Prepared for

American Electric Power

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Columbus, Ohio 43215

LOCATION RESTRICTION EVALUATION

CARDINAL FAR 1 RSW LANDFILL

BRILLIANT, OHIO

Prepared by

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LIST OF ACRONYMS

AEP	American Electric Power
BAC	Bottom Ash Complex
BAP	Bottom Ash Pond
CCR	Coal Combustion Residual
ESP	Electrostatic Precipitators
FAD	Fly Ash Dam
FAR	Fly Ash Reservoir
FGD	Flue Gas Desulphurization
g	acceleration due to gravity
gpm	gallons per minute
mg/l	milligram per liter
MSE	Mechanically Stabilized Earth
NPDES	National Pollutant Discharge Elimination System
ODNR	Ohio Department of Natural Resources
OAC	Ohio Administrative Code
PGA	Peak Ground Acceleration
PFBC	Pressurized Fluidized Bed Combustion
PMF	Probable Maximum Flood
PVC	Polyvinyl Chloride
RCP	Recirculation Pond
RSB	Recompacted Soil Barrier
RSL	Recompacted Soil Liner
RSW	Residual Solid Waste
RSW L	Residual Solid Waste Landfill
SCR	Selective Catalytic Reduction
TDS	Total Dissolved Solids
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

1. OBJECTIVE

1.1 Purpose

The purpose of this report is to provide an assessment of the Location Restriction Requirements associated with the Fly Ash Reservoir 1 Residual Solid Waste Landfill (FAR 1 RSW Landfill) located at the Cardinal Operating Company's Cardinal Plant relative to its compliance with the United States Environmental Protection Agency (USEPA) Coal Combustion Residual (CCR) Rule Sections 40 CFR 257.60, 61, 62, 63 and 64.

This report was prepared in accordance with American Electric Power (AEP) Letter of Authorization 7716390037x104.

1.2 Organization of Report

This report is organized as follows:

- Section 2 presents background information on the power plant and the CCR units;
- Section 3 presents an evaluation of the CCR unit with respect to the elevation of the base of the unit above the uppermost aquifer (40 CFR §257.60;
- Section 4 presents an evaluation of the CCR unit with respect to wetlands (40 CFR §257.61);
- Section 5 presents an evaluation of the CCR unit with respect to fault areas (40 CFR §257.62);
- Section 6 presents an evaluation of the CCR unit with respect to seismic impact zones (40 CFR §257.63);
- Section 7 presents an evaluation of the CCR unit with respect to unstable areas (40 CFR §257.64);
- Section 8 provides recommendations to address non-compliances, if any; and
- Section 9 provides a certification from a qualified Professional Engineer (PE).

1.3 Coordinate System and Datum

The horizontal coordinate values provided in this report are based upon the North American Datum of 1927 (NAD27). The vertical datum utilized for reporting the elevations within this report is National Geodetic Vertical Datum of 1929 (NGVD 29).

2. BACKGROUND INFORMATION

2.1 Facility Location Description

The Cardinal Plant is a three-unit, 1,830 MW total capacity coal-fired generating station located in Jefferson County south of Brilliant, Ohio along the Ohio River. Each generating unit is equipped with an electrostatic precipitator (ESP) for removal of fly ash particulate matter, a selective catalytic reduction (SCR) system for removal of nitrogen oxide, and flue gas desulphurization (FGD) systems for removal of sulfur dioxide (AEP 2005a). The existing CCR unit considered in this location restriction evaluation is the FAR 1 RSW Landfill. The FAR 1 RSW Landfill and its location with respect to Fly Ash Reservoir 2 (FAR II), the Bottom Ash Complex (BAC) and the main plant area are shown on Figure 2-1. Reference to FAR II in reference documents use both the FAR II and FAR 2 designations, but they are referring to the same reservoir.

2.2 Description of CCR Units

The FAR 1 RSW Landfill is a dry landfill disposal facility located approximately one-mile north of the plant site in a portion of Blockhouse Hollow (also referred to as Blockhouse Run in references and drawings) that was formally surface mined for the Pittsburgh No. 8 coal. The footprint of the landfill overlies approximately 75 acres of the former and FAR 1. FAR 1 has been undergoing closure under OEPA issued permits and was expected to be completed around 2038 (AEP, 2005a). FAR 1 no longer impounds water or receives CCR, is considered an inactive surface impoundment and would need to complete closure according to the CCR Rule. The FAR 1 RSW Landfill is an existing, active CCR landfill which receives gypsum waste and which may also receive solid waste from the Bottom Ash Pond (BAP). Two of the six cells of the landfill are in operation at the time the CCR Rule became effective. Construction of the remaining future cells would be considered a lateral expansion. The landfill uses FAR II as its leachate and stormwater collection pond. Therefore, several Cardinal waste storage units are mentioned in this FAR 1 RSW Landfill CCR assessment document.

2.2.1 Embankment Configuration

The FAR 1 RSW Landfill is an active dry landfill that overlies the former FAR 1 and minespoil bench. The landfill was permitted in 2007 and is composed of six internal cells with a layout as shown in Figure 2-2. The landfill was designed with a five-foot thick compacted layer of added geologic material (referred to as the isolation clay layer) placed to separate the landfill lining system from the subgrade fill and uppermost shallow aquifer. The landfill cells that have been constructed (Cells 1 and 3) are under filling operations and have been lined with 1.5 ft of recompacted soil liner (RSL) material and a 30-mil thick polyvinyl chloride (PVC) geomembrane, except along the southwestern perimeter highwall. At the highwall location, Cell 1 and Cell 2 are immediately adjacent and in contact with the rock highwall where the lining fill adjacent to the highwall includes a highwall drainage layer, a 5-ft thick isolation layer, and a 3-ft thick RSL (AEP, 2005a; AEP, 2007). Cell 2 has not been

constructed. Future cell construction would be considered a lateral expansion and will need to be redesigned to meet the CCR Rule requirements. Rule requirements do accept approved alternatives to the lower component of the liner system.

Approximately five acres of the former FAR 1 footprint on the east and south sides lie outside of the limits of the landfill. The final cover system for these areas of FAR 1 was design as a two-foot thick recompacted soil barrier (RSB) layer and a one-foot thick vegetative soil layer, but would need to be redesigned to comply with the CCR Rule. This includes the area between the southeast end of the landfill and the upstream clay slope of FAD 1. The permitted cover requirements were included in the existing landfill permit and construction documents (AEP, 2006; AEP, 2010).

2.2.2 Area and Volume

The FAR 1 RSW Landfill is approximately 348 acres. A total of 127 acres will be used for residual waste placement. The remaining 221 acres are occupied by associated facilities, including leachate and stormwater conveyance, FAR II (locations restrictions evaluation described in separate CCR unit report), haul roads, and groundwater monitoring wells. The volume of waste which can be contained by the landfill facility is approximately 18,244,000 cubic yards.

2.2.3 Construction and Operational History

Construction of the FAR 1 RSW Landfill began in 2006 with general site excavation and Stage A construction beginning in 2007. The sequential development of the landfill was altered in a permit modification in April 2008, is ongoing, and development occurs in two phases (i.e., Phase 1 and Phase 2) according to the permit (AEP, 2006). Phase 1 (which includes Cells 1 and 3) of the proposed landfill was developed at the northwest end along the excavated minespoil bench area and the southern portion of the 14-acre Tidd Plant Pressurized Fluidized Bed Combustion (PFBC) ash placement area (AEP, 2005a; AEP, 2006). Phase 2 (which includes Cells 2, 4, 5 and 6) will be developed over FAR 1 and the excavated minespoil bench and will also proceed from the northwest to the southeast to allow for a period of continuous preloading advancement of the Phase 2 cells that lie over the FAR 1 ash. The development of Cells 1 and 3 containments have been completed and under filling operations with FGD gypsum. Preloading of Cells 4, 5 and 6 is occurring with preload fill and temporary stockpiles of material.

As mentioned in report Section 2.2, FAR II serves as the leachate and stormwater collection basin for the RWL. In the future it will be necessary to construct alternative collection basins, either separately or part of the closure construction for FAR II.

2.2.4 Surface Water Control

Surface water control at the FAR 1 RSW Landfill directs all runoff to FAR II. The active surface of the landfill within the waste limits is graded with slopes at a minimum of two percent to provide

drainage to the perimeter of the area and to chimney drains where both are transferred into the leachate collection system which is gravity piped to FAR II. Permanent and temporary ditches located outside the contained limit of waste and at the perimeter of the facility collect surface runoff and redirects the flow by ditch and pipe to FAR II. The surface water control system was designed to convey the peak discharge from a 25-year, 24-hour storm event.

Surface water draining into FAR II is collected within the main (north) branch of Blockhouse Hollow and contained by Fly Ash Dam 1 (FAD 1) and Fly Ash Dam 2 (FAD 2) and discharged as part of the ash reservoir water through the FAD 2 principal or service spillway.

2.3 Previous Investigations

Several geotechnical and hydrogeologic investigations were completed in advance of the development of the FAR 1 RSW Landfill. These assessments include:

- Geotechnical Investigation Report: Permit-to-Install Application Cardinal FAR 1 Residual Waste Landfill Facility. May 2006. Geosyntec Consultants.
- Draft Engineering Feasibility Study for the Cardinal Plant FGD Project: FAR 1 Landfill Evaluation and Design. April, 2004. Geosyntec Consultants.
- Stability Analysis Report: Permit-to-Install Application: Cardinal FAR 1 Residual Waste Landfill Facility. August, 2005. Geosyntec Consultants.
- Hydrogeologic Investigation Report: Permit-to-Install Application Cardinal FAR 1 Residual Waste Landfill Facility. May 2006. Geosyntec Consultants.

Because surface runoff, subsurface drainage, and leachate collected from the landfill discharge into FAR II, monitoring wells from the former FAR I, FAR II, and the landfill were incorporated into one facility-wide monitoring network. The network is sampled semi-annually with investigation details and results summarized in reports. These summaries include boring and well details. The most recent report is titled "*Fall 2014 Groundwater Monitoring Data and Statistical Analyses for Cardinal Operating Company's Cardinal Waste Management Units,"* (AEP, 2014).

2.4 Hydrogeologic Setting

2.4.1 Climate

The hydrologic conditions of the FAR 1 RSW Landfill and FAR II sites are addressed in Section 3. Climate data used in the design was modeled for Pittsburgh, Pennsylvania, located approximately 40 miles from Brilliant, Ohio (AEP, 2005c).

The 2015 average monthly temperature and precipitation values for the Brilliant, Ohio area are presented in the table below (NOAA, 2016). The climatological data was collected from the nearest weather station (USC00338025) located in Steubenville, OH.

NOAA Climatological Summary (2015)		
Month	**Average Temperature (°F)**	**Average Precipitation (inches)**
January	23.0	2.16
February	16.0	1.34
March	30.9	4.02
April	51.1	3.60
May	64.6	2.95
June	70.0	10.69
July	71.4	4.66
August	70.5	2.81
September	69.3	6.70
October	53.2	2.56
November	47.8	1.17
December	46.6	3.24

2.4.2 Regional and Local Geologic Setting

The geology at the FAR 1 RSW Landfill and the vicinity consists of nearly horizontal sequences of lower Permian and upper Pennsylvanian sedimentary rock. The Permian-age Dunkard Group occurs only on the tops of some ridges above an elevation of approximately 1,250 ft above mean sea level, northwest and west of landfill and FAR II sites.

The geologic setting at the vicinity of FAR 1 RSW Landfill and FAR II indicates that the Monongahela Group is up to 230-ft thick in Jefferson County, consisting of shale, sandstone, limestone, coal, and clay. These rocks form much of the slopes above the current levels of the landfill and FAR II sites. Below the Monongahela Group is the Conemaugh Group, which is generally over 500-ft thick in Jefferson County. The Conemaugh Group consists of shale, sandstone, limestone, coal, and clay, including the Morgantown Sandstone, which is a developed aquifer in the area. Beneath the Morgantown Sandstone is a sequence of the Conemaugh Group including the Elk Lick Limestone, the

Skelly Limestone and shale, the Ames Limestone, several thick shale sequences, and the Cow Run Sandstone (AEP, 2005a).

2.4.3 Surface Water and Surface Water-Groundwater Interactions

The intermittent stream of the western branch of Blockhouse Hollow at the northwest end of the FAR 1 RSW Landfill was historically re-routed during surface mining operations and flows in a constructed stream channel along the bottom of the highwall slope north of the landfill and former FAR 1. Blockhouse Hollow then drains into FAR II. Surface water northeast of the landfill flows to, or is collected and drained to, Blockhouse Hollow. Drainage from the highwall adjacent to Cells 1 & 2 of the landfill is collected in an engineered highwall drainage layer and conveyed through the landfill subsurface drainage layer and piping to a perimeter solid wall transmission pipe that discharges into the Blockhouse Hollow channel draining to FAR II (AEP, 2006; AEP, 2007). Perimeter landfill and final cover system surface water will be collected and conveyed in piping to either Blockhouse Hollow or piping that drains directly to FAR II. Landfill contact stormwater is collected and transferred to the leachate collection system. Both surface stormwater and leachate are transferred to FAR II as FAR II serves as the facilities sedimentation pond and leachate collection pond.

2.4.4 Water Users

Based on water well records obtained from the ODNR online search tools (ODNR, 2011), the nearest domestic water supply wells are located approximately one mile east of the landfill. The well records indicate well depths ranging from 30 to 110 ft below ground surface within shale and sandstone aquifers. According to the Jefferson County Water and Sewer District, there are no surface water intakes supplying water to the town of Brilliant, Ohio. Brilliant's water source comes from two groundwater wells located at a water treatment plant approximately two miles east of the FAR 1 RSW Landfill.

3. REQUIRED ISOLATION FROM UPPERMOST AQUIFER

3.1 Aquifer Description and Piezometric Analysis

According to §257.60(a) of the CCR rule, the term "uppermost aquifer" has the same definition as under the general provisions §257.40 where it is defined as: "the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility's property boundary. This definition includes a shallow, deep, perched, confined, or unconfined aquifer, provided that it yields usable water".

For purposes of this report, it is assumed that the uppermost useable aquifer has the following characteristics: (1) groundwater production rate over a 24-hour period of at least 0.1 gallons per minute (gpm); and (2) groundwater quality with total dissolved solids (TDS) less than 10,000 milligrams per liter (mg/L).

3.1.1 FAR I Residual Solid Waste Landfill

The FAR 1 RSW Landfill overlies the former FAR I reservoir, which had surface elevations from approximately 990 to 1,020 ft. Based upon these elevations and the elevations of the material underlying the original FAR I topography, the uppermost aquifer consists of saturated unconsolidated material, limestone, and sandstone sedimentary units, primarily the Connellsville Sandstone, Summerfield Limestone and Bellaire Sandstone units. This upper aquifer system is separated from the lower aquifer, the Morgantown Sandstone, by a shale aquitard averaging approximately 45 feet in thickness (AEP, 2005a). The uppermost aquifer system potentiometric elevation ranges from 1000 ft along the northwest side to 960 ft along the southeast side of the unit.

Based on ODNR water well logs, the nearest wells with a recorded pumping rate (not including wells screened in the alluvial sediments near the Ohio River) occur approximately one mile west of the landfill. These wells are screened within limestone and shale units, and at a similar elevation to the uppermost aquifer system at the landfill. These wells have recorded pumping rates ranging from 1 to 8 gpm. Another series of wells are located approximately 3 miles southwest of the landfill, and are screened within sandstone and siltstone units at a similar elevation to the Morgantown Sandstone near the landfill. These wells have recorded pumping rates ranging from 3 gpm to 60 gpm, and may be representative of the pumping rates that would occur within the Morgantown Sandstone at the landfill.

During the fall 2014 groundwater monitoring event conducted by AEP, no wells sampled in the vicinity of the landfill exceeded a total TDS concentration of 10,000 mg/L.

Based on the information gathered from ODNR, previous analytical data, and geological conditions at the landfill, the uppermost continuous and usable aquifer is considered to be the unconsolidated material, limestone, and sandstone sedimentary units (hereby referred to as the Shallow Aquifer) which lie above the shale aquitard and Morgantown Sandstone.

3.2 Compliance

The landfill was constructed over top of the former FAR I reservoir and was designed with a 5-ft thick compacted layer of added geologic material (referred to as the isolation clay layer) placed to separate the landfill lining system from the subgrade fill and uppermost aquifer. In addition to the isolation layer, each cell that has been constructed, was designed and lined with 1.5 ft of RSL material and a 30-mil thick PVC geomembrane (AEP, 2005a; AEP, 2006). Future cell construction will need to be redesigned to meet the CCR Rule requirement. Rule requirements stated in §257.70(c) does allow approved alternatives to the lower component of the liner system.

This presence of the 5-ft clay isolation layer below the landfill lining system provides adequate separation from the uppermost aquifer system. Therefore, the FAR 1 RSW Landfill meets the compliance requirements of §257.60(a) for the presence of an isolation layer.

4. WETLANDS IMPACT

4.1 Review of Local Wetlands

Geosyntec reviewed the United States Fish and Wildlife Service (USFWS) inventory data, and other wetland information provided to us and also visited the Cardinal site to review ground conditions that may be indicative of wetlands.

The impact of FAR 1 RSW Landfill to wetlands was addressed in the PTI Volume 1 Narrative Report and Documentation Letters on Wetland in Vol. 1 Appendix B. (AEP, 2005a). In these documents, OEPA and USACE concurred with AEP's wetland delineation for areas within 1000 ft of the limit of waste and they concluded that the wetlands within the proposed landfill area are not jurisdictional since the vegetation had germinated on older fly ash and that hydric soils were not present. In addition, the USFWS inventory file (USFWS, 2007) was reviewed and data was placed on a more current October 24, 2014 USDA FSA aerial photograph. The resulting map is presented in Figure 4-1. Figure 4-1 shows one area at the base of the west high wall within the minespoil area classified as "PEM1A" and two areas classified as "PSS1A" above the highwall. The area at the base of the highwall is within the landfill limits, the other areas outside and above the highwall. They are temporary surface water confinements and not jurisdictional wetlands. Based on observations from site visits, review of borrow area studies in 2006, and review of AEP Cell 1 Certification Report construction photos (AEP, 2008), the temporarily flooded areas located at the base of the highwall on minespoil and above the high wall are impounded shallow surface water between the and are not wetlands. Site reconnaissance and the USACE review indicated that no true wetlands are present within the landfill limits. The intermittent stream of the western branch of Blockhouse Hollow at the northwest end of the FAR 1 RSW Landfill was historically re-routed during surface mining operations and is shown as a constructed stream channel along the bottom of the north highwall slope north of the landfill and former FAR 1. Based on the above there are no remaining wetlands within the limits of FAR 1 RSW Landfill.

4.2 Compliance

The wetland impact from construction of the FAR I RWL is non-existent within the landfill limits. All contact water within the waste limits is collected, transferred to the leachate collection system, and treated as necessary before being piped to FAR II. The clean surface runoff water is collected and transferred to the relocated Blockhouse Hollow stream which flows into FAR II.

5. FAULT AREAS

5.1 Regional Geologic Structural Features and Tectonic Setting

Based on a review of the available geologic literature within the vicinity of the Site, there are no active seismogenic faults that cross through, or project toward the Site. This includes the FAR 1 RSW Landfill.

5.2 Compliance

The compliance assessment with respect to fault areas indicates that a CCR unit cannot be located within 200 ft of a fault that has had displacement in Holocene time. The following information suggests that the FAR 1 RWL is not affected by faults.

- According to Ohio EPA DSIWM-27-20-128 (OEPA, 2004), "To date, no fault in Ohio has exhibited evidence of movement during Holocene time."

- The United States Geological Survey (USGS) seismic hazard program includes maps depicting faults during the Holocene epoch (about the last 10,000 years). Figure 5-1 indicates that no fault zones exist at the Site (or in Ohio) (USGS, 2014).

Based on the information provided in this section, the Cardinal Site, including FAR 1 RSW Landfill is in compliance with the requirements of §257.62 for fault areas.

6. SEISMIC IMPACT ZONES

6.1 Definition and Regional information

The CCR rule prohibits new CCR landfills, existing and new CCR surface impoundments and all lateral extensions from being located in seismic impact zones unless the owner or operator makes a demonstration, certified by a qualified professional engineer, that all containment structures, including liners, leachate collection systems, and surface water control systems, are designed to resist the maximum horizontal acceleration in lithified earth material from a probable earthquake.

A seismic impact zone means an area having a 2% or greater probability that the maximum expected horizontal acceleration, expressed as a percentage of the earth's gravitational pull (acceleration, "g"), will exceed 0.10 g in 50 years. Seismic zones, which represent areas of the United States with the greatest seismic risk, are mapped by the USGS and readily available for all the United States (USGS, 2008). (http://earthquake.usgs.gov/hazards/apps/).

The maximum horizontal acceleration in lithified earth material means the maximum expected horizontal acceleration at the ground surface as depicted on a seismic hazard map, with a 98% or greater probability that the acceleration will not be exceeded in 50 years. This translates to a 10 % probability of exceeding the maximum horizontal acceleration in 250 years (which is equivalent to a 2% probability of exceeding the maximum horizontal acceleration in 50 years).

6.2 Compliance

The compliance assessment with respect to seismic impact zone for the FAR 1 RSW Landfill includes:

- Identify location of the Site (i.e., latitude and longitude).
- Using seismic hazard maps, determine the peak ground acceleration (PGA) corresponding to a 2% probability of exceedance in 50 years[1].
- If the peak ground acceleration (PGA) is less than 0.1 g, then the Site is not located in a seismic impact zone.

The Cardinal site is located at Latitude: 40.2716°; Longitude: -80.655°. The PGA is 0.048 g at bedrock (Figure 6-1 for the deaggregation analysis).

[1] The PGA was computed using the "2008 Interactive Deaggregation" at http://geohazards.usgs.gov/deaggint/2008/.

Based on the information provided in this section, the Cardinal FAR 1 RSW Landfill is not in a seismic impact zone and is therefore in compliance with the requirements of §257.63 for seismic impact zones.

7. UNSTABLE AREAS

7.1 Definition and Review of Local Conditions

USEPA has adopted the following definitions that are relevant to the evaluation of compliance with respect to unstable areas:

- *Unstable area* means a location that is susceptible to natural or human-induced events, or forces capable of impairing the integrity of some or all of the structural components responsible for preventing releases from a CCR unit. Natural unstable areas include those areas that have poor soils for foundations, areas susceptible to mass movements, and karst terrains.

- *Structural components* mean liners, leachate collection systems, final covers, run-on/run-off systems, and any other component used in the construction and operation of a CCR unit.

- *Poor foundation conditions* means those areas where features exist which may result in inadequate foundation support for the structural components of a CCR unit.

- *Areas susceptible to mass movement* means those areas of influence (i.e., areas characterized as having an active or substantial possibility of mass movement) where the movement of earth material at, beneath, or adjacent to the CCR unit, because of natural or man-induced events, results in the downslope transport of soil and rock material by means of gravitational influence. Areas of mass movement include, but are not limited to, landslides, avalanches, debris slides and flows, solifluction, block sliding, and rock fall.

- *Karst terrain* means an area where karst topography, with its characteristic erosional surface and subterranean features, is developed as the result of dissolution of limestone, dolomite, or other soluble rock. Characteristic physiographic features present in karst terrains include, but are not limited to, dolines (sinkholes), vertical shafts, sinking streams, caves, seeps, large springs, and blind valleys.

7.2 Compliance

7.2.1 Areas Susceptible to Bearing Capacity, Static Stability, Seismic Stability or Settlement Failures

FAR 1 RSW Landfill is a Class III residual solid waste landfill and therefore accepts only solid waste, primarily synthetic gypsum produced by the plants FGD systems. The landfills permit-to-install package (PTI) Volume 3 (AEP, 2005b) included a Stability Analysis Report that provides slope stability, uplift, liquefaction and settlement analysis evaluations of the landfill interim and final conditions and an evaluation of FAD 1 slope stability. S&ME also evaluated the stability of FAD 1

during the FAR II dam raising design (AEP, 2012) that increased the FAR II water level by 14 feet. The calculated factors of safety are acceptable with respect to an evaluation of an unstable area.

Settlement analyses were also performed for the FAR 1 RSW Landfill. Results are provided and summarized in the landfill Stability Analysis Report (AEP, 2005b). These settlement analyses considered settlement of recompacted minespoil, preloaded fly ash in the FAR 1 portion, placed FGD gypsum, interim and final cover soils and variations in construction phases. Results were evaluated with respect to settlement and stresses in the geosynthetic liner layers, leachate collection piping and percent grade changes. Computed settlements (total and differential) and their effects on structural components were acceptable.

7.2.2 Areas Susceptible to Liquefaction

Due to the low seismicity of this region of Ohio, widespread liquefaction hazards within natural soil materials in the vicinity of the Site, including the CCR units, are not anticipated.

A liquefaction potential assessment and liquefaction analysis of the fly ash foundation of the FAR I RSW Landfill is included in the landfill Permit-to-Install document, Volume 3 Appendix C. Results show that the proposed design addresses potential liquefaction.

7.2.3 Areas Susceptible to Mass Movements

Observations of road cuts and former coal mine high-walls show there are potential areas of landslides and rock falls in the vicinity of FAR 1 RSW Landfill and FAR II. Areas where minespoil is present in slopes steepened by road building or other grading operations have shown evidence of slumping. For the FAR 1 RSW Landfill, the majority of minespoil materials was removed and recompacted to construct a portion of the foundation subgrade for the landfill. The potential for unstable slopes in minespoil materials were not anticipated to impact the landfill construction. The top of the mining remnant highwall which abuts the southern margin of the landfill has been cut back to minimize potential rock falls during landfill cell construction.

7.2.4 Areas Impacted By Natural and Human Induced Activities

Human induced activities that could result in unstable areas in the vicinity of the site are generally limited to former or future surface and subsurface mining activities. FAR 1 is located in a region that was formerly stripped mined for Pittsburgh #8 coal with remaining highwalls on the east and west sides of the mined area. There were no underground mines within close limits of the landfill that would affect landfill stability. Documentation letters and location figures with respect to underground mines, air shafts, mine openings, and oil and gas wells are presented in the landfill PTI Volume 1 as part of the Narrative Report and Appendix B (AEP, 2005a). Figure 7-1 shows the locations of underground mines in the vicinity of the landfill and FAR II.

Potential drawdown from nearby wells is not anticipated to have an adverse effect on the site due to the low yield and low capacity of these wells. Seismic activity is very low. No other naturally induced unstable conditions are anticipated.

7.2.5 Presence of Karst Terrain

There are several limestone strata underlying the site, however, there are no observed or reported karst features evident. Further, Jefferson County is not located within the area mapped by the ODNR as a potential karst area in Ohio (ODNR, 2006). Figure 7-2 shows the potential karst locations within Ohio and those locations not known to contain any karst features.

7.2.6 Areas Susceptible to Coastal and River Erosion

FAR 1 RSW Landfill is not located in areas susceptible to coastal or river erosion as the Ohio River is approximately one mile away. Backup of streams and FAR II discharge flow would be expected during extreme or historic flooding.

7.3 Summary of Unstable Area Compliance

The FAR 1 RSW Landfill is compliant with the requirements of §257.64 with respect to foundation and dike stability, mass movement, human induced activities, presence of karst terrain, and embankment erosion based on the PTI design and construction (which is currently underway).

8. RECOMMENDATIONS

There are no location restriction recommendations for the existing FAR 1 RSW Landfill. Design of future landfill cells will need to be modified to comply with CCR requirements. This includes evaluating the lower clay liner unit and designing a new leachate and stormwater collection basin if FAR II becomes unavailable for use.

9. CERTIFICATION BY A QUALIFIED PROFESSIONAL ENGINEER

I certify that I have reviewed this Location Restriction Evaluation and based on the evaluations presented in this report, the existing FAR I Residual Waste Solid Landfill Cells 1 and 3 at the American Electric Power Company's Cardinal Plant is, in my professional opinion, demonstrated to be in compliance with those EPA minimum location restriction requirements listed below. Cells 2, 4, 5 and 6 have not yet been constructed. By means of this certification, I am stating that the demonstrations contained herein meet the requirements of:

FAR I Residual Waste Solid Landfill

- Section 40 CFR §257.60 for Isolation from Uppermost Aquifer;
- Section 40 CFR §257.61 for Wetlands;
- Section 40 CFR §257.62 for Fault Areas;
- Section 40 CFR §257.63 for Seismic Impact Zones; and
- Section 40 CFR §257.64 for Unstable Areas.

Daniel G. Bodine

Printed Name of Registered Licensed Professional Engineer

Daniel G. Bodine

Seal and Signature

July 26, 2016

Date

E-61363

Registration License No.

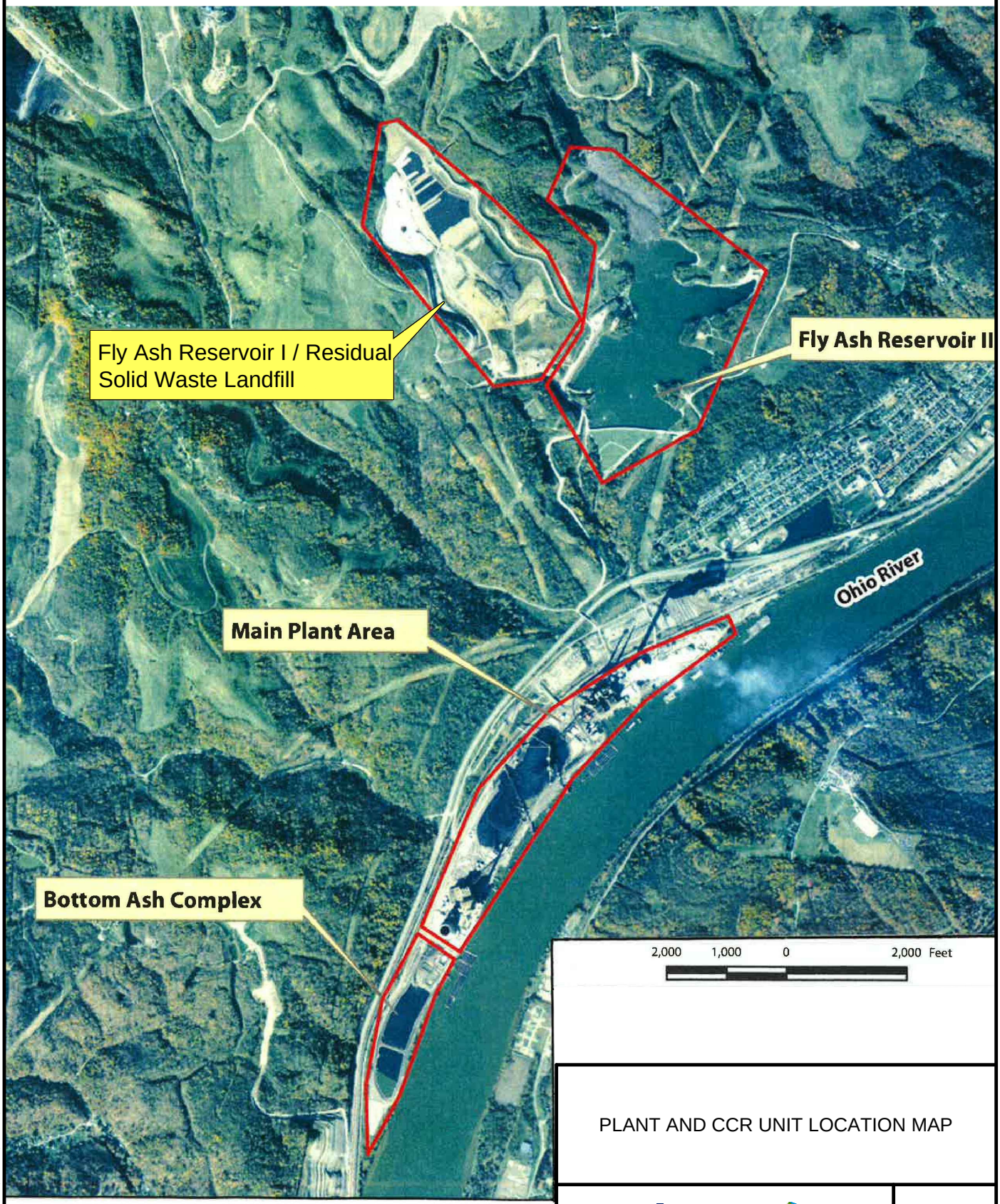
Ohio

Registration State

July 26, 2016

Date

FIGURES



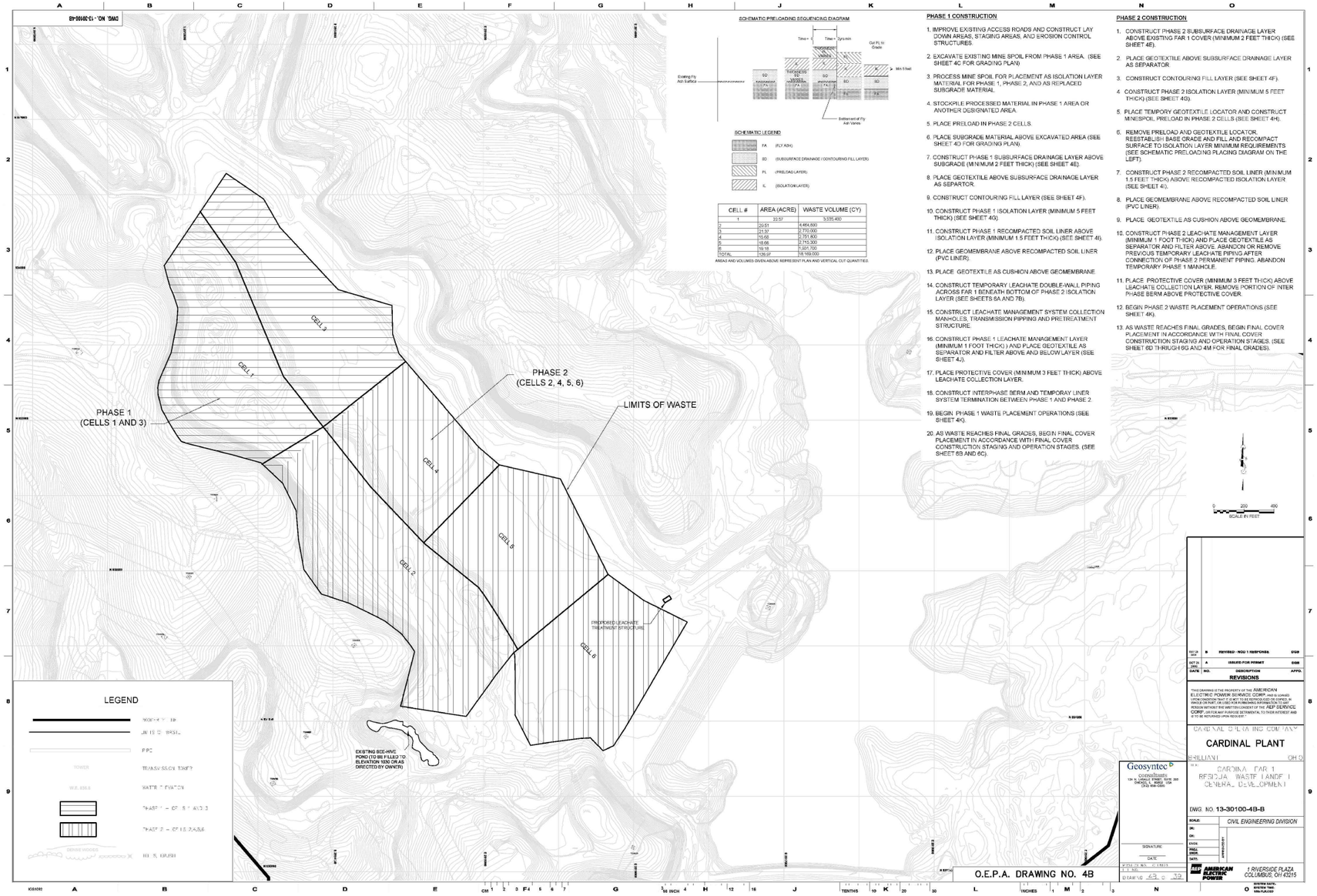
PLANT AND CCR UNIT LOCATION MAP

Geosyntec consultants

OAK BROOK, IL | AUGUST 2015

FIGURE 2-1

H:\A\AEP\MISC\FAR\RWL\FIGURE 2-1



SCHEMATIC PRELOADING SEQUENCING DIAGRAM

SCHEMATIC LEGEND

FA (FLY ASH)
SD (SUBSURFACE DRAINAGE / CONTOURING FILL LAYER)
PL (PRELOAD LAYER)
IL (ISOLATION LAYER)

CELL #	AREA (ACRE)	WASTE VOLUME (CY)
1	22.57	3,335,400
2	20.51	4,464,800
3	21.37	2,770,000
4	15.68	2,751,800
5	18.66	2,715,300
6	19.18	1,931,700
TOTAL	126.97	18,169,000

AREAS AND VOLUMES GIVEN ABOVE REPRESENT PLAN AND VERTICAL CUT QUANTITIES.

PHASE 1 CONSTRUCTION

1. IMPROVE EXISTING ACCESS ROADS AND CONSTRUCT LAY DOWN AREAS, STAGING AREAS, AND EROSION CONTROL STRUCTURES.
2. EXCAVATE EXISTING MINE SPOIL FROM PHASE 1 AREA. (SEE SHEET 4C FOR GRADING PLAN).
3. PROCESS MINE SPOIL FOR PLACEMENT AS ISOLATION LAYER MATERIAL FOR PHASE 1, PHASE 2, AND AS REPLACED SUBGRADE MATERIAL.
4. STOCKPILE PROCESSED MATERIAL IN PHASE 1 AREA OR ANOTHER DESIGNATED AREA.
5. PLACE PRELOAD IN PHASE 2 CELLS.
6. PLACE SUBGRADE MATERIAL ABOVE EXCAVATED AREA (SEE SHEET 4D FOR GRADING PLAN).
7. CONSTRUCT PHASE 1 SUBSURFACE DRAINAGE LAYER ABOVE SUBGRADE (MINIMUM 2 FEET THICK) (SEE SHEET 4E).
8. PLACE GEOTEXTILE ABOVE SUBSURFACE DRAINAGE LAYER AS SEPARTOR.
9. CONSTRUCT CONTOURING FILL LAYER (SEE SHEET 4F).
10. CONSTRUCT PHASE 1 ISOLATION LAYER (MINIMUM 5 FEET THICK) (SEE SHEET 4G).
11. CONSTRUCT PHASE 1 RECOMPACTED SOIL LINER ABOVE ISOLATION LAYER (MINIMUM 1.5 FEET THICK) (SEE SHEET 4I).
12. PLACE GEOMEMBRANE ABOVE RECOMPACTED SOIL LINER (PVC LINER).
13. PLACE GEOTEXTILE AS CUSHION ABOVE GEOMEMBRANE
14. CONSTRUCT TEMPORARY LEACHATE DOUBLE-WALL PIPING ACROSS FAR 1 BENEATH BOTTOM OF PHASE 2 ISOLATION LAYER (SEE SHEETS 6A AND 7B).
15. CONSTRUCT LEACHATE MANAGEMENT SYSTEM COLLECTION MANHOLES, TRANSMISSION PIPPING AND PRETREATMENT STRUCTURE.
16. CONSTRUCT PHASE 1 LEACHATE MANAGEMENT LAYER (MINIMUM 1 FOOT THICK) AND PLACE GEOTEXTILE AS SEPARATOR AND FILTER ABOVE AND BELOW LAYER (SEE SHEET 4J).
17. PLACE PROTECTIVE COVER (MINIMUM 3 FEET THICK) ABOVE LEACHATE COLLECTION LAYER.
18. CONSTRUCT INTERPHASE BERM AND TEMPORAY LINER SYSTEM TERMINATION BETWEEN PHASE 1 AND PHASE 2.
19. BEGIN PHASE 1 WASTE PLACEMENT OPERATIONS (SEE SHEET 4K).
20. AS WASTE REACHES FINAL GRADES, BEGIN FINAL COVER PLACEMENT IN ACCORDANCE WITH FINAL COVER CONSTRUCTION STAGING AND OPERATION STAGES. (SEE SHEET 6B AND 6C).

PHASE 2 CONSTRUCTION

1. CONSTRUCT PHASE 2 SUBSURFACE DRAINAGE LAYER ABOVE EXISTING FAR 1 COVER (MINIMUM 2 FEET THICK) (SEE SHEET 4E).
2. PLACE GEOTEXTILE ABOVE SUBSURFACE DRAINAGE LAYER AS SEPARATOR.
3. CONSTRUCT CONTOURING FILL LAYER (SEE SHEET 4F).
4. CONSTRUCT PHASE 2 ISOLATION LAYER (MINIMUM 5 FEET THICK) (SEE SHEET 4G).
5. PLACE TEMPORY GEOTEXTILE LOCATOR AND CONSTRUCT MINESPOIL PRELOAD IN PHASE 2 CELLS (SEE SHEET 4H).
6. REMOVE PRELOAD AND GEOTEXTILE LOCATOR, REESTABLISH BASE GRADE AND FILL AND RECOMPACT SURFACE TO ISOLATION LAYER MINIMUM REQUIREMENTS (SEE SCHEMATIC PRELOADING PLACING DIAGRAM ON THE LEFT).
7. CONSTRUCT PHASE 2 RECOMPACTED SOIL LINER (MINIMUM 1.5 FEET THICK) ABOVE RECOMPACTED ISOLATION LAYER (SEE SHEET 4I).
8. PLACE GEOMEMBRANE ABOVE RECOMPACTED SOIL LINER (PVC LINER).
9. PLACE GEOTEXTILE AS CUSHION ABOVE GEOMEMBRANE.
10. CONSTRUCT PHASE 2 LEACHATE MANAGEMENT LAYER (MINIMUM 1 FOOT THICK) AND PLACE GEOTEXTILE AS SEPARATOR AND FILTER ABOVE. ABANDON OR REMOVE PREVIOUS TEMPORARY LEACHATE PIPING AFTER CONNECTION OF PHASE 2 PERMANENT PIPING. ABANDON TEMPORARY PHASE 1 MANHOLE.
11. PLACE PROTECTIVE COVER (MINIMUM 3 FEET THICK) ABOVE LEACHATE COLLECTION LAYER. REMOVE PORTION OF INTER PHASE BERM ABOVE PROTECTIVE COVER.
12. BEGIN PHASE 2 WASTE PLACEMENT OPERATIONS (SEE SHEET 4K).
13. AS WASTE REACHES FINAL GRADES, BEGIN FINAL COVER PLACEMENT IN ACCORDANCE WITH FINAL COVER CONSTRUCTION STAGING AND OPERATION STAGES. (SEE SHEET 6D THRUGH 6G AND 4M FOR FINAL GRADES).

REV	DATE	DESCRIPTION	APPD.
B		REVISED - NOD 1 RESPONSE	EGB
A		ISSUED FOR PERMIT	EGB

REVISIONS

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CARDINAL OPERATING COMPANY

CARDINAL PLANT

BRILLIANT OHIO

CARDINAL FAR 1 RESIDUAL WASTE LANDFILL GENERAL DEVELOPMENT

DWG. NO. 13-30100-4B-B

SCALE: CIVIL ENGINEERING DIVISION

DR: CH: ENGR: PROJ. MGR: DATE:

SIGNATURE DATE

APPROVED: CONTRACT NO. DRAWING NO. 4B REV. B

AMERICAN ELECTRIC POWER 1 RIVERSIDE PLAZA COLUMBUS, OH 43215

Geosyntec consultants 134 N. LaSalle, Suite 300 Chicago, Illinois 60602 (312) 658-0500

SYSTEM DATE: SYSTEM TIME: TIME PLOTTED:

FAR I RSW LANDFILL GENERAL DEVELOPMENT

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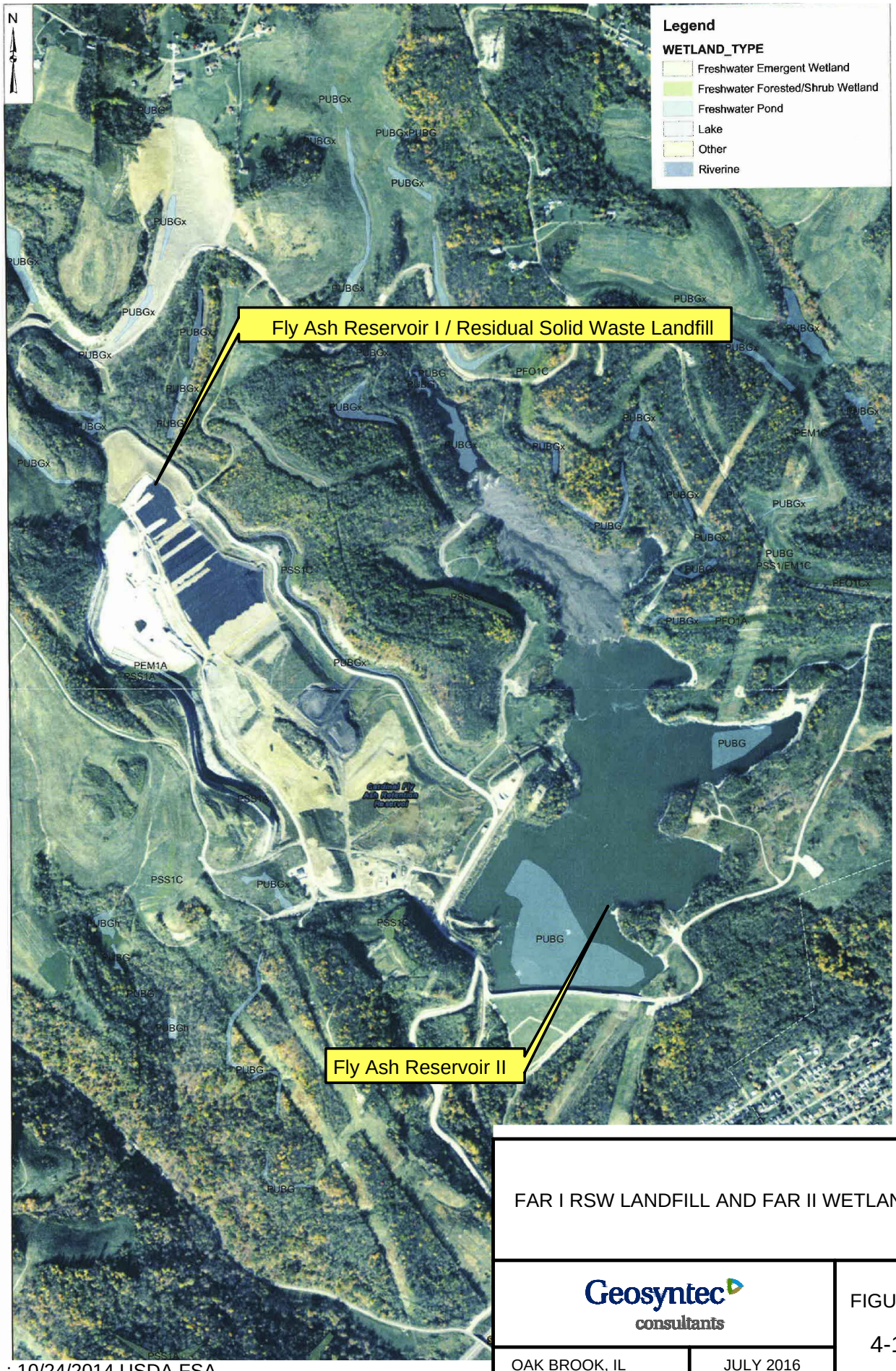
FIGURE 2-2

H:\A\AEP\MISC\FAR\RWL\FIGURE 2-2 (WETLAND)



AERIAL: 10/24/2014 USDA FSA

FAR I RSW LANDFILL AND FAR II WETLAND

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JULY 2016

FIGURE 4-1

H:\A\AEP\MISC\FAR\RWL\FIGURE 4-1 (WETLAND)

U.S. GEOLOGICAL SURVEY. (2014). "USGS INTERACTIVE FAULT MAP OF THE UNITED STATES", EARTHQUAKE HAZARDS PROGRAM, QUATERNARY FAULT AND FOLD DATABASE OF THE UNITED STATES.
http://earthquake.usgs.gov/hazards/qfaults/map

Path:

FAULT AREAS IN OHIO

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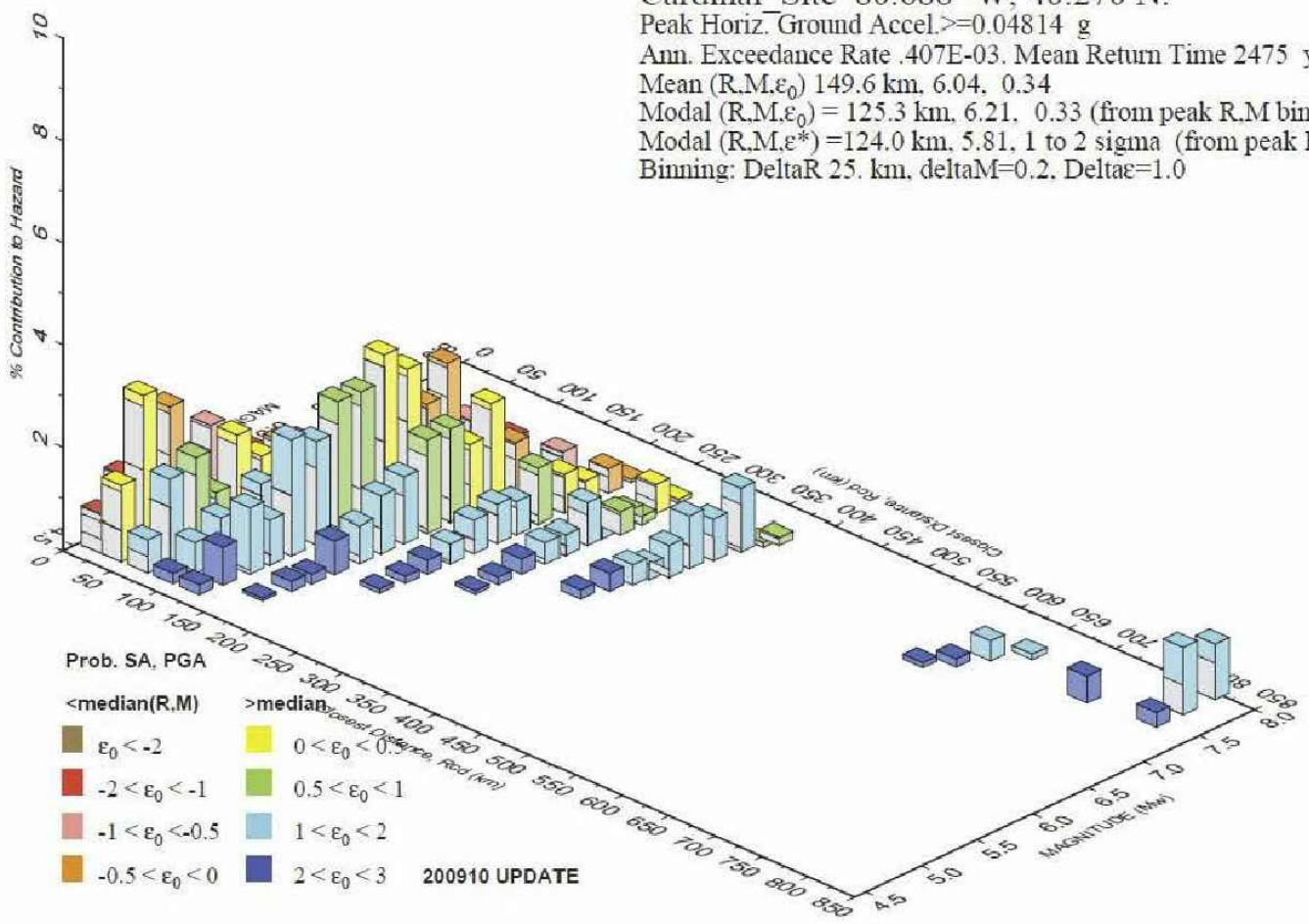
FIGURE 5-1

PSH Deaggregation on NEHRP BC rock
Cardinal_Site 80.688° W, 40.270 N.
Peak Horiz. Ground Accel.>=0.04814 g
Ann. Exceedance Rate .407E-03. Mean Return Time 2475 years
Mean (R,M,ε_0) 149.6 km, 6.04, 0.34
Modal (R,M,ε_0) = 125.3 km, 6.21, 0.33 (from peak R,M bin)
Modal (R,M,ε*) =124.0 km, 5.81, 1 to 2 sigma (from peak R,M,ε bin)
Binning: DeltaR 25. km, deltaM=0.2, Deltaε=1.0



GMT 2015 Jul 15 19:40:26 Distance (R), magnitude (M), epsilon (E0,E) deaggregation for a site on rock with average vs= 760. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

HTTP://EARTHQUAKE.USGS.GOV/HAZARDS/APPS/, USGS NATIONAL SEISMIC HAZARD ANALYSIS , 2008

DEAGGREGATION ANALYSIS FOR
CARDINAL FAR I RSW LANDFILL

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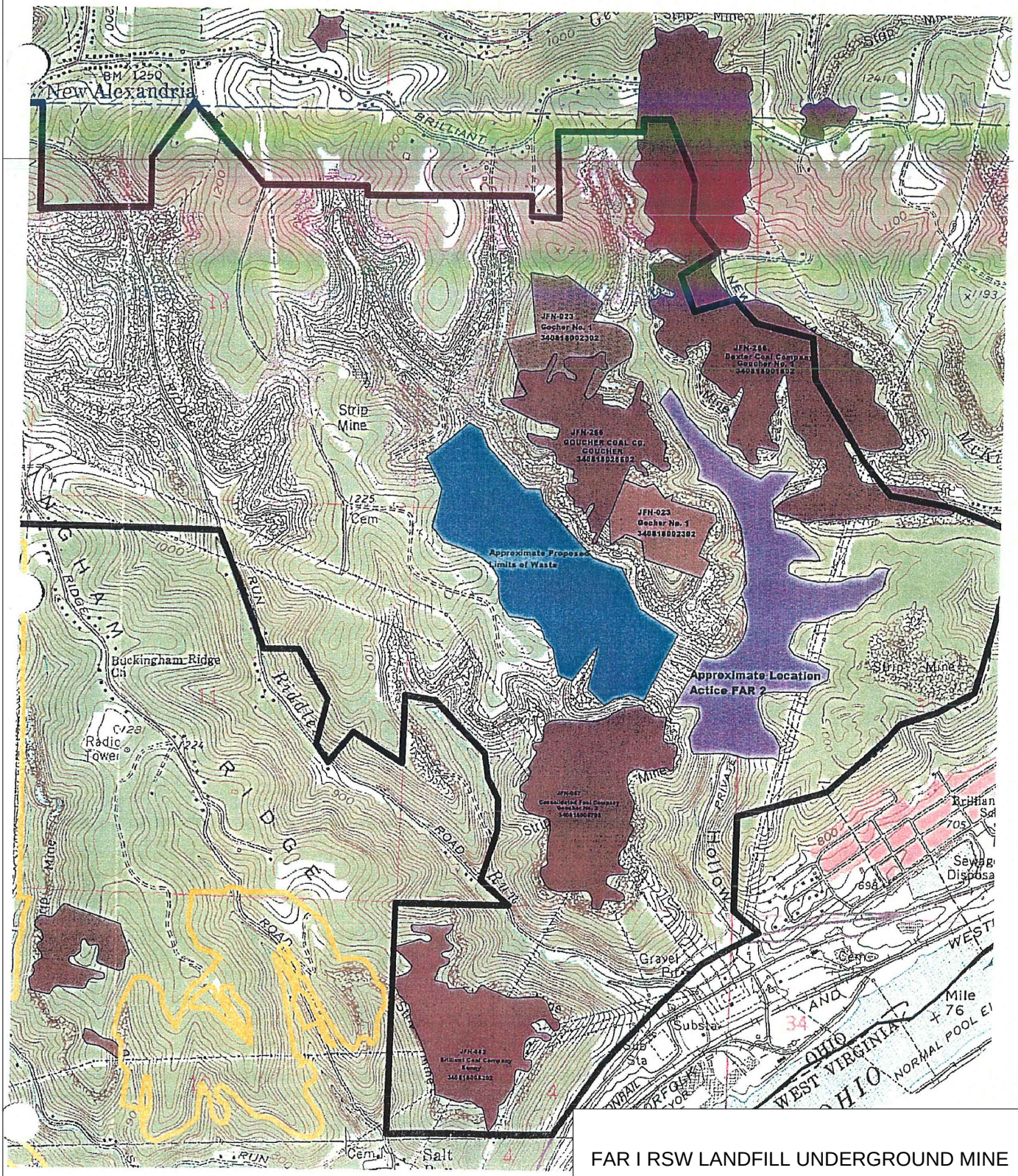
FIGURE
6-1

DRAWING2

Cardinal Plant - FAR 1 RSW Landfill and FAR II



LEGEND:

- PERMITTED MINE
- ABANDON UNDERGROUND MINE
- FAR I RWL
- FAR II
- AEP PROERTY

FAR I RSW LANDFILL UNDERGROUND MINE LOCATIONS

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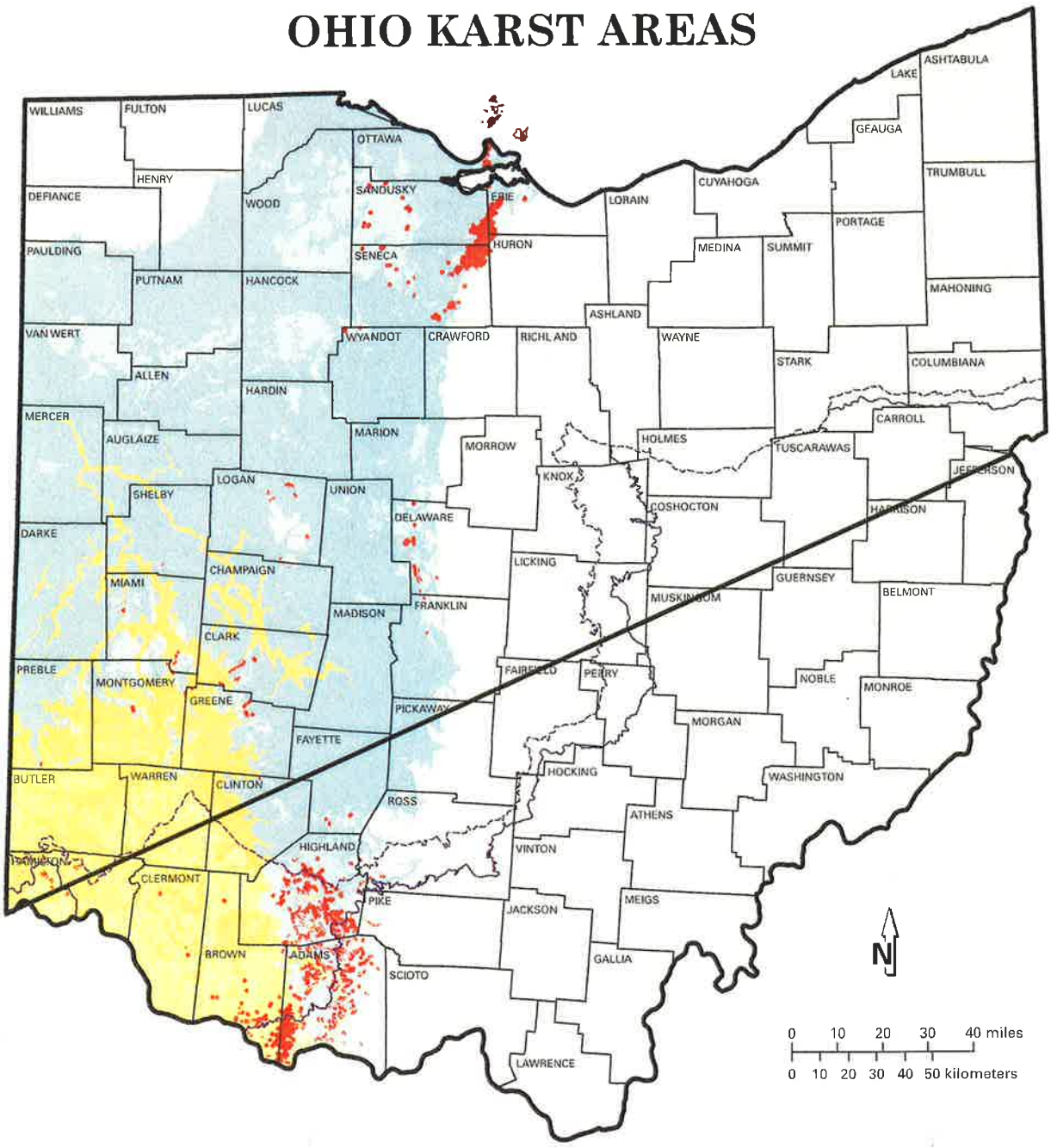
FIGURE 7-1

H: \A\AEP\MISC\FAR\RWL\FIGURE 7-1

OHIO KARST AREAS



EXPLANATION

- Silurian- and Devonian-age carbonate bedrock overlain by less than 20 feet of glacial drift and/or alluvium
- Silurian- and Devonian-age carbonate bedrock overlain by more than 20 feet of glacial drift and/or alluvium
- Interbedded Ordovician-age limestone and shale overlain by less than 20 feet of glacial drift and/or alluvium
- Interbedded Ordovician-age limestone and shale overlain by more than 20 feet of glacial drift and/or alluvium
- Probable karst areas
- Area not known to contain karst features
- Wisconsinan Glacial Margin
- Illinoian Glacial Margin

Recommended citation: Ohio Division of Geological Survey, 1999 (rev. 2002, 2006), Known and probable karst in Ohio: Ohio Department of Natural Resources, Division of Geological Survey Map EG-1, generalized page-size version with text, 2 p., scale 1:2,000,000.

Figure 7-2

Ohio Karst Areas

APPENDIX A

REFERENCES

American Electric Power Service Corporation (AEP) and Geosyntec Consultants, Permit To Install Application – Cardinal FAR 1 Residual Waste Landfill Facility Volume 1- Narrative Report, May 2006; for Geologic Setting Volume 2-Hydrogeological Investigation Report, October 2005 (AEP, 2005a).

AEP and Geosyntec Consultants (2005b). Permit To Install Application – Cardinal FAR 1 Residual Waste Landfill Facility Volume 3- Stability Analysis Report, October 2005.

AEP and Geosyntec Consultants (2005c). Permit To Install Application – Cardinal FAR 1 Residual Waste Landfill Facility Volume 4 – Calculations.

AEP and Geosyntec Consultants (2006). PTI Drawings for Cardinal FAR 1 RWL including 2008 PTI Modification, DWGs 2006, 2007 & 2008.

AEP and Geosyntec Consultants (2007). Stage A Construction of Cardinal FAR 1 RWL, DWG Sheets 1-23, 2007.

AEP (2008). FAR 1 RWL Cell 1 Construction Certification Report Photographs, Exhibits 1-9.

AEP and Geosyntec Consultants (2010). Stage B Construction of Cardinal FAR 1 RWL, DWG Sheets 24-36, 2010.

AEP (2014). Fall 2014 Groundwater Monitoring Data and Statistical Analyses for Cardinal Operating Company's Cardinal Waste Management Units, December 31, 2014.

NOAA (2016). National Oceanic and Atmospheric Administration - Annual Climatological Summary, Station: Steubenville, OH US GHCND: USC003380025 http://www.ncdc.noaa.gov/cdo-web/search?datasetid=GHCNDMS

Ohio Department of Natural Resources (ODNR) – Ohio Division of Geological Survey, Ohio Karst Areas, 1999 (Rev. 2006). http://geosurvey.ohiodnr.gov/portals/geosurvey

ODNR. (2011). Water Well Log Interactive Map. https://apps.ohiodnr.gov/water/maptechs/wellogs/appNEW/ERINMapSearch.shtml

OEPA (2004). OHIO Environmental Protection Agency (2004). Procedural and Technical Considerations for the Holocene Faults Location Restriction Demonstration, Policy DSIWM-27-20-128.

USFWS (2007). United States Fish and Wildlife Service - National Wetland Inventory Data (2007) for the FAR 1 RWL and FAR II areas plotted over United States Department of Agriculture (USDA) Aerial Photo (Oct. 10, 2014).

USGS (2008). U.S. Geological Survey - National Seismic Hazard Analysis, http://earthquake.usgs.gov/hazards/apps/

USGS (2014). USGS Interactive Fault Map of the United States - Earthquake Hazards Program. Quaternary Fault and Fold Database of the United States. http://earthquake.usgs.gov/hazards/qfaults/map/