > 50 (80 km) mi from the New Madrid seismic zone in an area that contains no historic earthquakes within a radius of >25 mi (40 km). This and the fact that no faults that displace Tertiary or Quaternary sediments have been observed in this area strongly suggests that there are no active faults within two miles or probably a much larger radius of the Johnsonville site.

Conclusions

1. The Johnsonville Steam Plant and associated ash ponds are located in an area of low seismicity along the Tennessee River in west-Central Tennessee >50 mi from the east flank of the New Madrid seismic zone. The USGS seismic hazard map (Petersen et al., 2014), however, placed the Johnsonville area in the moderate seismic hazard category.

2. The steam plant and ash ponds are sited on middle to late Paleozoic carbonates and shale, with the ash ponds located on Quaternary alluvium and terrace deposits.

3. Both folds and faults have been observed in the area, but the folds and any normal faults may be related to solution collapse of carbonate rocks. Thrust faults likely are related to Paleozoic deformation that occurred in concert with the formation of the Pascola arch that connects the Nashville and Ozark domes.

4. None of the literature reviewed, including published papers, TVA reports, and reports from other organizations, have indicated the existence of any active or potentially active faults within two miles of the Johnsonville Steam Plant ash ponds.

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APPENDIX B
NEOTECTONIC ANALYSIS

CCR Unit Location Restrictions Demonstrations – TVA Johnsonville Fossil Plant, New Johnsonville, Tennessee

Neotectonics Analysis

September 24, 2018

Prepared for:

Tennessee Valley Authority

Prepared by:

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Project Number:
175568235.203.1

FINAL REPORT

Revision	Description	Author		Quality Check		Independent Review	
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0	IFR	M. Verpaelst	2018-07-31	S. Tsang	2018-08-01	R. Guthrie	2018-08-01
1	IFU	M. Verpaelst	2018-09-24	S. Tsang	2018-09-24	R. Guthrie	2018-09-24

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1.0 INTRODUCTION

Stantec Consulting Ltd. (Stantec) was retained by the Tennessee Valley Authority (TVA) to conduct a Phase 1 Assessment for a fault area demonstration of the TVA Johnsonville Fossil Plant in New Johnsonville, Tennessee. The demonstration is required by the U.S. Environmental Protection Agency (EPA) Disposal of Coal Combustion Residuals (CCR) from Electric Utilities rule. This investigation includes:

- A literature review of publicly available data of known active or potentially active (last 11,700 years) faults in the vicinity of the Active Ash Pond 2 (AAP2).
- A neotectonics analysis within a two-mile radius of the AAP2 site, hereafter referred to as the study area (Figure 1-1).

The neotectonics analysis was conducted to support the fault area demonstration only and the conclusions are not valid for other applications. The neotectonics analysis is based on a literature review of cited references, desktop lineament and drainage mapping based on interpretation of DEM hillshade and aerial photographs, and no fieldwork was conducted to verify actual conditions within the study limits.

1.1 SCOPE OF WORK

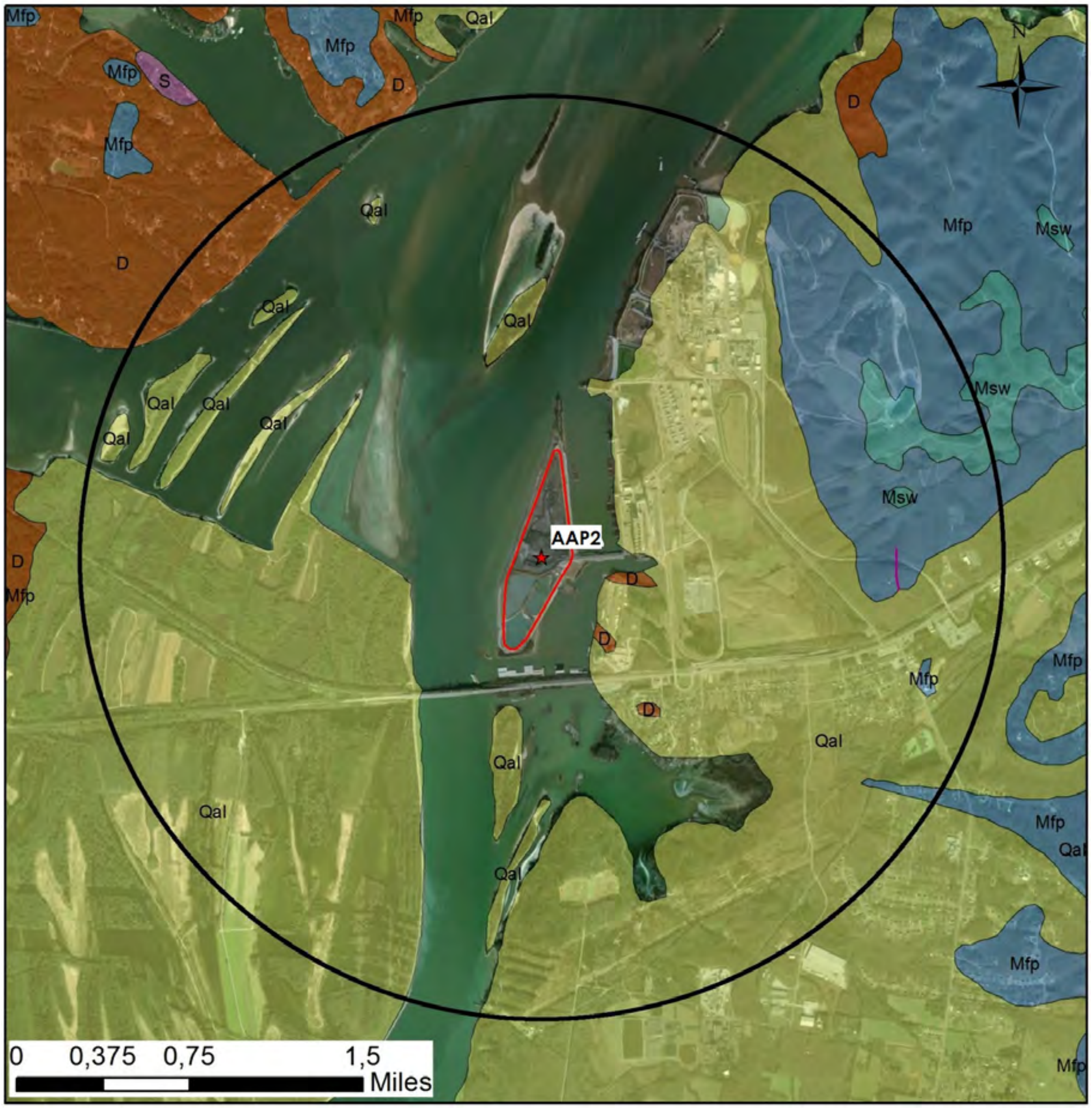
For this investigation, we define neotectonics as the study of geologically recent (last 11,700 years—Holocene Epoch) movement and deformation of the earth's crust and measurement of its local effects on the creation of geomorphological features observed at the surface. The scope of work for this neotectonics analysis comprises three tasks:

Task 1 builds on the literature review findings by utilizing the online USGS seismic hazard map, the USGS online interactive faults map, the U.S. Department of Agriculture soil survey website, the State of Tennessee TNMAP GIS Services website, and the Tennessee GIS Clearinghouse website. Publicly available maps, reports and scientific literature relevant to the terrain conditions in the vicinity of TVA's Johnsonville Fossil Plant were also reviewed.

Task 2 involves a lineament analysis where lineaments are mapped from air photographs and hillshade imagery built from Digital Elevation Model (DEM), within a two-mile radius of the AAP2 site. The mapping was carried out in ESRI ArcGIS® software to facilitate plotting of maps and viewing spatial data.

Task 3 involves a drainage analysis of well-defined drainage patterns (dendritic, parallel, trellis, rectangular, radial, annular and contorted), which are not redirected by anthropogenic activity.

Figure 1-1 Geologic Map of the Study Area[1]



AAP2 – Active Ash Pond 2 (red); Inferred fault (purple)

Map Symbol	Age	Description
Qal	Quaternary	Alluvial - Clay, silt, sand and gravel
Msw	Mississippian	Dolomitic and cherty limestone and shale
Mfp	Mississippian	Chert, siltstone and shale
D	Devonian	Limestone, Chert, mudstone and sandstone
S	Silurian	Limestone, mudstone and shale

[1]Modified from Nicholson et al. (2005) (USGS Geologic map data compilation of Tennessee) and Hardeman et al. (1966) (1:250,000 scale). Devonian limestones, Cherts, mudstones and sandstones are inferred to be overlain by Quaternary alluvial deposits mapped along the Tennessee River (Kellberg 1948). Image source: 2015 Bing imagery.

2.0 BACKGROUND INFORMATION

2.1 DATA SOURCES

Readily available background information relevant to the neotectonics analysis and geological conditions was gathered and reviewed. This information included (but was not limited to):

- 1:7,000,000 scale physical divisions map of the United States (Fenneman and Johnson 1957)
- 1:250,000 scale Geologic map of Tennessee (Hardeman et al. 1966)
- USGS Geologic map data compilation (Nicholson et al. 2005)
- USGS National Seismic Map (Petersen et al. 2014)
- United States Department of Agriculture - web soil survey
- U.S. Quaternary Faults and Folds Database (USQFFD)
- State of Tennessee TNMAP GIS Services: Environmental/Hydrological Features
- Karst in the United States: A Digital Map Compilation and Database (Weary and Doctor 2014)
- USGS Magnetic anomaly map of North America (Bankey et al. 2002)
- Tennessee GIS Clearinghouse website
- USGS - The national map office
- 1: 250,000 scale Geologic map of Tennessee, West and West-Central Sheets (Hardeman et al. 1966)
- 2015 aerial photographs from Bing imagery
- 2017 DEM (30 foot-grid) from the USGS National Map office
- Google Earth ® historical air photos
- Publicly available literature relevant to the terrain conditions in the area (Kellberg 1948, 1949; White 1960; Frankel et al. 2009)

2.2 PROJECT SETTING

Physiography

The study area is located within the Western Highland Rim and the Gulf Coastal Plain physiographic regions of Tennessee. The Western Highland Rim (east of the study area) is characterized by rolling hills and karst plains that have been dissected by many streams and rivers. The Gulf Coastal Plain found west of the Tennessee River, is characterized by lowlands with rolling hills, swamp lands and flood plains.

The northerly flowing Tennessee River (Kentucky Reservoir) dissects the study area. The range in relief in the study area is approximately 300 feet from the western shore of the Tennessee River (340 feet above sea level) to the eastern uplands (640 feet above sea level). The AAP2 site is located on a constructed island on the eastern shore of the Tennessee River at approximately 360 feet above sea level.

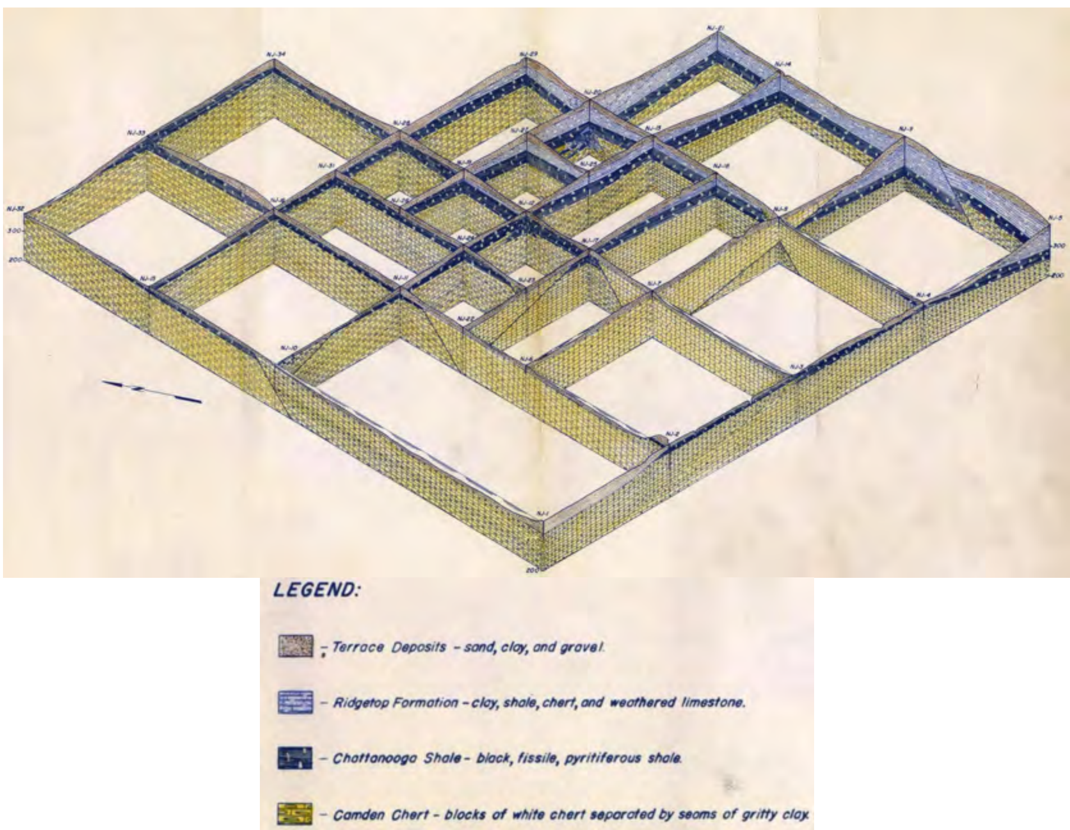
Bedrock Geology

The TVA Johnsonville Fossil Plant lies between the Nashville dome to the east and the New Madrid seismic zone to the west. Regional bedrock geology shows the study area is underlain by Silurian to Mississippian Formations comprising limestone, chert and other horizontally bedded sedimentary rocks that have been only slightly tilted by development of regional structures (Figure 1-1). With the presence of dolomitic and calcareous rocks within the study area, the potential for karstification is present (Weary and Doctor 2014).

No recent or Quaternary faults and folds were recorded within the vicinity of the study area (USQFFD). One north-south trending fault was mapped within the study area, at approximately 1.5 mile east from the AAP2 site (Hardeman et al. 1966). White (1960) attributed folds' occurrence in the region, to solution collapse of carbonate rocks (Hatcher 2018).

Four relatively small thrust faults were recorded from historical drill holes on the eastern shore of Tennessee River, at approximately 0.5 mile southeast from the AAP2 site and one larger fault was inferred from the differences in elevation between drill holes (Kellberg 1948). These faults had a northwest-southeast trend—dipping to the southwest at approximately 60 degrees—and include a few subparallel subsidiary faults; they are likely related to the incompetency of the Camden chert to withstand regional stresses. All these faults were only found underneath the overlying quaternary alluvial deposits (Figure 2-1), confirming that faulting is most likely prior to Holocene (last 11,700 years). This fault system seems to be controlled by the northwest-trending branch of the Nashville dome and is assumed to have occurred somewhere between the Mississippian and Cretaceous Periods (360 M to 66 M years before present (ybp)) (Kellberg 1948).

Figure 2-1 Isometric Projection of the Geologic Sections at the New Johnsonville Site[2]

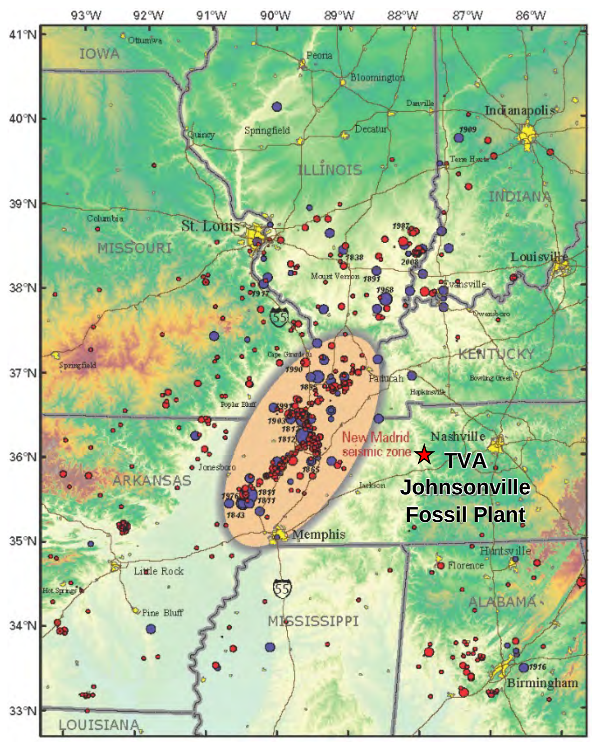


[2] Illustration Exhibit 2 from Kellberg (1948).

The TVA Johnsonville Fossil Plant is located far from recorded earthquake epicenters (Figure 2-2). The 2014 USGS National Seismic Hazard Model contours probabilistic seismic hazard with a 2-percent probability of exceedance in 50 years is presented in Figure 2-3. The map was derived from information on potential earthquake hazards based on probabilistic risk assessment, and incorporates new findings on earthquake ground shaking, faults, seismicity, and geodesy (Petersen et al. 2014). The seismic hazard map shows a low to moderate hazard for the TVA Johnsonville Fossil Plant.

Published geophysical data for the region show that the TVA Johnsonville Fossil Plant is in a magnetic low with small variations of amplitude (Bankey et al. 2002).

Figure 2-2 Topographic Map Showing Earthquakes Epicenters Greater than Magnitude 2.5[3]



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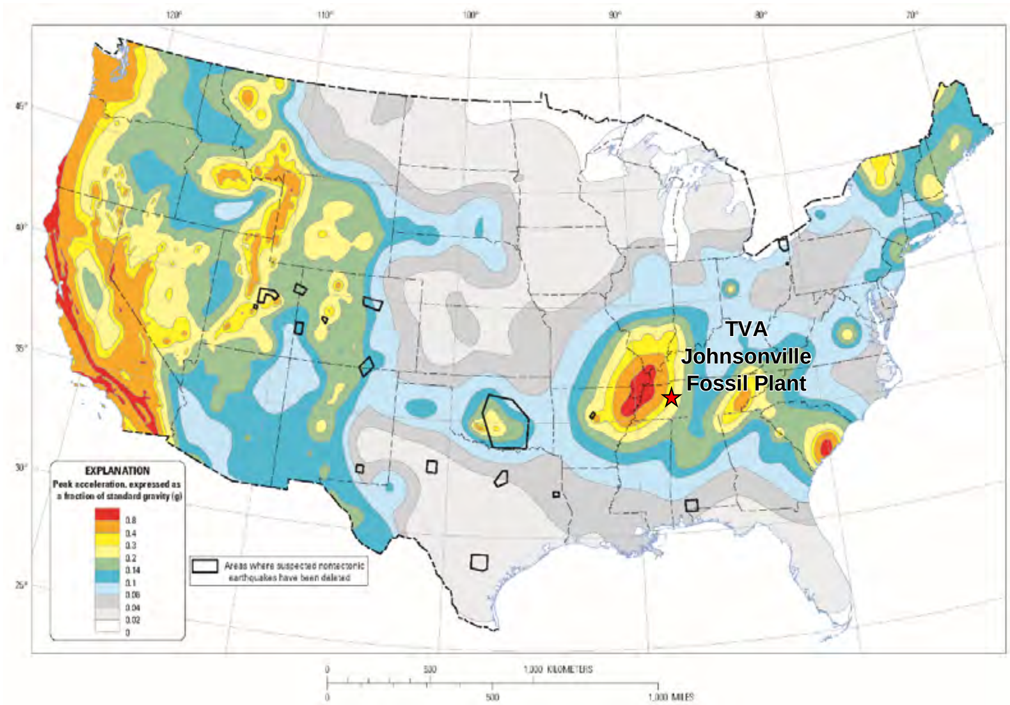
[3] Illustration from Frankel et al. (2009). Topographic map showing earthquakes greater than 2.5. Red circles are earthquakes that occurred after 1972, and blue circles are earthquakes that occurred before 1973. Larger circles represent larger earthquakes.

Figure 2-3 2014 USGS National Seismic Hazard Map, Two-Percent Probability of Exceedance in 50 Years Map of Peak Ground Acceleration



Surficial Geology

The study area was not glaciated during the Pleistocene (2.6 M to 12,000 ybp).

The United States Department of Agriculture - web soil survey, provides an overview of unconsolidated deposits within the study area. In the uplands, bedrock is unconformably overlain by blankets of clayey to gravelly residuum of weathered bedrock, with localized areas comprising either slope alluvium[4] derived from weathered bedrock or veneers of loess (formed from the accumulation of windblown silt).

The lowlands surrounding the Tennessee River mostly consists of veneers and blankets of clayey to gravelly alluvium overlying residuum of weathered bedrock and bedrock. The alluvium is derived from the St. Louis and Warsaw limestones, and from the Fort Payne and Camden cherts found upstream (Kellberg 1948). The alluvium was deposited at a time where isostatic levels were low. Since then, isostatic uplift occurred, and the river incised to a lower elevation. Thin veneers of loess are also found overlying the alluvial deposits.

Historical exploratory drilling near the AAP2 site, indicated alluvial deposits ranging from 13 to 67 feet in depth; this section is, however, covered by the waters of the Kentucky Reservoir (Kellberg 1948).

[4] Slope alluvium: deposit of clay, silt, sand and gravel, weathered in situ, then transported downslope and deposited by slope wash.

3.0 LINEAMENT ANALYSIS

The desktop lineament analysis utilizes 2015 aerial photographs and hillshade imagery derived from the 2017 DEM. The aerial photographs and hillshade imagery, along with readily available GIS layers (faults and earthquakes epicenter inventory, geology, surficial material, drainage flowlines), were viewed and interpreted in ESRI ArcGIS® software.

The lineament analysis is based on visible interpretation of mappable linear, rectilinear or curvilinear surface features that are suspected to reflect subsurface phenomena. Changes in elevation, slope gradients and surface patterns are also used to identify lineaments. Lineament mapping is frequently supported by geophysical data[5].

Ten lineaments were mapped within the study area (L1, L3 to L5, L12 to L17) and seven were mapped outside (L2, L6 to L11, L18 to L20) (Figure 3-1). Lineament L1, observed from regional topography, shows a northwest-southeast trend and may be a fault. However, it is covered by quaternary alluvial sediments, and its orientation corresponds with the thrust faults that are assumed to have occurred somewhere between the Mississippian and the Cretaceous Periods (360 M to 66 M ybp), as discussed by Kellberg (1948). It is inferred to be inactive.

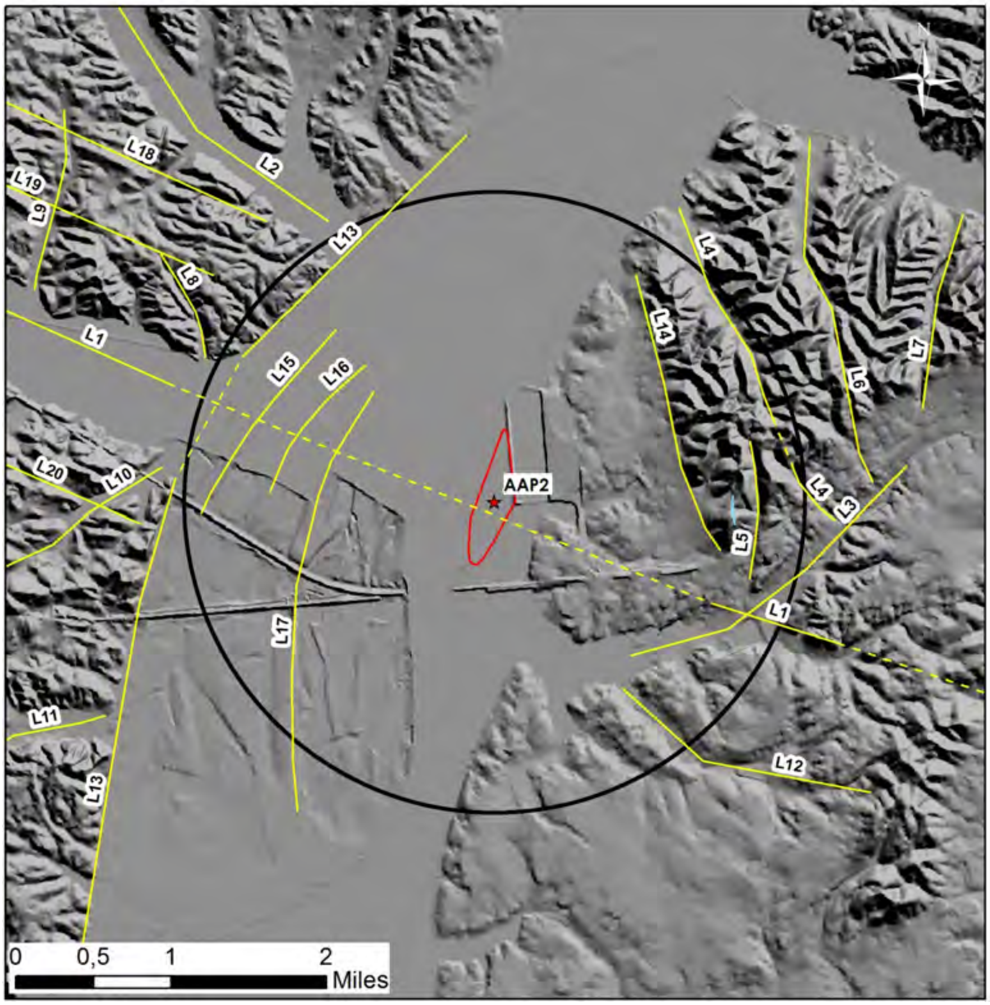
Lineaments L2 to L12 were interpreted as the result of stream erosion of residual soils overlying soft sedimentary bedrock. Of these, one is a remnant of the Tennessee River at a time when elevations were lower (L3). However, it is possible that the streams exploited weaknesses in the bedrock (such as pre-Holocene faults or joint sets). The geological setting, and the development of streams and topography of the region, suggests that these linear features are not associated with active faults. Note that lineaments L4 to L9 are oriented in a north-south subparallel trend are in accordance with a fault mapped in the study area by Hardeman et al. (1966). If faults and folds occurred as a result of solution collapse of carbonate rock, as White (1960) discussed, these would only be localized.

Lineaments L18 to L20 were interpreted as potential faults. They were found dissected by stream erosion (L8 to L10), meaning that they are anterior to those. Their northwest-southeast trend, similar to lineament L1, may suggest that they occurred somewhere between the Mississippian and Cretaceous Periods (360 M to 66 M ybp),

Lineaments L13 and L14 were interpreted as geological contacts between the uplands and the Tennessee River floodplain deposits. These features are remnants of past erosion when the river was at a higher level. Lineaments L15 to L17 are landforms features (river banks) formed by the meandering of the Tennessee River and are not active faults.

[5] Publicly available geophysical data include a digital magnetic anomaly database (Bankey 2002). This database is regional and coarse and shows no anomalies for the study area.

Figure 3-1 Mapped Lineaments (Yellow) Overlain on 2017 DEM Hillshade Image



AAP2 – Active Ash Pond 2 (red)

4.0 DRAINAGE ANALYSIS

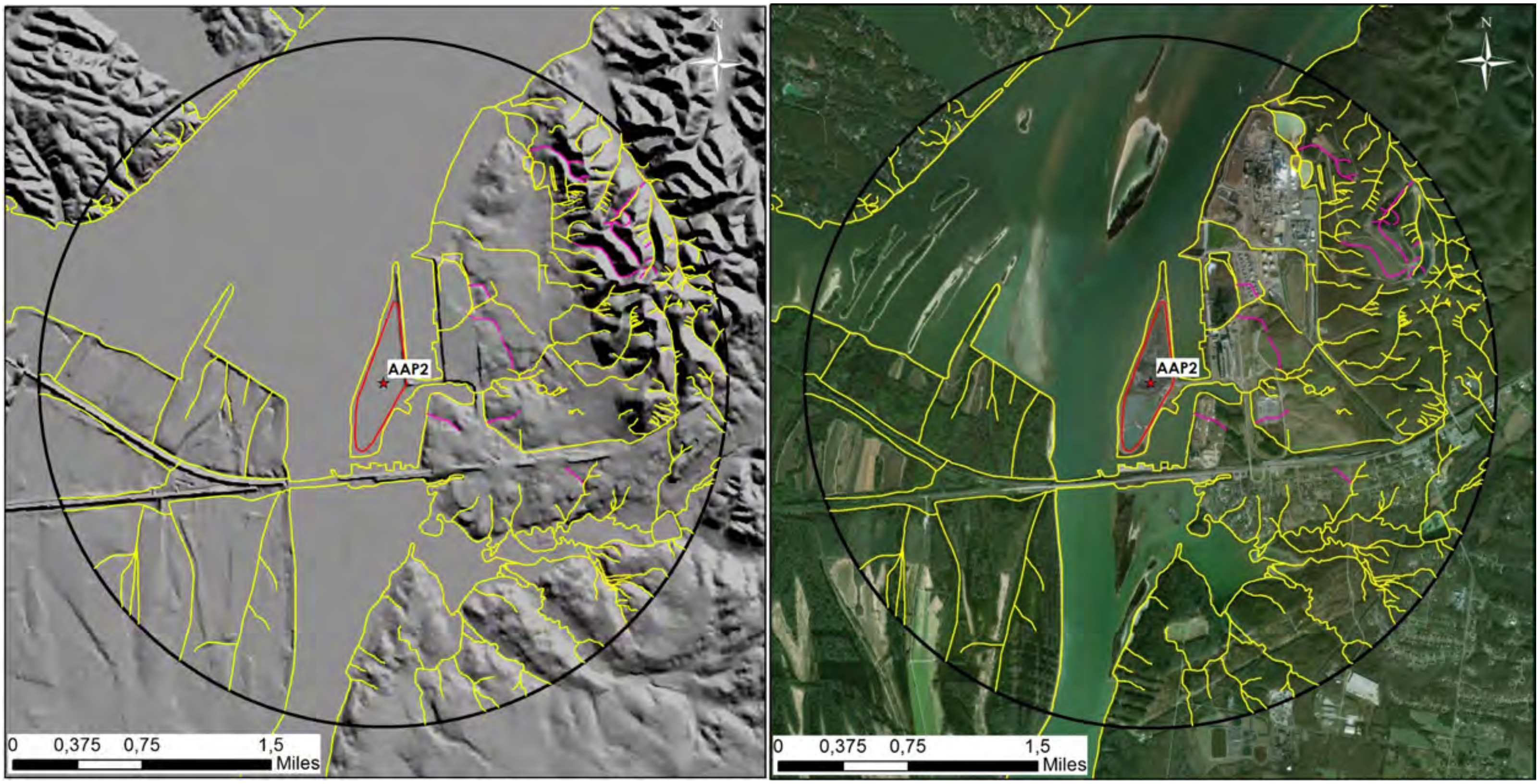
Drainage analysis is useful in interpretation of geologic structures - it includes consideration for drainage patterns, drainage texture, individual stream patterns and drainage anomalies. Deviations from an expected pattern, such as flow in a direction that is oblique from the regional topographical gradient, could be related to structural or lithologic discontinuities.

The drainage analysis was conducted using ESRI ArcGIS® software and carried out through the interpretation of aerial photographs, hillshade imagery, and the State of Tennessee TNMAP GIS Services Hydrological Features Dataset. The aerial photographs and hillshade imagery was used to delineate the drainage networks of streams and historical drainage features at scales ranging from 1:2,000 to 1:5,000 (Figure 4-1). Historical drainage mapping was based on the comparison of both the aerial photographs and hillshade imagery (see Appendix A for the historical air photo review of the study area). Historical drainage features refer to areas where anthropogenic modification of the land was significant enough to change the drainage pathways regardless of the topography. A comparison of the State of Tennessee TNMAP GIS Services Hydrological Features Dataset and mapping from the drainage analysis is presented in Figure 4-2.

In the study area, the drainage network has a predominant dendritic drainage pattern, which is consistent with the horizontal underlying sedimentary strata. The alluvial plain located on the western shore of the Tennessee River also presents a dendritic drainage pattern but is relatively younger.

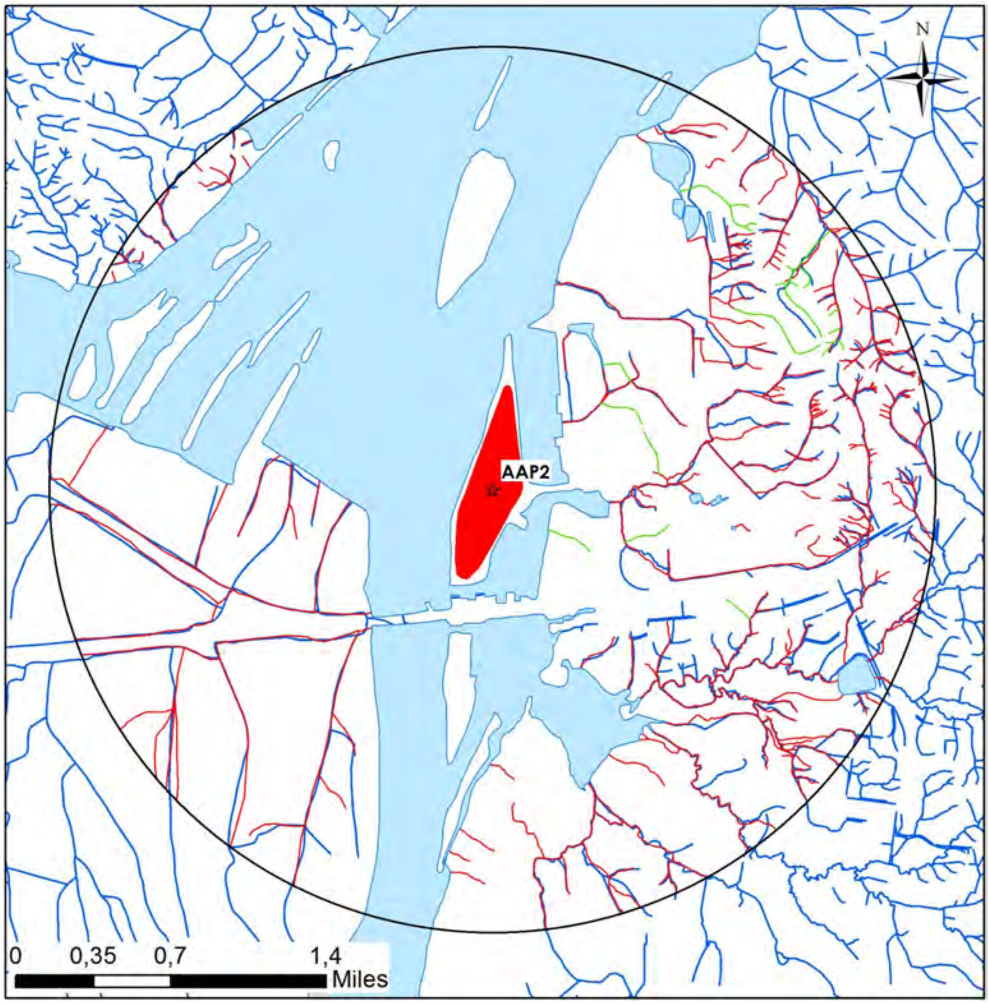
The only abnormal drainage deviations observed are the result of redirection by anthropogenic activity. No fault scarps or other tectonic features associated with active (Holocene-age) faults were observed within the study area.

Figure 4-1 Drainage Network Mapping (Yellow) and Historical Drainage Mapping (Purple) on DEM Hillshade Image (Left) and Overlay on Aerial Photograph (Right)



AAP2 – Active Ash Pond 2 (red)

Figure 4-2 State of Tennessee TNMAP GIS Services Hydrological Features Dataset (Blue) Compared with the Detailed Drainage Analysis Mapping (Red) and Historical Drainage Analysis Mapping (Green)



AAP2 – Active Ash Pond 2 (red)

5.0 SUMMARY OF KEY FINDINGS

A neotectonics analysis of the TVA Johnsonville Fossil Plant in New Johnsonville, Tennessee, was completed within a two-mile radius centered on the AAP2 site. The neotectonics analysis involved an extended review of publicly available information (geology, faults, hydrology, seismic hazard, geophysical surveys, Quaternary history, surficial deposits, pedology), lineament analysis, and drainage analysis. The findings from a separate literature review show that the study area is located along the present-day hinge between the Nashville dome to the east and the Mississippi Embayment syncline to the west, an area of low seismicity (Hatcher 2018). None of the literature reviewed indicated the existence of any active (Holocene-age) fault within two miles of the TVA Johnsonville Fossil Plant associated ponds (Hatcher 2018).

The lineament analysis identified eleven linear features (L2 to L12) that have been interpreted as the result of stream erosion of residual soils overlying soft sedimentary bedrock. Of these, one is a remnant of the Tennessee River at a time when elevations were lower, and six present a north-northwest trend, which is consistent with the fault system mapped to the east of the study area (Hardeman et al. 1966). These features are interpreted to be older than the Holocene. One lineament (L1) corresponds to thrust faults identified by Kellberg (1948) and likely occurred between the Mississippian and Cretaceous Periods (360 M to 66 M ybp). While substantially older than the timeframe under consideration (by millions of years), it nonetheless is inferred to extend beneath the AAP2. Three lineaments (L18 to L20) were found dissected by stream erosion; they may be linked with the thrust faults identified by Kellberg (1948) and may have occurred between the Mississippian and Cretaceous Periods. Two linear features (L13 and L14) were interpreted as geological contacts between the uplands and the Tennessee River floodplain deposits. These features are remnants of past erosion when the river was at a higher level. Three linear features (L15 to L17) are landform features associated with the meandering Tennessee River and alluvial deposition of material on the shores not associated with active faults.

The drainage analysis shows a predominant dendritic drainage pattern which is consistent with the underlying horizontal sedimentary strata. The alluvial plain located on the western shore of the Tennessee River, also shows a dendritic drainage pattern, but is relatively younger. The only abnormal drainage deviations observed are the result of redirection by anthropogenic activity (e.g., ditches, river training).

No fault scarps or other tectonic features associated with active (Holocene-age) faults were observed within a two mile-radius of the AAP2 site.

Limitations. The desktop neotectonics analysis presented in this report is based on a review of available aerial photographs and hillshade imagery derived from DEM. As LiDAR data were not available, only a 30-foot-grid DEM was used to cover the study area; meaning lineament and drainage analysis may not be as accurate as the (5 foot-grid) LiDAR data. Also, stereoscopic air photo interpretation was not conducted as part of the assessment.

Note that the modification of surficial Quaternary sediments due to the construction of the Active Ash Pond 2 and other anthropogenic areas can mask the identification of Holocene-age neotectonics features.

Given that the region as a low to moderate seismic hazard and that no active (Holocene-age) fault features within 200 feet of the AAP2 site were identified during the neotectonics analysis (lineament and drainage network mapping), no further work is recommended.

6.0 CLOSURE

This document entitled "CCR Unit Location Restrictions Demonstrations – TVA Johnsonville Fossil Plant, New Johnsonville Tennessee" (Report) was prepared by Stantec Consulting Services Inc. ("Stantec") for the Tennessee Valley Authority. This Report supports the fault area demonstration only for the TVA Johnsonville Fossil Plant and the conclusions are not valid for other applications. This Report is based on a literature review of cited references, a desktop lineament and drainage mapping exercise based on interpretation of DEM hillshade and satellite imagery. The material in this Report reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the Report. The opinions in the Report are based on conditions and information existing at the time the Report was published and do not take into account any subsequent changes.

Yours very truly,

STANTEC CONSULTING LTD.

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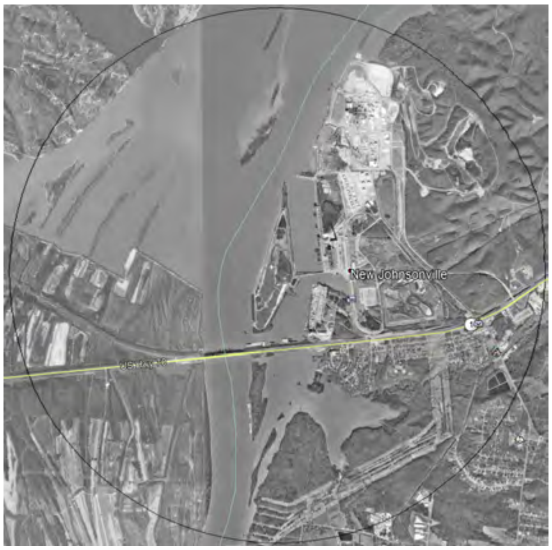
Appendix A Google Earth Historical Air Photo Review of the Study Area[6]

1999



2007

2008

2010

[6] Historical air photos from Google Earth®

2012

2015