Expert Opinion of Mark A. Quarles, P.G.

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Sierra Club, Environmental Law and Policy Center, Prairie Rivers Network, and Citizens Against Ruining the Environment v. Midwest Generation, LLC

Prepared for:

Sierra Club
50 F Street NW
8th Floor
Washington, DC 20001

Prepared by:

BBJ GROUP

1616 Westgate Circle
Brentwood, Tennessee 37027

Mark A. Quarles, P.G.
Georgia Professional Geologist No. 2266
New York Professional Geologist No. 779
Tennessee Professional Geologist No. 3834

Complainant's
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1.0 INTRODUCTION

1.1 Purpose and Scope

BBJ Group, LLC (BBJ) was retained by the "Complainants" (Sierra Club, Environmental Law and Policy Center, Prairie Rivers Network, and Citizens Against Ruining the Environment) to evaluate relevant portions of the current record to assist them in determining necessary steps to select an appropriate groundwater remedy based upon regulatory standards established by the Illinois Environmental Protection Agency (IEPA) and the Illinois Pollution Control Board ("Board").

I requested and reviewed reports and analyses provided by the Complainants from the administrative record, based upon my input of what types of documents would provide the most useful information. Of those documents, the Board's June 29, 2019 Interim Opinion and Order of the Board ("Opinion") regarding operations, storage, fill, and disposal areas, and groundwater contamination and reports that discussed the geologic and hydrogeologic conditions, were the most useful for my analysis. Further, I gathered additional background information developed by Midwest Generation, LLC ("MWG") and provided to the public on its website (https://www.nrg.com/legal/coal-combustion-residuals.html) required by the U.S. Environmental Protection Agency (US EPA) and its Coal Combustion Residuals Rule ("CCR Rule").

Reports and analyses that I relied upon to formulate my opinion are cited in this report and are listed in Section 6, References. The page numbers to those citations throughout this report are based upon the PDF page number(s) in each document.

1.2 Board Opinion and Conclusions

The Complainants filed a seven-count complaint in 2012 against MWG at four coal-fired power plants: Joliet 29 Station (Joliet), Powerton Station (Powerton), Will County Station (Will County), and Waukegan Station (Waukegan). That complaint alleged groundwater contamination and open dumping in violation of the Illinois Environmental Protection Act (Act) and Board regulations. Both the Complainants and MWG agreed that contaminants found in the groundwater at all four stations are known constituents associated with coal combustion wastes (CCWs) or coal combustion residuals ("CCRs"). (Opinion at 78). The Board defines CCWs as "any fly ash, bottom ash, slag, or flue gas or fluid bed boiler desulfurization by-products generated as a result of the combustion of ...coal, or ... coal in combination with [other material]." (Opinion at 14). CCWs and CCRs are commonly called "coal ash."

The Board concluded in its Opinion that "Environmental Groups met their burden in establishing that it is more probable than not that MWG violated the Act and Board regulations as alleged in the amended complaint." (Opinion at 1). My report cites to the Opinion numerous times because the Opinion and its findings provide a factual foundation for the basis of pollution liability. The Board concluded in its Opinion that the current record was insufficient "to determine the appropriate relief in this proceeding", and that additional hearings were necessary to determine the appropriate relief. (Opinion at 2).

The purpose of the relief is to determine an appropriate remedy to comply with the Act. Given the Board's decision that MWG has not yet thoroughly examined the active and historical disposal and fill areas at each power plant, the next step is for MWG to complete a nature and extent investigation at each of the four stations. Those investigations should be sufficient to support a remedy to comply with the Act. Significant Board conclusions related to past actions by MWG and those that are necessary in the future include:

- Active coal ash ponds or historical coal ash disposal sites or fill areas are sources of the groundwater contamination. (Opinion at 79).
- Historical liners in ash disposal ponds "can and do crack or become damaged on occasions" and that "it is more likely than not that the ash ponds did leach contaminants into groundwater." (Opinion at 26).
- MWG caused or allowed discharge of coal ash constituents into groundwater at all four stations in excess of the Board's Class I groundwater standards and in excess of statewide 90th percentile concentrations for sulfate and boron. (Opinion at 92).
- MWG violated Section 12(a) of the Act at all four stations because MWG caused or allowed discharge of coal ash contaminants into groundwater. (Opinion at 92).
- MWG violated Section 12(d) of the Act at the Powerton station because MWG placed coal ash cinders directly upon the land, thereby creating a water pollution hazard. (Opinion at 86).
- MWG violated Section 21(a) of the Act at all four stations by allowing coal ash to consolidate in the fill areas around the ash ponds and in historical coal ash storage areas and by not taking measures to remove or prevent its leaking contaminants into groundwater – therefore, creating open dumping conditions. (Opinion at 14 and 92).
- Coal ash is more likely than not spread out in the fill areas across of the four power plants and is contributing to groundwater quality exceedences in monitoring wells. (Opinion at 28, 41, 56, 57, 68, and 92).
- Groundwater contamination persists even after MWG concluded corrective actions required by its Compliance Commitment Agreements (CCAs) and Groundwater Management Zones (GMZs). (Opinion at 79). Also, the CCAs at all four stations that required on-going monitoring and inspections were "intended to avoid and detect any further contamination, or monitor the effectiveness of a corrective action, rather than remedy any contamination or remove the contaminant source." (Opinion at 82).
- MWG is liable for exceedences of a Part 620 standards at Waukegan because no GMZ exists, and MWG is also responsible for exceedences prior to establishing GMZs in 2013 at Joliet, Powerton, and Will County. (Opinion at 80). Also, a GMZ is not a permanent solution. (Opinion at 80).
- Although MWG was aware of contamination, MWG did not: undertake any further actions to stop or even identify the specific source(s) and had not taken actions to further investigate historic disposal areas; install additional groundwater monitoring wells; or complete further inspections of the ash ponds or the land around the ash ponds in areas that showed persistent groundwater exceedances. (Opinion at 79).
- Environmental Land Use Controls (ELUCs) at Powerton, Waukegan, and Will County restricted the use of the area for the future (e.g., installing potable water wells). (Opinion at 79). MWG did not "take active actions" to ensure that the contamination does not spread

beyond MWG property. (Opinion at 79). Further, ELUCs established by MWG at Powerton and Will County are not considered to be "corrective actions" because they were designed to protect against exposure to contaminated groundwater, rather than to remedy the contamination. (Opinion at 83).

- There is no evidence to expect that groundwater quality at Joliet, Powerton, or Will County will naturally return to Class I groundwater quality standards. (Opinion at 83).
- There is insufficient information for the Board to determine the appropriate relief. (Opinion at 92).

2.0 DISPOSAL PRACTICES AND GROUNDWATER CONDITIONS

2.1 Joliet Station Coal Ash Disposal

The Board concluded that historical coal ash disposal areas and coal ash fill areas at the Joliet station are likely contributing to groundwater contamination. (Opinion at 28). Further, when discussing liners in disposal areas at Joliet, the Board concluded that liners at existing ash ponds "can and do crack or become damaged on occasions" and that based upon the record, the lined ash ponds likely "did leach contaminants into the groundwater." (Opinion at 26).

Although Joliet did not become operational until 1966, the station property had been used as a coal ash disposal site (called a "landfill") prior to that time for the Joliet #9 power plant located across the Des Plaines River. That power plant began burning coal in 1917. (ENSR 1998 Phase 1 Joliet at 12 and 13). As a result, unlined coal ash disposal occurred at Joliet for decades prior to the station become operational.

As of 2020, Joliet had three active coal ash disposal ponds that were constructed in 1978 with Poz-o-Pac™ liners: Ash Pond 1, Ash Pond 2, and Ash Pond 3. Those ponds are illustrated on **Figure 1**. Those ponds were relined with a high-density polyethylene (HDPE) liner placed over the original liner in 2007, 2008, and 2013, respectively. (Opinion at 22). As a comparison, the CCR Rule requires that liners for new and lateral extensions of existing ash ponds be constructed of a composite liner consisting of *both* [emphasis supplied] a geomembrane and at least a two-foot layer of compacted soil with a permeability no greater than $1x10^{-7}$ centimeters per second – or an alternate composite liner that meets the same performance standard. (40 CFR Part 257.71). As discussed below, coal ash from historical disposal activities exists around those ponds. Ash Ponds 1 and 2 were closed between 2015 and 2019, respectively, but Ash Pond 3 remains active. (Opinion at 23). MWG has not yet made a determination on its public website that Ash Pond 3 meets the location restriction requirement that the bottom of the wastes be separated from the uppermost aquifer by a minimum of five feet. (40 CFR Part 257.60).

The Board identified three historical unlined coal ash disposal sites that contain wastes generated before MWG began operating in 1966: the Northeast Area (the landfill area), the Southwest Area, and the Northwest Area, as illustrated on **Figure 2**. (Opinion at 26). An aerial photograph taken in 1973 that illustrates those historical disposal areas is included as **Figure 2**. The Board also concluded that coal ash fill is present around the current (i.e., active) ash ponds, as evidenced by coal ash in borings drilled around those ponds. (Opinion at 28).

A hydrogeologic assessment was performed at Joliet in 2011 by Patrick Engineering, Inc. (Patrick) to evaluate the potential for Ash Ponds 1, 2, and 3 to contaminate groundwater, to characterize the subsurface geologic and hydrogeologic conditions, and to identify potable water wells within 2,500 feet of the ash ponds. In summary, that investigation concluded the following key points:

- The combined size of the three active ash ponds is approximately 10 acres. (Patrick 2011 Joliet at 3).

- Antimony, chloride, manganese, sulfate, and Total Dissolved Solids (TDS) were detected at one or more wells at concentrations that exceeded the Part 620 Class I groundwater quality standards. (Patrick 2011 Joliet at 9).
- The investigation was inconclusive on the contribution of the three ash ponds to the contamination because in some cases, the highest constituent concentrations were reported in hydraulically upgradient wells. (Patrick 2011 Joliet at 9).
- The uppermost aquifer occurred 29 to 34 feet below ground surface (BGS) in sandy loam soils (measured from the top of pond fill embankments). (Patrick 2011 Joliet at 10). The shallow aquifer flowed towards the Des Plaines River during most periods of the year. (Patrick 2011 Joliet at 4 and 10).
- The site is located within the Joliet Depression, which is a "cone of depression of the groundwater surface caused by the large withdrawals of the groundwater from the deeper aquifers due to industrial and municipal use in the area." (Patrick 2011 Joliet at 4).
- The calculated groundwater seepage velocity was 0.30 feet per day, based upon the highest aquifer hydraulic conductivity (3.896×10^{-3} feet/second [ft./sec.]). (Patrick 2011 Joliet at 10).
- The potable water well search identified 17 wells within 2,500 feet of the ash ponds and "most of these wells are screened in much deeper aquifers." (Patrick 2011 Joliet at 10.)

Joliet has a GMZ that was approved by IEPA in August 2013. The GMZ is for an area around and hydraulically downgradient of Ash Ponds 1, 2, and 3. MWG acknowledged that the station was subject to the Class I groundwater classification, and MWG agreed to line Ash Pond 3 with an HDPE liner. (Opinion at 24 and 25). The CCA covering the ash ponds at Joiiet did not include a requirement for an Environmental Land Use Control (ELUC). (Opinion at 24 and 25).

2.2 Powerton Station Coal Ash Disposal

As with Joliet, the Board concluded that historical coal ash disposal areas and coal ash fill areas at Powerton are also likely contributing to groundwater contamination. (Opinion at 42). Further, the Board concluded that liners at existing ash ponds "can and do crack or become damaged on occasions" and that based upon the record, the lined ash ponds likely "did leach contaminants into the groundwater." (Opinion at 40). The Board also concluded that coal ash fill exists beyond the footprints of current disposal areas, and that some of that coal ash is submerged in as much as nine feet of groundwater. (Opinion at 41).

The Powerton station began producing electricity in the late 1920s (units 1 – 4) and was upgraded with new units in the early 1970s. (ENSR 1998 Phase 1 Powerton at 15). As of 2019, the current coal ash disposal or related treatment ponds included four ponds: the Ash Bypass Basin, Ash Surge Basin, Metal Cleaning Basin, and Secondary Settling Basin located in the immediate vicinity of the Former Ash Basin, as illustrated on **Figure 3**. (Opinion at 36 and 37). The Ash Surge Basin and Ash Bypass Basins are currently used to collect bottom ash. (Opinion at 36).

The Former Ash Basin was constructed with the bottom below the uppermost aquifer and therefore does not meet the CCR Rule-required five-foot separation (40 CFR Part 257.60) from the bottom of the pond to the uppermost aquifer. (Location Restrictions FAB Powerton at 1). MWG determined that the required five-foot separation from the uppermost aquifer was met for the Ash Bypass Basin and Ash Surge Basin (Location Restrictions Ash Burge Basin and Bypass Basin Powerton at 1).

The Ash Bypass Basin, Ash Surge Basin, and Metal Cleaning Basin were constructed in 1978 with Poz-o-Pac™ liners. (Opinion at 36). All active ponds were relined with an HPDE liner over the original liner between 2010 and 2013. (Opinion at 36). As a comparison, the CCR Rule requires that liners for new and lateral extensions of existing ash ponds be constructed of a composite liner consisting of *both* [emphasis supplied] a geomembrane and at least a two-foot layer of compacted soil with a permeability no greater than $1x10^{-7}$ centimeters per second – or an alternate composite liner that meets the same performance standard. (40 CFR Part 257.71). The originally constructed bottom elevation of the Ash Surge Basin was 452 feet mean sea level (MSL), the area around it consisted of coal ash and clayey soil fill, and the typical water elevation in the pond was approximately 462 feet MSL. (History of Construction Powerton Ash Surge and Bypass Basins at 14, 22, and 26).

Three historical coal ash storage sites exist according to the Board: East Yard Run-off Basin, Limestone Run-off Basin, and the Former Ash Basin. (Opinion at 40 and 41). The locations of those areas are illustrated on **Figures 3** and **4**. Only the Limestone Runoff Basin was lined as of the Board's Opinion in 2019. Fly ash has never been directed to the active ash ponds, but bottom ash has been sluiced to those ponds. (Opinion at 36). Bottom ash is removed from the basins and hauled off-site for mine disposal. (Opinion at 36).

MWG estimated that coal ash disposal in the Former Ash Basin ended in the 1970s. (History of Construction FAB Powerton at 2). The Former Ash Basin was constructed with a bottom elevation that is below the uppermost aquifer, meaning that coal ash has been submerged in groundwater. (Location Restrictions Powerton at 1). The Former Ash Basin was modified in 2010 by building a berm across the basin to support a railroad spur, forming the North Pond and South Pond sections. That berm was constructed of coal ash. (History of Construction FAB Powerton at 3).

According to the 1955 topographic map provided as **Figure 4,** the ground surface at what is now the Former Ash Basin was approximately 450 feet above MSL and approximately 440 feet MSL where the Ash Surge Basin and Bypass Basin are currently located. An aerial photograph taken in 1961 and a topographic map from 1967 (see also **Figure 4**) illustrate that:

- The Former Ash Basin is a much larger footprint than currently described by KPRG – extending beneath the active ash basins. Plus, wells used in the current groundwater monitoring system are drilled into areas of historical waste placement,
- Another suspected disposal area (not previously recognized by the Board) is located between the intake and discharge channels,
- Another suspected coal ash pond is located southeast of the power plant, and
- Groundwater monitoring wells used by MWG for current compliance purposes are located within areas of historical ash disposal.

A hydrogeologic assessment was also performed at Powerton in 2011 to evaluate the potential for three active ash ponds (Ash Surge Basin, Ash Bypass Basin, and Secondary Settling Basin) to contaminate groundwater, to characterize the subsurface geologic and hydrogeologic conditions, and to identify potable water wells within 2,500 of those ash ponds. In summary, that investigation concluded the following key points:

- The combined size of the three active ash ponds is approximately 11 acres. (Patrick 2011 Powerton at 3).
- Manganese and boron were detected at one or more wells exceeding the Part 620 Class I groundwater quality standards. (Patrick 2011 Powerton at 9).
- The investigation was inconclusive on the contribution of the three ash ponds to the contamination because in some cases, the highest constituent concentrations were reported in hydraulically upgradient wells. (Patrick 2011 Powerton at 9.)
- The uppermost aquifer occurred from 18 to 28 feet BGS in sand, gravel, and clayey soils (measured from the top of basin fill). The shallow aquifer flowed towards the Illinois River located to the north / northwest during "most periods of the year." (Patrick 2011 Powerton at 4 and 9.)
- The potentiometric surface diagram (i.e., groundwater directional flow map) excluded some wells (MW-2, MW-6, and MW-8) around the three active ponds and the Former Ash Basin (MW-2) because the groundwater elevations were "apparent anomalies", being inexplicably different than other wells. The anomalies "could be due to localized differences in lithology or localized areas of recharge", and more data were needed from future sampling events to evaluate those comparatively higher elevations. (Patrick 2011 Powerton at 10 and 22). In fact, Patrick concluded that the accurate groundwater flow direction is unknown and likely shifts seasonally. (Patrick 2011 Powerton at 22).
- The calculated groundwater seepage velocity was 2.27 feet per day based upon the highest aquifer hydraulic conductivity (4.7×10^{-3} ft./sec.). (Patrick 2011 Powerton at 10.)
- The potable water well search identified six wells within 2,500 feet of the ash ponds; each well was screened "below 50 feet"; and of those wells, two provide water to Powerton (unspecified use). (Patrick 2011 Powerton at 10.)

Powerton has an ELUC and GMZ that were approved in August and October 2013, respectively. The GMZ and ELUC are for an area around and hydraulically downgradient of the active ash ponds and the Former Ash Basin. In its application for the GMZ, MWG acknowledged that the station was subject to the Class I groundwater quality standards and agreed to re-line the Ash Surge Basin and Secondary Settling Basin with a HDPE liner. (Opinion at 38 and 39).

KPRG completed two Alternate Source Determinations (ASDs) in April 2018 and March 2019 on behalf of MWG to evaluate if groundwater constituents reported in monitoring wells (associated with the CCR Rule monitoring system) were contaminated by leakage from the Ash Surge Basin, the Ash Bypass Basin, or from an alternate "historical" source. KPRG relies on groundwater monitoring results from three "upgradient" wells (MW-01, MW-09, and MW-19) that were used to develop site-specific groundwater protection standards ("GWPs"). (KPRG 2019 Powerton at 7). KPRG concluded that four wells (MW-09, MW-11, MW-12, and MW-19) used in its 2018 ASD were all drilled into historical coal ash. (KPRG Powerton 2019 at 203). KPRG collected samples of current ash material (bottom ash) and water from the basins, analyzed them by the Leaching Environmental Assessment Framework ("LEAF") leaching test method, and compared the results to groundwater quality from adjacent monitoring wells. (KPRG Powerton 2019 at 200 and KPRG Powerton 2020 at 218). Upon completion of those ASD analyses, KPRG concluded that:

- **2018 ASD**: the Ash Surge Basin "is not the source of the downgradient monitoring well SSIs (statistically significant increases) and that there is an alternate source(s) of impacts. However, the data relative to the ABB (Ash Bypass Basin) was not as definitive and potential contribution of leachate from the ABB to the local groundwater impacts could not be ruled out." Further, KPRG added that the Ash Bypass Basin was a possible contaminant source – "considering the identification of a tear in the liner at the end of August 2018." (KPRG 2019 Powerton at 8 and 207).
- **2019 ASD**: the Ash Surge Basin and Ash Bypass Basin "are not the source of downgradient monitoring well detections above established GWPSs and that there is an alternate source(s) of impacts." Most notably, neither KPRG nor MWG attempted to identify the source(s) of that contamination as being a current or historical disposal area. (KPRG 2020 Powerton at 7).

2.3 Waukegan Station Coal Ash Disposal

Similarly, as the Board determined for Joliet and Powerton, the Board concluded that it is likely that historic disposal areas and coal ash fill areas at the Waukegan station are causing or contributing to groundwater quality standard exceedances. (Opinion at 68). Also, the Board concluded that liners at Waukegan "can and do crack or get damaged on occasions" and that it is likely that those ash ponds "did leach contaminants into the groundwater." (Opinion at 66).

The Waukegan station began burning coal to produce electricity in the early 1920s and was upgraded with new units in the 1950s and 1960s. (ENSR 1998 Phase 1 Waukegan at 11). The current coal ash treatment and disposal units includes two ash ponds: the East Ash Basin and the West Ash Basin, as illustrated on **Figure 5**. Although power generation began in the 1920 and coal ash would have been generated, the East and West Basins were not constructed until 1977.

The Board concluded that at least one historical unlined coal ash disposal area exists at the site (called the Former Slag / Fly Ash Storage area located west of West Ash Basin). The Board also concluded that coal ash is present on the property in areas outside of that historical area and outside of the current ash ponds. (Opinion at 67). Those areas are illustrated on **Figure 6**.

Pond construction drawings for the East and West Ash Basins indicate that the area had already been used for disposal, given the presence of existing dikes and the occurrence of slag and fly ash on the ground surface where the East and West Ash Basins were being constructed. (History of Construction Waukegan at 4 and 15). In addition, the planned construction materials of the dikes of the East and West Basins were slag and fly ash. (History of Construction Waukegan at 15). An aerial photograph taken in 1972 (**Figure 6**) – five years prior to construction of the new East and West Basins – illustrates that:

- The former disposal area is located beneath the current East and West Basins,
- The hydraulically downgradient monitoring wells used by MWG for current compliance purposes for the East and West Basins were drilled into historical ash of the original basin, and
- Hydraulically upgradient monitoring wells were sometimes drilled into historical fly ash and slag disposal areas.

MWG has confirmed that it knew of historical, unlined coal ash disposal in the area west of the East and West Basins; MWG has never removed any historical coal from that area; and the area has not been closed with an impermeable cap. (Opinion at 67). The Board concluded that coal ash was buried around the East and West Ash Basins as deep as 22 feet BGS, and that some of that coal ash was saturated in groundwater. (Opinion at 67).

Both the East and West Basins were originally constructed with a Hypalon geomembrane liner, but those liners were relined with an HDPE liner in 2003 and 2004, respectively. (Opinion at 64). As a comparison, the CCR Rule requires that liners for new and lateral extensions of existing ash ponds be constructed of a composite liner consisting of *both* [emphasis supplied] a geomembrane and at least a two-foot layer of compacted soil with a permeability no greater than $1x10^{-7}$ centimeters per second – or an alternate composite liner that meets the same performance standard. (40 CFR Part 257.71). The ponds are used for disposal of bottom ash, and fly ash is transported off-site for beneficial reuse. (Opinion at 64). The reported bottom elevations of the ponds are approximately 585 feet MSL, compared to common groundwater elevations between 582 and 583 feet MSL. (Opinion at 64). As such, there is only approximately two to three feet separating the bottom of the liner from groundwater. MWG concluded however, that the East and West Ash Basins were in compliance with the CCR Rule-required five-foot separation because its statistical analyses indicted that groundwater elevations are below and do not intersect with the bottom of the ash ponds and the liner, and the liner will prevent a "hydraulic connection" to groundwater if "unusually high" groundwater fluctuations occur. (Location Restrictions Waukegan at 2).

A hydrogeologic assessment was also performed at the Waukegan station in 2011 to evaluate the potential for the two active ash ponds (East Ash Pond and West Ash Pond) to contaminate groundwater, to characterize the subsurface geologic and hydrogeologic conditions, and to identify potable water wells within 2,500 of the ash ponds. In summary, that investigation concluded the following key points:

- The combined size of the two active ash ponds is approximately 25 acres. (Patrick 2011 Waukegan at 3).
- Antimony, arsenic, boron, sulfate, and TDS were detected at one or more wells exceeding the Part 620 Class I groundwater quality standards. (Patrick 2011 Waukegan at 9).
- The investigation was inconclusive on the contribution of the two active ash ponds to the contamination because in some cases, the highest constituent concentrations were reported in hydraulically upgradient wells. (Patrick 2011 Waukegan at 9).
- Although the uppermost aquifer occurred at 22 to 23 feet BGS, those measurements were based upon wells drilled from the top of MWG-constructed basin embankments and not the original ground surface. (Patrick 2011 Waukegan at 9 and 18). The top of the groundwater surface was instead very shallow, less than five feet below the adjacent land surface. (Patrick 2011 Waukegan at 18). The shallow groundwater flows towards Lake Michigan. (Patrick 2011 Waukegan at 9).
- The soil types in borings drilled for wells was very porous sand, silt, and gravel. (Patrick 2011 Waukegan at 9).
- The calculated groundwater seepage velocity was 0.59 feet per day based upon the highest aquifer hydraulic conductivity (4.0×10^{-3} ft./sec.). (Patrick 2011 Waukegan at 10).

- The potable water well search identified eight wells within 2,500 feet of the ash ponds. None were located to the east or south of the ash ponds towards Lake Michigan. (Patrick 2011 Waukegan at 10).

The Waukegan station does not have a GMZ for any portion of the property but does have an ELUC. The ELUC was originally recorded in 2003 by MWG for a portion of the western property due to past industrial activities at a tannery located on adjacent property to the west, and possible migration of tannery-related contaminants onto MWG property. MWG applied for and received an extension of the tannery related ELUC in August 2013 to extend coverage from the western property boundary, to the area beneath the current ash ponds, and to Lake Michigan to the east. (Opinion at 65).

KPRG completed two ASDs in April 2018 and March 2019 on behalf of MWG to evaluate if groundwater constituents reported in monitoring wells associated with the CCR Rule monitoring system were contaminated by leakage from the East Ash Basin, the West Ash Basin, or from an "alternate" source. (KPRG 2019 Waukegan at 4 and KPRG 2020 Waukegan at 6). Notably, KPRG did not specifically name "historical" disposal areas as possible source(s) in either ASD – as it did for the Powerton ASDs. Similar to the ASDs at Powerton, KPRG collected coal ash (bottom ash) and water from current basins, analyzed them by the LEAF method, and compared the results to groundwater monitoring well results. Upon completion of those analyses, KPRG included that:

- **2018 ASD**: "SSIs for boron, pH, and sulfate were not the result of a release of leachate from the regulated units (East and West Ash Ponds) but rather from other potential source(s)." (KPRG 2019 Waukegan at 6). KPRG concluded that downgradient wells used in its comparative analyses (MW-01 through MW-04) have had historically high concentrations of boron and sulfate (both are indicators of coal ash), and each of those wells were drilled into ash pond embankments that were constructed with coal ash. (KPRG 2019 Waukegan at 105).
- **2019 ASD**: SSIs for calcium and total dissolved solids (TDS) for well MW-16 "are not the result of leakage of leachate from the regulated units but rather from other potential source(s)." (KPRG 2020 Waukegan at 5 and 6). KPRG also concluded that MW-16 was drilled into an embankment at least partially constructed of coal ash and that the constituents in the well are related to "other sources" in the upgradient direction near another well (MW-5). (KPRG 2020 Waukegan at 103 and 104). MW-5 is located within the Former Slag and Fly Ash Storage Area illustrated on **Figure 6**.

2.4 Will County Station Coal Ash Disposal

Similarly, as the Board determined for Joliet, Powerton, and Waukegan, the Board concluded that it is likely that historic disposal areas and coal ash fill areas at Will County are causing or contributing to groundwater standard exceedances. (Opinion at 57). Also, the Board concluded that liners in disposal units at Will County "can and do crack or get damaged on occasions" and that it is likely that those ash ponds "did leach contaminants into the groundwater." (Opinion at 55).

Will County became operational in 1955 and was updated with new boilers in 1957 and 1963. The station is bordered on the east by the Chicago Sanitary & Ship Canal and on the west by the Des Plaines River. (ENSR 1998 Will County at 14). Four ponds were part of the original ash treatment system: Ash Pond 1N, Ash Pond 1S, Ash Pond 2S, and Ash Pond 3S. Those areas are illustrated on **Figure 7**. Those ponds were constructed in 1977 with Poz-o-Pac™ liners, and Ponds 2S and 3S also had a bituminous coating. (Opinion at 52).

The current coal ash disposal system includes two active basins: South Ash Pond 2S and South Ash Pond 3S. Those ponds were relined with HDPE liners over the original liners in 2009. (Opinion at 52). As a comparison, the CCR Rule requires that liners for new and lateral extensions of existing ash ponds be constructed of a composite liner consisting of *both* [emphasis supplied] a geomembrane and at least a two-foot layer of compacted soil with a permeability no greater than $1x10^{-7}$ centimeters per second – or an alternate composite liner that meets the same performance standard. (40 CFR Part 257.71). Bottom ash is collected in those active ponds, and fly ash is transported off-site for beneficial reuse. (Opinion at 51).

The Board concluded that three historical unlined coal ash disposal areas exist at the site: Ponds 1N and 1 South; fill areas outside of the ponds; and an alleged Slag and Bottom Ash Placement Area to the south. (Opinion at 56). Those areas are illustrated in **Figure 8**.

Former Ash Ponds 1N and 1S were removed from service in 2010, yet still contained ash years later. Further, both Ponds 1N and 1S were constructed with bottoms that were at least one foot below average groundwater elevations. According to the record, groundwater was able to seep into the ash basins, and leachate was able to seep out of the basins. (Opinion at 56). According to MWG's analysis, current and active Ash Pond 2S and Ash Pond 3S do not have the CCR Rule-required five-foot separation from the bottom of the ponds to the uppermost aquifer. (Location Restrictions Will County at 1). Groundwater beneath Ash Pond 3S is approximately one foot below the bottom of the pond. (Opinion at 52). Therefore, Ash Pond 3S does not have the required five-foot separation.

Soil borings demonstrated that coal ash is buried outside of the ash ponds. Borings drilled around the ash ponds had coal ash in them up to 12 feet BGS, demonstrating that coal ash was not limited to the current size of Pond 1N. Further, coal ash was saturated in groundwater in the soil boring advanced for well MW-2. (Opinion at 56). Patrick investigations in 2010 and 2011 demonstrated that "thick layers of coal ash" existed around the ash ponds – particularly along the eastern edge of the ponds and within borings associated with five of six monitoring wells considered by KPRG to be hydraulically upgradient wells for compliance monitoring purposes. (Opinion at 56 and KPRGb 2020 Will County at 5). As shown on **Figure 8**, an aerial photograph taken in 1962 and a 1963 topographic map illustrate:

- The current ash ponds were once part of a single large pond.
- Upgradient groundwater monitoring wells used in the current compliance monitoring system were drilled immediately adjacent to (MW-1, MW-3, MW-4, MW-5, and MW-6) or within (MW-2) the footprint of the original ash pond.

A hydrogeologic assessment was also performed at Will County in 2011 to evaluate the potential for four active ash ponds (Ash Pond 1N, Ash Pond 1S, Ash Pond 2S, and Ash Pond 3) to contaminate groundwater, to characterize the subsurface geologic and hydrogeologic conditions, and to identify potable water wells within 2,500 of the ash ponds. In summary, that investigation concluded the following key points:

- The total acreage of the four active ash ponds is approximately eight acres. (Patrick 2011 Will County at 3).
- Manganese, boron, sulfate, and TDS were detected at one or more wells exceeding the Part 620 Class I groundwater quality standards. (Patrick 2011 Will County at 9).
- The investigation was inconclusive on the contribution of the four active ash ponds to the contamination because in some cases, the highest constituent concentrations were reported in hydraulically upgradient wells. (Patrick 2011 Will County at 9).
- Coal, coal cinders, and / or coal ash were detected in the borings drilled for five of the 10 wells installed. (Patrick 2011 Will County at 22, 23, 24, 25, and 27). As such, at least 5 wells used for current compliance monitoring were drilled through coal ash. All ten of the wells were drilled through clay and porous fill that consisted of sand, crushed rock and limestone, cobbles, and gravel. (Patrick 2011 Will County at 22 through 31).
- The uppermost aquifer was found approximately eight to 11 feet BGS and was most commonly present in unconsolidated fill, soil, and coal ash (MW-2) materials above the top of bedrock. (Patrick 2011 Will County at 22 through 31). The wells were however, drilled and screened mostly into the deeper limestone bedrock.
- Groundwater flow is "variable" and in two directions "during most periods of the year" – both eastward to the Chicago Sanitary & Ship Canal and westward into the Des Plaines River. (Patrick 2011 Will County at 4 and 10). Patrick did not develop a potentiometric surface diagram like it did for the other three power plants.
- The aquifer hydraulic conductivity ranged from 2.07×10^{-4} to 6.38×10^{-5} ft./sec. (Patrick 2011 at 10).
- Patrick did not calculate a groundwater velocity rate because it could not calculate "a reliable hydraulic gradient" due to the "apparent complexity of the shallow flow system." (Patrick 2011 at 10).
- The site is located within the Joliet Depression. (Patrick 2011 Will County at 4).
- The potable water well search identified six wells within 2,500 feet of the ash ponds, and three of those wells are located on MWG property. (Patrick 2011 Will County at 32). Patrick concluded that those wells are drilled more than 1,500 feet BGS and are screened beneath an aquitard. (Patrick 2011 Will County at 10).

Although the groundwater seepage velocity was not determined in the 2011 hydrogeologic investigation, more recent groundwater monitoring results at Will County demonstrate that the seepage velocity ranged from 0.5 to 1.0 foot per day. (KPRG 2020 Will County 16).

Will County has an ELUC and GMZ that were approved in September 2013, respectively. The GMZ and ELUC are for an area around and hydraulically downgradient of four ash ponds (Ash Pond 1N, Ash Pond 1S, Ash Pond 2S, and Ash Pond 3S) and extending to the Des Plaines River to the west and the Chicago Sanitary & Ship Canal to the east. The GMZ does not include non-community wells and requires that un-used community wells be properly abandoned. MWG acknowledged that the station was subject to the Class I groundwater classification, and MWG agreed to line Ash Pond 2S with a HDPE liner, remove Ash Pond 1S and Ash Pond 1N from service, and install a dewatering system to keep water levels in Ash Ponds 1S and 1N to less than one foot depth. (Opinion at 53 and 54). Ash Pond 2S was relined with a HPDE liner in 2013, and Ash Pond 3S was relined with a HDEP liner in 2009. (Opinion at 52). As a comparison, the CCR Rule requires that liners for new and lateral extensions of existing ash ponds be constructed of a composite liner consisting of *both* [emphasis supplied] a geomembrane and at least a two-foot layer of compacted soil with a permeability no greater than 1×10^{-7} centimeters per second – or an alternate composite liner that meets the same performance standard. (40 CFR Part 257.71).

KPRG completed an ASD in April 2018 on behalf of MWG to evaluate if groundwater constituents reported in monitoring wells associated with the CCR Rule were contaminated by leakage from Ash Pond 2S, Ash Pond 3S, or from an alternate source(s). KPRG collected water and coal ash from each of those bottom ash ponds, completed the LEAF method analyses, and compared the results to upgradient and downgradient monitoring wells. (KPRG 2019 at 86 and 87). Upon completion of that analysis, KPRG included that "SSIs for chloride, fluoride, and TDS are not the result of a release of leachate from the regulated units (Ponds 2S and 3S) but rather from other potential source(s)" because upgradient and downgradient groundwater well concentrations were different than the ash leachate produced in the LEAF analysis. (KPRG 2019 Will County at 7 and 87).

3.0 TECHNICAL ANALYSES

3.1 Regulatory Basis for a Groundwater Remedy

The Board concluded in its Opinion that Class 1, Part 620 groundwater quality standards have been exceeded at each of the four stations between 2010 and 2017. (Opinion at 2). The Board also concluded that are three possible sources of groundwater contamination at each of the four stations: active coal ash ponds / basins, historical coal ash disposal sites, and historical coal ash fill areas. (Opinion at 78, 79, and 90). Given that unlined coal ash disposal at each station began decades ago and shallow groundwater exists at each site, waste constituent leaching to groundwater has likely occurred at Joliet, Powerton, and Waukegan for over 100 years and for nearly 70 years at Will County.

As previously discussed, the Board also concluded monitoring and inspection programs associated with the CCAs were intended to avoid and detect any further contamination or monitor the effectiveness (or not) of a corrective action, rather than remedy the contamination or remove its source. Further, the CCAs, GMZs, and ELUCs have not resulted in MWG undertaking any further action to i.) stop or even identify the specific source(s) of contamination, ii.) further investigate historical disposal and fill areas spread out on the properties, iii.) install additional groundwater monitoring wells, or iv.) further inspect any of the coal ash ponds or areas around those ponds that have evidence of contamination.

Although approved GMZs exist at Joliet, Powerton, and Will County, the Board has concluded that those zones do not prevent MWG from being liable for contamination that occurred prior to 2013 when the GMZs were established. (Opinion at 80). No such GMZ exists for the Waukegan station. (Opinion at 80). The Board concluded that GMZs are not a permanent solution for contamination. (Opinion at 80). Given that the Board concluded that Class I groundwater standards have been exceeded at least as early as 2010, MWG is responsible for contamination from any of the potential sources of coal ash related contamination.

The Board concluded that ELUCs at Powerton, Waukegan, and Will County stations are not considered to be corrective actions because they were designed to protect against exposure of contaminants, rather than remedying the contamination. (Opinion at 65 and 83). As such, the ELUCs do not relieve MWG of its responsibility to complete a groundwater corrective action.

Given that the Board concluded that there is no evidence to expect that groundwater will return to Class I standards naturally – even after completion of the CCA-required corrective actions – MWG is now required to conduct corrective actions. Prior to a remedy being selected, MWG must first identify the source(s) of contamination and then determine the nature and extent of that contamination.

Source identification and completion of a nature and extent investigation is the next step to remedy the violations of Section 12(a) for causing or allowing the discharge of contaminants to the environment; of Section 12(a) for exceeding statewide concentrations of sulfate and boron; of Section 12(d) for depositing coal ash directly upon the ground and creating a water pollution hazard;

and of Section 21(a) for allowing coal ash to consolidate in fill areas and without taking measures to remove it or prevent its leaking of contaminants to groundwater. MWG cannot design and implement remedies to address those violations without first knowing:

- Where the historical and recent coal ash is located throughout the properties at each station and the volume and type of those materials, and
- Under what conditions the coal ash exists on or near the ground surface relative to groundwater and saturation in the disposal areas.

3.2 Missed Opportunities to Define Contaminant Sources

Although MWG has investigated active disposal areas to some degree, those results raise more questions than provide answers. A thorough investigation to define the nature and extent of contamination would define the source(s) of groundwater contamination. As previously discussed, MWG has only completed limited subsurface investigations required by IEPA and according to the CCR Rule. Those investigations were limited in scale and scope and in fact, created significant, additional unanswered questions regarding the source(s) of contamination. For example, consider:

- Hydrogeologic Investigations (2011) were only performed around the active ash basins / ponds at each of the four stations, and each of the investigations were "inconclusive" on the source(s) of contamination. As a result, the source(s) of the contamination has gone undefined.
- ASDs at the Powerton, Waukegan, and Will County stations only investigated the ash and water from the active basins that were being used to store bottom ash – yet historical coal ash disposed in the area could have possibly included fly ash, slag, and cinders, and the ash ponds embankments may have been constructed in part with fly ash, for example. MWG only concluded that the active ponds were not the source of contamination, and that the contamination was from other potential, undefined source(s).

The hydrogeologic investigations performed in 2011 (Patrick) determined without explanation, that the highest constituent concentrations in groundwater were sometimes found in hydraulically *upgradient* [emphasis supplied] wells – in the *opposite direction* [emphasis supplied] of where contaminants from active ash basins are supposed to flow. Boring and well logs from Will County, demonstrate that wells were drilled into coal ash – possibly explaining the higher upgradient concentrations.

The more recent ASDs completed by KPRG, are good examples of continued missed opportunities for MWG to define historical disposal and fill areas as source(s) of contamination. KPRG was careful in its ASDs to only evaluate contaminant potential from the *active* [emphasis supplied] disposal areas. KPRG failed to conclude in the ASDs for Powerton, Waukegan, and Will County that historic sources were likely contributors to current groundwater contamination – despite KPRG mentioning that historic sources were possible sources at both Powerton and Waukegan. KPRG also should have known that historical coal ash was present adjacent to the ash ponds at Will County, and it knew that wells were drilled into historic coal ash at Powerton and Waukegan. KPRG did not specifically conclude that historical coal ash disposal or fill activities were likely responsible for groundwater contamination at any location – choosing instead to conclude that *undefined potential sources* [emphasis supplied] were responsible for the groundwater contamination.

As illustrated in **Figure 4** (Powerton), **Figure 6** (Waukegan), and **Figure 8** (Will County), wells used by MWG and KPRG in the active basin monitoring systems are:

- **Powerton and Waukegan**: Within historical coal ash disposal areas,
- **Will County**: Immediately adjacent to and sometimes in coal ash in the ash basins, and
- **Within the radius of influence of mounded groundwater**: Groundwater would have flowed radially in a 360-degree direction from unlined surface impoundments at all locations where sluicing occurred – resulting in groundwater flowing in the upgradient direction currently interpreted by KPRG.

As previously discussed, KPRG concluded in its ASDs that the active ash ponds were not the sources of groundwater contamination – even though the Board concluded that the liners likely leaked, and the basins were re-lined because of that leakage. Next, Patrick concluded in its 2011 hydrogeologic investigations that groundwater elevation "anomalies" existed around the active basins due to differences in "lithology" or localized areas of "higher recharge." Given these conclusions by KPRG and Patrick, I performed a follow-up analysis. My review of that data indicates that the historically placed coal ash *and* [emphasis supplied] more recent leakage from the Ash Surge Basin may have both contributed to contamination, based upon the following:

- **Recent basin leakage** - Given that the Ash Surge Basin had been lined since 1978 and relined in 2013, there should not have been much "recharge" to groundwater from precipitation because the liner would have prevented most precipitation seepage into groundwater. However, groundwater sampling in April 2020 shows a groundwater elevation (451 feet MSL) that is mounded beneath the ash basins and within one foot of the bottom of the Ash Surge Basin (452 feet MSL) and immediately beneath the 12-inch thick Poz-o-Pac™ liner (451 feet MSL). (Opinion at 36 and KPRG 2020b Powerton at 5). This one-foot separation does not meet the CCR Rule-required five-foot separation for location restrictions – conflicting with KPRG's October 2018 determination that adequate separation exists. The KPRG-prepared potentiometric surface diagram is included in **Figure 9**. In contrast, the potentiometric surface diagram that I prepared using the same elevations illustrates mounded groundwater and radial groundwater flow conditions emanating from the Ash Surge Basin and the Ash Bypass Basin (also in **Figure 9**). Both diagrams show groundwater less than five feet below the bottom of the Ash Surge Basin. The likely logical explanation for the "higher recharge" according to Patrick in 2011 and the 2020 mounded groundwater, is more recent leakage from one or more ash basins.
- **Historical leakage** – Although KPRG concluded that the contamination in wells was not due to leakage from the Ash Surge Basin during completion of the ASDs in 2018 and 2019, KPRG apparently did not consider that MWG constructed the Ash Surge Basin over coal ash or that the embankments of the Ash Surge Basin were constructed partially of bottom ash, cinders, and / or fly ash. (History of Construction at 22 and 35). The historical aerial photograph and topographic map in **Figure 4** illustrate that the Ash Surge Basin and other basins in that area

were constructed over the historical disposal area (i.e. "tailings pond" in the figure) known as the Former Ash Basin.

3.3 Requirements to Identify Contaminant Sources

The Board concluded that the CCAs, GMZs, and ELUCs do not relieve MWG from its responsibilities to identify and investigate all sources of groundwater contamination and even recognized that MWG used the CCAs to "avoid and detect any further contamination." The Board also recognized that MWG failed to install additional groundwater monitoring wells or further inspect the ash pond areas or the areas around those ponds.

Constituents can leach from coal ash and into ground from active or historical sources of contamination. Leachability from coal ash can also vary between fly ash and bottom ash, for example. As a result, both current and historical sources of contamination are possible sources of current groundwater contamination. The leachate quality also can change over time – depending on for example, coal source, pollution control technologies used, and geochemical changes in the basins and underlying groundwater. A remedial strategy that only addresses current or active disposal areas (mainly bottom ash) misses even larger areas of contamination associated with historic disposal and fill areas (also including fly ash, cinders, and slag). Likewise, investigations that focus solely on historical areas might miss leakage from currently active disposal and treatment areas.

Source identification is a critical component of a site investigation. IEPA rules (e.g., 35 Illinois Administrative Code Section 740.420) require that *sources and potential sources* [emphasis supplied] of contamination be identified and thoroughly investigated. As a result, for a remedy to be successful, MWG will need to thoroughly identify known and potential sources of that contamination in areas that have been recently used for coal ash disposal, in addition to any known, suspected, or potential historical source areas. Source identification is just one component of a nature and extent investigation.

3.4 Nature and Extent Investigative Requirements

Given the Board's conclusion that some of the historical basins were unlined and that even the lined ash ponds leaked contaminants into the groundwater, the shallow groundwater has been historically prone to contamination for decades. The extent of that contamination and the geologic and hydrogeologic conditions have not been defined site-wide at each station. Once a source(s) of contamination is identified, additional information should be collected to determine, for example:

- How much coal ash exists in unlined disposal and storage areas,
- What types of coal ash exist (e.g. fly ash, bottom ash, slag, and cinders),
- How much saturated and unsaturated coal ash exists,
- The thickness of any saturated coal ash,
- The vertical and horizontal migration of contaminants into the aquifer,
- The chemical and geochemical conditions in the saturated ash and the aquifer,
- The direction of groundwater flow from the disposal and fill areas, and
- Migration pathways of contaminants from the source(s).

Defining the nature and extent of contamination is a basic foundation of any environmental investigation defined by State and Federal regulations. Consider the following examples from US EPA and IEPA regulations:

- **CCR Rule** (40 CFR Part 257.98 (g.)(1)) – "Characterize the nature and extent of the release and any relevant site conditions that may affect the remedy ultimately selected." The rule also requires that the "characterization must be sufficient to support a complete and accurate assessment of the corrective action measures necessary to effectively clean up all releases from the CCR unit..." The rule specifies that the minimum investigative measures include 1.) installing additional groundwater monitoring wells necessary to define the contaminant plume, 2.) collecting data on the nature and estimated quantity of the release, 3.) installing and sampling at least one additional well at the facility boundary in the direction of groundwater flow, and 4.) sampling all wells to characterize the nature and extent of the release. All such activities are needed for MWG to develop an Assessment of Corrective Measures report. (40 CFR Part 259.96).
- **IEPA Rules** (35 Illinois Administrative Code Section 740.415 and 740.420): A site investigation is required to identify "all or specified recognized environmental conditions at a remediation site, the related contaminants of concern, and associated factors that will aid in the identification of risks to human health, safety, and the environment, the determination of remediation alternatives, and the design and implementation of a Remedial Action Plan." An investigation is required to determine the nature and extent of contamination.

Investigations to define the nature and extent of contamination most commonly incorporate intrusive subsurface investigative techniques such as borings into soil and coal ash and groundwater monitoring wells. Sometimes, such intrusive investigations also include non or less-intrusive geophysical methods to provide a "picture" by depth to guide the intrusive investigation with target sampling points. A thorough investigation is necessary to locate all sources of contamination, determine the nature and extent of that contamination, and determine the characteristics of the site that would be useful to evaluate and select one or more remedies for environmental media (e.g., soil, groundwater, sediment, surface water). Also, without such information, the volume and extent of the waste and affected media will not be known.

The coal ash ponds / basins at each of the four stations are located close to and sometimes adjacent to large surface water bodies (e.g., Des Plaines, Illinois, Lake Michigan, and the Chicago Ship & Sanitary Canal). They are also possibly located in floodplains or certainly close to floodplains, and an actual determination should be made for each power plant. Soil borings and groundwater monitoring wells drilled at each site demonstrate that groundwater is very shallow and in porous soils, and the shallow groundwater flows into receiving surface waters at each station.

MWG is required to complete an investigation to identify sources and potential sources of contamination. Potential sources would include areas suspected of being disposal areas. A thorough investigation to define the nature and extent of contamination would define the possible receptors to coal ash related contamination. Example human and / or ecological receptors and exposure pathways include:

- **Surface water erosion and transport** - Coal ash disposal areas can be prone to erosion and wash-out into a surface water because disposal areas are located very close to rivers, streams, canals, and / or Lake Michigan.
- **Groundwater discharges into vegetated areas** – Disposal areas are commonly located within shallow groundwater areas, and that groundwater can discharge into wetlands and vegetated areas nearby. **Figure 10**, for example, illustrates what seems to be distressed vegetation east of the East Ash Basin at Waukegan recently in June 2020.
- **Groundwater discharges along shorelines** – Shallow groundwater perpetually discharges into the receiving surface water bodies, and those discharges can accumulate coal ash related constituents in the sediments and surface water with human and ecological risks. An example of contaminated coal ash groundwater (e.g., red water seeps) discharging into the Vermillion River and accumulating in sediments is illustrated below:

- **Groundwater connectivity to water supply wells** - the shallow water table aquifer at the stations has the potential to be used for potable, industrial, irrigation, and commercial supplies and can also potentially migrate into deeper aquifers.

As previously discussed for Joliet and Will County stations, those power plants are located within the "Joliet Depression". Pumping of large potable and industrial water wells locally near any power plant, for example, can create a cone of depression (i.e., drawdown) of both deep and shallow aquifers, in addition to changing the direction of groundwater flow of the aquifers. Also, industrial uses of groundwater for manufacturing operations, for example, rely on high quality water, even in the absence of human health-based exceedances. As a result, localized groundwater quality at the stations can have both multiple concerns for receptors. A nature and extent study would thoroughly evaluate possible coal contaminant migration risks with local drinking water and non-drinking water groundwater users.

3.5 Data Implications for Existing Compliance Monitoring

The Board determined that upgradient wells were sometimes located in historical coal ash disposal or fill areas and as a result, that prior disposal may be the cause of those higher upgradient concentrations used by MWG for compliance and reporting purposes. Further, KPRG has admitted that wells used for current IEPA and US EPA compliance monitoring programs are drilled into historical wastes – and that sometimes the unexplained highest contaminant concentrations are in hydraulically upgradient wells.

The significance of "upgradient" groundwater quality cannot be overstated because those hydraulically upgradient wells determine if MWG is required to perform additional investigative or corrective actions according to the CCR Rule, for example. MWG uses those upgradient wells as baseline regulatory comparisons to hydraulically downgradient wells. If MWG uses upgradient wells that are already contaminated from the current ash ponds or historical coal ash, MWG is comparing wells to already contaminated conditions. The groundwater sampling results would therefore only require MWG to perform more in-depth sampling (e.g., for metals like arsenic) and corrective actions if concentrations vary from groundwater quality that is already contaminated.

3.6 Regulatory Implications for Saturated Coal Ash

As previously discussed, the Board concluded existing data demonstrated coal ash was disposed in basins below and within the uppermost aquifers at Powerton, Waukegan, and Will County Stations. The shallow aquifers beneath each of the four stations are porous and have relatively high groundwater seepage velocities. Those seepage velocities indicate the relative ease and speed for contaminants to migrate from disposal areas. A site-wide understanding of where the historical and current disposal areas have affected groundwater quality and how potential receptors have been affected is critical when evaluating remedies.

The US EPA, in its CCR Rule, understood the risks associated with saturated coal ash and coal ash that is located too close to the underlying aquifer. The US EPA requires existing unlined coal ash disposal sites to close if the base of the disposal area is closer than five feet from the upper limit of the uppermost aquifer. (40 CFR Part 257.60). Further, closure-in-place is not allowed unless the closure method controls, minimizes, or eliminates, to the maximum extent feasible, post-closure infiltration of liquids into the wastes (e.g., rainfall and snow) and releases from the unit (e.g., leachate) to groundwater or surface waters. (40 CFR Part 257.102(d).). The degree of coal ash saturation on each power plant property is therefore a very important factor in evaluating remedial alternatives. Only by completing a site-wide investigation of active and historical disposal and fill areas, will MWG know that information.

Constituents can readily leach from coal ash and into groundwater, and groundwater is hydraulically connected to surface waters located close to the disposal and fill areas at each station. Leaching can continue from saturated coal ash slowly and perpetually into the future. Further, leaching conditions can change over time, as the geochemical conditions of the aquifer and coal ash change.

4.0 REMEDIAL ACTION

4.1 Recent Cases of Coal Ash Removal Actions

The CCR Rule requires coal ash disposal sites meeting certain criteria to close by two options: closure-by-removal where wastes are excavated and hauled to a lined disposal area or beneficially used or closure-in-place where wastes remain separated from groundwater and are covered by an impermeable membrane. (40 CFR Part 257.102 (c) and (d)). Saturated coal ash cannot be closed in-place according to the CCR Rule because leaching to groundwater will continue from unlined disposal areas. (40 CFR Part 257.102 (d)(i.)). Also, disposal units that contain coal ash that is located too close to the uppermost aquifer are required to close. (40 CFR Part 257.60(c)(4)).

Utilities across the United States began closure activities in response to the CCR Rule, based upon the results of the required assessments. Commonly, utilities have chosen to close disposal areas by closure-by-removal where the coal ash is excavated and then placed into a lined landfill. A list of 127 coal ash disposal units located in 27 states that was previously provided to MWG, is included in **Table 1**. Of those units, seven MWG ash ponds at Joliet (Ash Pond #2), Powerton (Ash Surge Basin and Ash Bypass Basin), Waukegan (East and West Ponds), and Will County (Ash Ponds 2S and 3S) and seven additional units in Texas owned by MWG's parent company (NRG) are all planned for closure-by-removal.

Nationally and in particular in Illinois, utilities have therefore determined that closure-by-removal is technically feasible and economically reasonable – even for very large disposal areas that are sometimes hundreds of acres in size and contain millions of cubic yards of coal ash. Closure-by-removal is particularly common at power plants where there is not adequate separation between the bottom of the wastes and the uppermost aquifer, or where the disposal area is located close to surface water bodies – conditions that exist at each of the four MWG power plants.

4.2 Investigative Results Used to Evaluate Remedies

Any current groundwater remedy needs to consider that both the historical and current disposal areas are possible source areas, consistent with the Board's conclusion that active *and* historical coal ash disposal areas are likely sources of contamination. To know which historical and active source areas are contributors to contamination, MWG needs to know where all those areas are (i.e., source identification) and under what conditions the coal ash exists in those areas (i.e., nature and extent of contamination).

Source identification and defining the nature and extent of contamination are fundamental first steps for selecting a remedy under IEPA and Federal programs such as the Resource Conservation and Recovery Act (RCRA, 42 U.S.C. Sections 6901 – 6992k), the Comprehensive Environmental Response, Compensation and Liability Act (CERLCA, 42 U.S.C. Sections 9601 - 9675), and other state-equivalent programs.

4.3 Components and Objectives of a Remedial Action Plan

Remedial actions or corrective actions are consistently required by IEPA, other states, and the US EPA when groundwater quality violations occur. Violations require completion of a plan to evaluate and correct that contamination – whether that plan is called a Feasibility Study, Assessment of Corrective Measures, Corrective Action Plan, or Remedial Action Plan.

As previously discussed, the Board concluded that ELUCs are not considered to be "corrective actions" because they were designed to protect against exposure to contaminated groundwater, rather than to remedy the contamination. (Opinion at 83). Also, the Board concluded that there is no evidence to expect that groundwater quality at Joliet, Powerton, or Will County will naturally return to Class I groundwater quality standards. (Opinion at 83). As a result, corrective actions are necessary to reduce constituent concentrations to Class I GWPSs.

The overall objectives of a groundwater corrective action should be to eliminate or reduce future generation of leachate and groundwater contamination; capture, contain, or minimize the groundwater plume; provide adequate treatment to meet IEPA groundwater and surface water quality standards and the 90th percentile background concentrations identified by the Board; mitigate the violations for open dumping; and mitigate ecological and biological impacts that may have occurred. Water quality attainment should not just be limited to human-health drinking water standards, but also consider aquatic toxicity, sediment chemistry and toxicity, and other adverse effects to the environment (e.g., wetlands and vegetation).

Based upon my experience – regardless of the state or Federal regulatory framework that requires such a plan – a remedial action or corrective action plan should include an alternatives analysis that considers multiple potential remedial technologies for each contaminated media (e.g., soil, groundwater). Each of those alternatives are then evaluated individually and collectively – based upon site-specific conditions determined during the nature and extent investigation – to then select a recommended remedial approach. An evaluation of these basic components of possible remedial alternatives is fundamental to evaluating and selecting a remedy:

- Ability of the remedy to protect human health and the environment,
- Ability of the remedy to control, reduce, or eliminate future releases of contaminants,
- Long and short-term effectiveness of the remedy and the degree of certainty that it will achieve the required objectives,
- Feasibility of implementation; and
- Whether remediation objectives will be achieved within a reasonable period of time.

5.0 SUMMARY AND CONCLUSIONS

5.1 Contaminant Sources

The contaminants in groundwater at the four stations are consistent with my experience in other coal ash disposal sites around the country. Leaching of coal ash constituents to groundwater from unlined disposal areas has been likely for nearly 100 years at Joliet, Powerton, and Waukegan and for nearly 70 years at Will County.

The Board concluded that active coal ash ponds and historical coal ash disposal sites and fill areas spread around the power plants are likely sources of the groundwater contamination, and that violations exist due to that contamination. In addition, the Board concluded that violations exist due to placement of coal ash onto the ground surface, thus creating a water pollution hazard, and that groundwater contamination is likely due to leakage and leachate migration from both lined and unlined disposal and fill areas. The Board also concluded that even though some original disposal areas were lined, those liners were susceptible to damage and cracks and likely leaked.

The Phase 1 ESAs by ENSR for each of the four power plants – completed nearly 23 years ago – identified numerous historical disposal and fill areas – yet the Board concluded MWG still had not investigated those areas. Soil borings and well construction diagrams for all sites demonstrate that historic coal ash fill areas are widespread, yet the exact locations and extent of all historic disposal and fill areas remain unknown. Historical coal ash can also contaminate groundwater. Current and historical data also demonstrate that current monitoring wells are drilled into coal ash. Further, MWG's current consultant (KPRG) and prior consultant (Patrick) apparently did not recommend that the nature and extent of that contamination be investigated – despite the knowledge that coal ash existed outside of current ash pond perimeters.

MWG plans to excavate coal ash from seven currently active ash ponds at Joliet, Powerton, Waukegan, and Will County. Even with that excavation of active ash ponds, soil borings drilled around those ash ponds have demonstrated that coal ash will remain after closure-by-removal and will be a likely continued source to groundwater contamination because:

- Coal ash was found in borings around the ash ponds at Joliet, Powerton, Waukegan, and Will County,
- Coal ash was found in ash pond embankments at Powerton and Waukegan,
- Coal ash was used to construct a railroad spur across the Former Ash Basin at Powerton, and
- Coal ash was found beneath the ash ponds at Powerton and Waukegan.

My analysis and the Board's conclusion in its Opinion – and even admitted by KPRG in recent ASDs – all demonstrate that monitoring wells were drilled into legacy ash and / or ash basin embankments that were constructed with coal ash. Even with this knowledge, MWG failed to assign blame or investigate further those previously undefined, "alternate" or potential sources.

Had MWG acknowledged the impact of historical contamination during completion of its ASDs, for example, KPRG and MWG could have assigned blame for groundwater contamination to historic sources – rather than just concluding that the contamination was not from the active ash basins. MWG, KPRG, and Patrick's lack of assigning possible contaminant blame and completing further investigations are consistent with the Board's prior determination that MWG's monitoring and inspection programs for the CCAs were intended to avoid and detect contamination. That avoidance was carried over to the monitoring programs associated with the CCR Rule and the CCAs.

Although MWG relined ash ponds with HDPE liners at each of the four stations, the HDPE liners were placed on top of the original liners that were prone to leak. The addition of the HDPE liner on top of the old liner may not meet the requirements of the CCR Rule, unless MWG demonstrates that a two-foot layer of soil with a hydraulic conductivity no greater than 1×10^{-7} centimeters per second also exists beneath the HPDE layer (or an alternate liner that meets the same performance equivalence).

MWG is required to define *probable and possible* [emphasis supplied] sources of contamination in a nature and extent investigation. MWG cannot possibly complete a groundwater remedy without first knowing the locations of all source areas and the conditions the coal ash exists at those locations.

Historical contamination in wells used for active basin compliance activities not only affects the need to identify source areas, complete a nature and extent investigation, and develop a remedy – but that contamination also adversely affects current CCA and CCR Rule compliance monitoring activities. MWG's use of contaminated background or baseline well data for CCR Rule purposes will only trigger the need to complete required assessments (and corresponding analyses of metals) or corrective actions – if groundwater quality worsens from concentrations possibly already indicative of contamination from historical leakage.

5.2 Need for a Nature and Extent Investigation

As discussed above, the first step in determining a suitable remedy at each of the four stations is for MWG to determine the source(s) of contamination, the types of coal ash (e.g. fly ash, bottom ash, cinders, and / or slag), the characteristics of where and how that material exists in the environment, and how much coal ash exists.

The investigation at each station should define the nature and extent of contamination for all active and historical disposal and fill areas. Site-specific factors gathered in an investigation should then be used by MWG to determine possible remedy options and determine how those remedies will be effective in improving groundwater quality over time. The nature and extent study that MWG is required to complete should include these components, at a minimum:

- Sampling, analyses, and field screening activities,
- Characterization of sources and potential sources of contamination,
- A determination of the degree of saturation of coal ash and connectivity to groundwater,
- A three-dimensional analysis (horizontally and vertically) and the nature, direction, and rate of movement of contaminants,
- Characterization of present and post-remediation exposure routes that may potentially threaten human or environmental receptors, and

- Characterization of significant physical features of the remediation site and vicinity that may affect contaminant fate and transport and present a risk to human health, safety, and the environment.

Groundwater elevations can also rise with climate change – possibly submerging even more coal ash in the future. The nature and extent investigations should consider that groundwater elevations might rise in the future and inundate even more coal ash. Precipitation that accumulates in coal ash can mound the groundwater, creating radial, 360-degree groundwater flow from unlined disposal areas. Further, higher hydraulic heads of that mounding can cause increased horizontal seepage velocities and a vertical gradient that can "push" contaminants deeper into the aquifer.

5.3 Remedy Selection

The Board concluded that MWG's use of the CCAs, GMZs, and ELUCs have not resulted in improvement in groundwater quality and will not prevent the continued spread of contaminants from source areas. As a result, MWG is required to complete other actions that result in a remedy that meets IEPA groundwater protection standards, in addition to state and Federal standards for other affected media such as wetlands and sediment.

The groundwater remedy should consider that groundwater at each station should be protected for current *and future* [emphasis supplied] uses. Potential current and future human receptors include not only possible drinking water exposures, but also industrial, commercial, or irrigation users that pump groundwater. The study should also recognize that ecological resources possibly remain threatened in the future without a proper remedy.

The remedies associated with each station should be capable of performing satisfactorily, reliably, and within a reasonable amount of time. Each potential remedy should be thoroughly evaluated in an alternatives analysis that is included in a corrective action or remedial action plan. An insufficiently performed nature and extent investigation risks selection of a remedy that will not meet the required groundwater clean-up objectives.

The same shallow, porous, and relatively rapid flow groundwater conditions that exist at each station that create contaminant migration threats, are favorable for a variety of groundwater remedies. Those factors make groundwater remedies more technologically practical and economically reasonable. Such high groundwater flow rates enable groundwater, for example, to be captured by pumping wells and for chemical treatment additives to be injected into the aquifer.

The coal combustion industry and in particular MWG, consider excavation or closure-by-removal to be a technologically practical and economically reasonable closure alternative. Closure of coal ash disposal areas by excavating coal ash and transporting that material to a lined landfill has been common across the United States. Even though MWG plans to close ash ponds at Joliet, Powerton, Waukegan, and Will County by excavation and removal, those closure efforts will be incomplete to remove contaminant sources if historical coal ash remains in adjacent areas or beneath the former active ash ponds. Closure by excavation is expected to improve groundwater quality over time because the source of the contaminants is removed.

6.0 REFERENCES

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16. Location Restrictions Powerton. Placement Above the Uppermost Aquifer Location Restrictions, Former Ash Basin, Geosyntec Consultants, April 2020.
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18. Location Restrictions Waukegan, Placement Above the Uppermost Aquifer Location Restrictions, East and West Basins, Geosyntec Consultants, October 2018.
19. Location Restrictions Will County. Placement Above the Uppermost Aquifer Location Restrictions, South Ash Ponds 2S and 3S, Geosyntec Consultants, October 2018.

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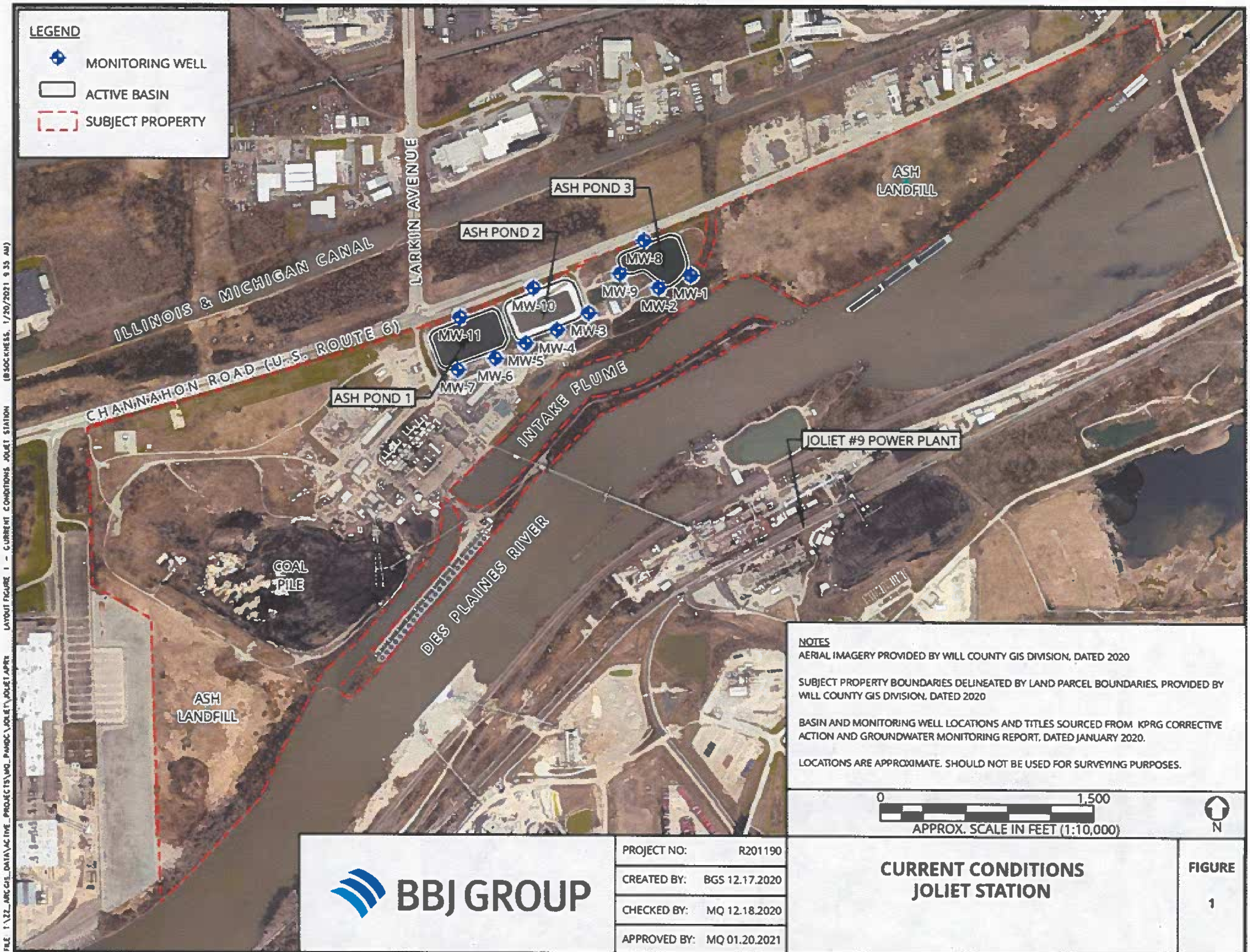
FIGURES


LEGEND
MONITORING WELL
ACTIVE BASIN
SUBJECT PROPERTY
ILLINOIS & MICHIGAN CANAL
CHANNAHON ROAD (U.S. ROUTE 6)
LARKIN AVENUE
ASH POND 1
ASH POND 2
ASH POND 3
MW-1
MW-2
MW-3
MW-4
MW-5
MW-6
MW-7
MW-8
MW-9
MW-10
MW-11
ASH LANDFILL
INTAKE FLUME
JOLIET #9 POWER PLANT
COAL PILE
DES PLAINES RIVER
ASH LANDFILL
NOTES
AERIAL IMAGERY PROVIDED BY WILL COUNTY GIS DIVISION, DATED 2020
SUBJECT PROPERTY BOUNDARIES DELINEATED BY LAND PARCEL BOUNDARIES, PROVIDED BY WILL COUNTY GIS DIVISION, DATED 2020
BASIN AND MONITORING WELL LOCATIONS AND TITLES SOURCED FROM KPRG CORRECTIVE ACTION AND GROUNDWATER MONITORING REPORT, DATED JANUARY 2020.
LOCATIONS ARE APPROXIMATE. SHOULD NOT BE USED FOR SURVEYING PURPOSES.
0
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APPROX. SCALE IN FEET (1:10,000)
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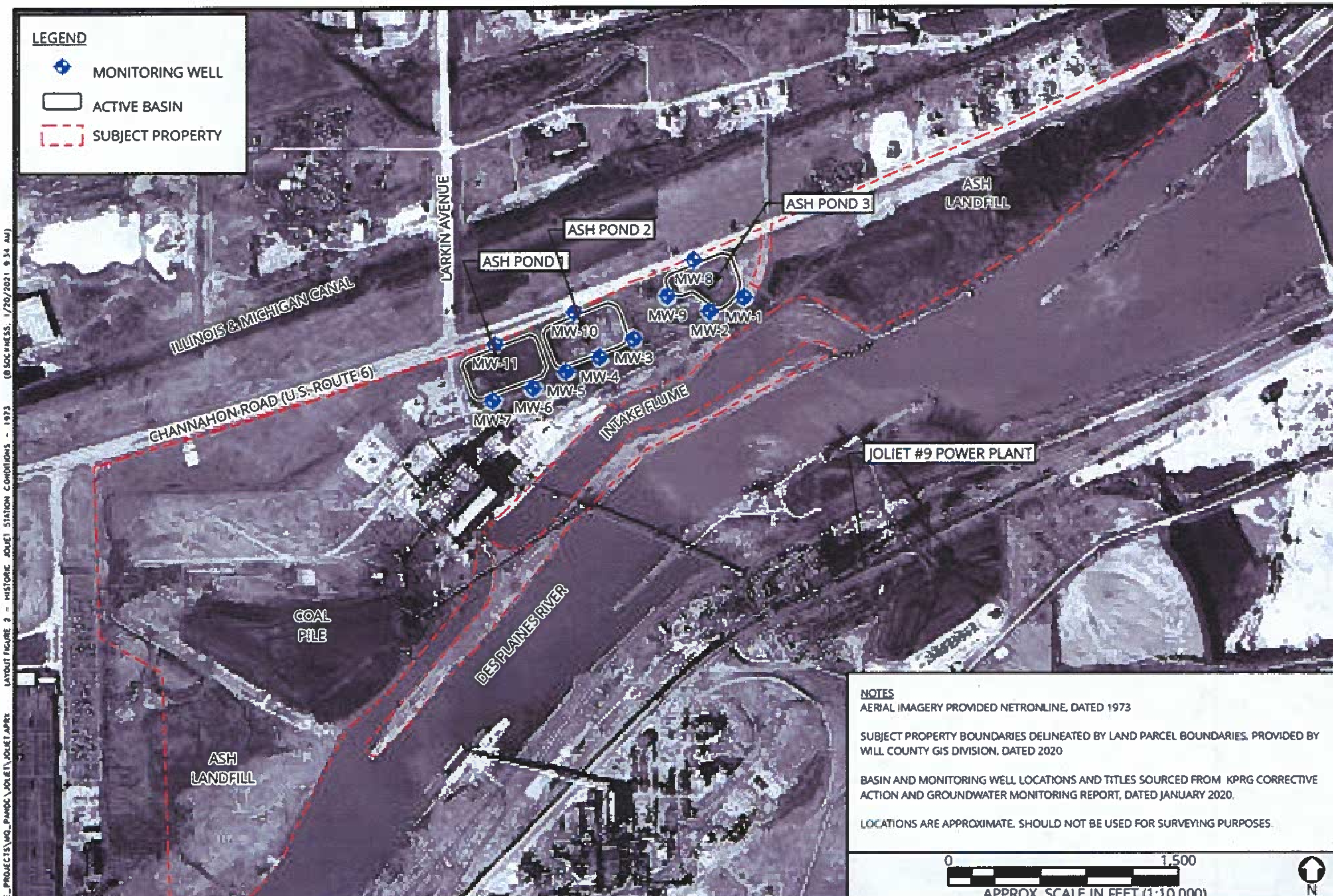
BBJ GROUP
PROJECT NO: R201190
CREATED BY: BGS 12.17.2020
CHECKED BY: MQ 12.18.2020
APPROVED BY: MQ 01.20.2021
CURRENT CONDITIONS
JOLIET STATION
FIGURE
1



NOTES
AERIAL IMAGERY PROVIDED NETRONLINE, DATED 1973

SUBJECT PROPERTY BOUNDARIES DELINEATED BY LAND PARCEL BOUNDARIES, PROVIDED BY WILL COUNTY GIS DIVISION, DATED 2020

BASIN AND MONITORING WELL LOCATIONS AND TITLES SOURCED FROM KPRG CORRECTIVE ACTION AND GROUNDWATER MONITORING REPORT, DATED JANUARY 2020.

LOCATIONS ARE APPROXIMATE. SHOULD NOT BE USED FOR SURVEYING PURPOSES.

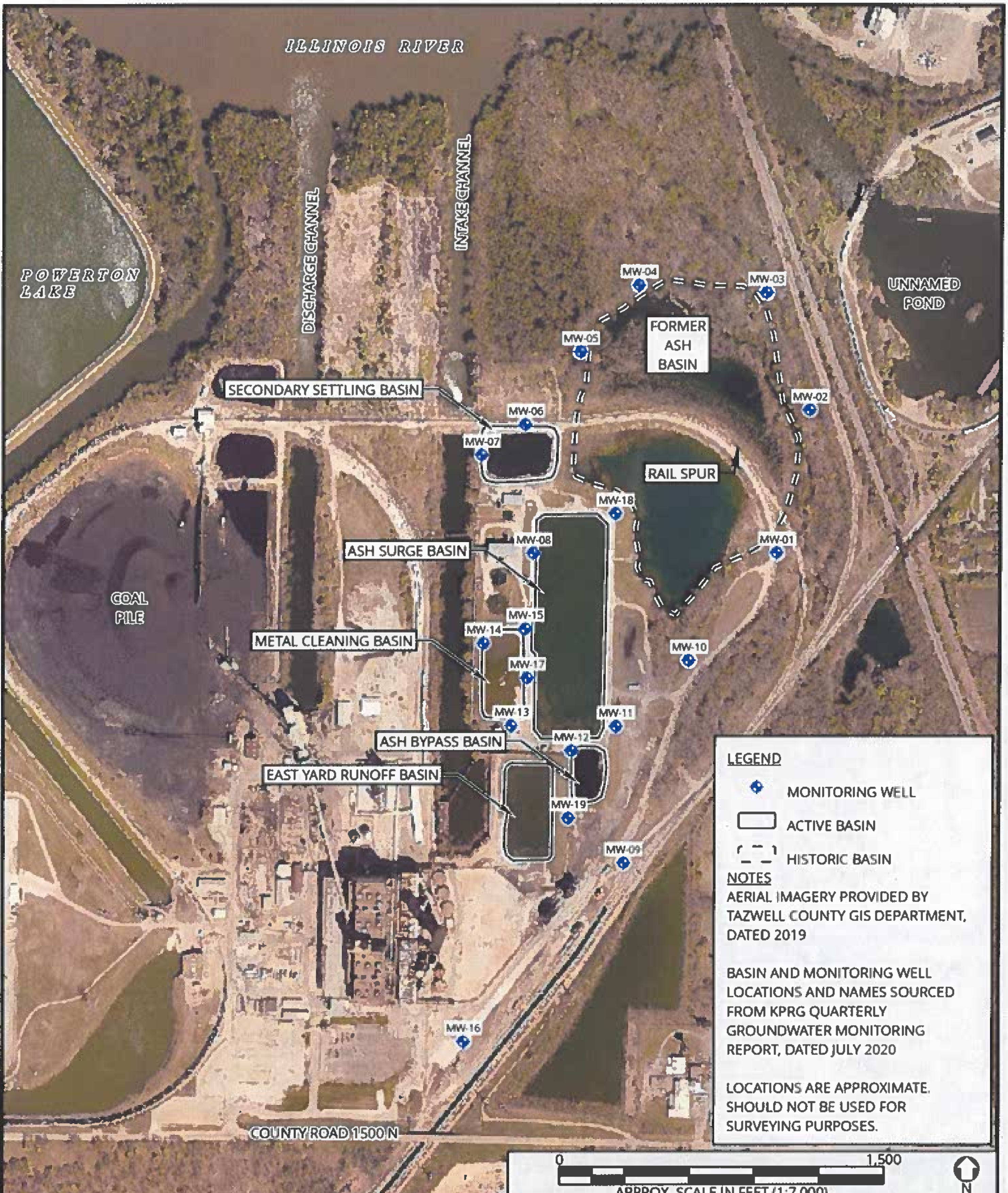
BBJ GROUP

PROJECT NO:	R2011900
CREATED BY:	BGS 12.17.2020
CHECKED BY:	MQ 12.18.2020
APPROVED BY:	MQ 01.20.2021

HISTORIC CONDITIONS - 1973
JOLIET STATION

FIGURE 2

FILE: I:\22_ARCGIS_DATA\ACTIVE_PROJECTS\MQ_PANDC\JOLIET\JOLIET.APRX LAYOUT FIGURE 2 - HISTORIC JOLIET STATION CONDITIONS - 1973 (BSOCKNESS; 1/20/2021 9:34 AM)

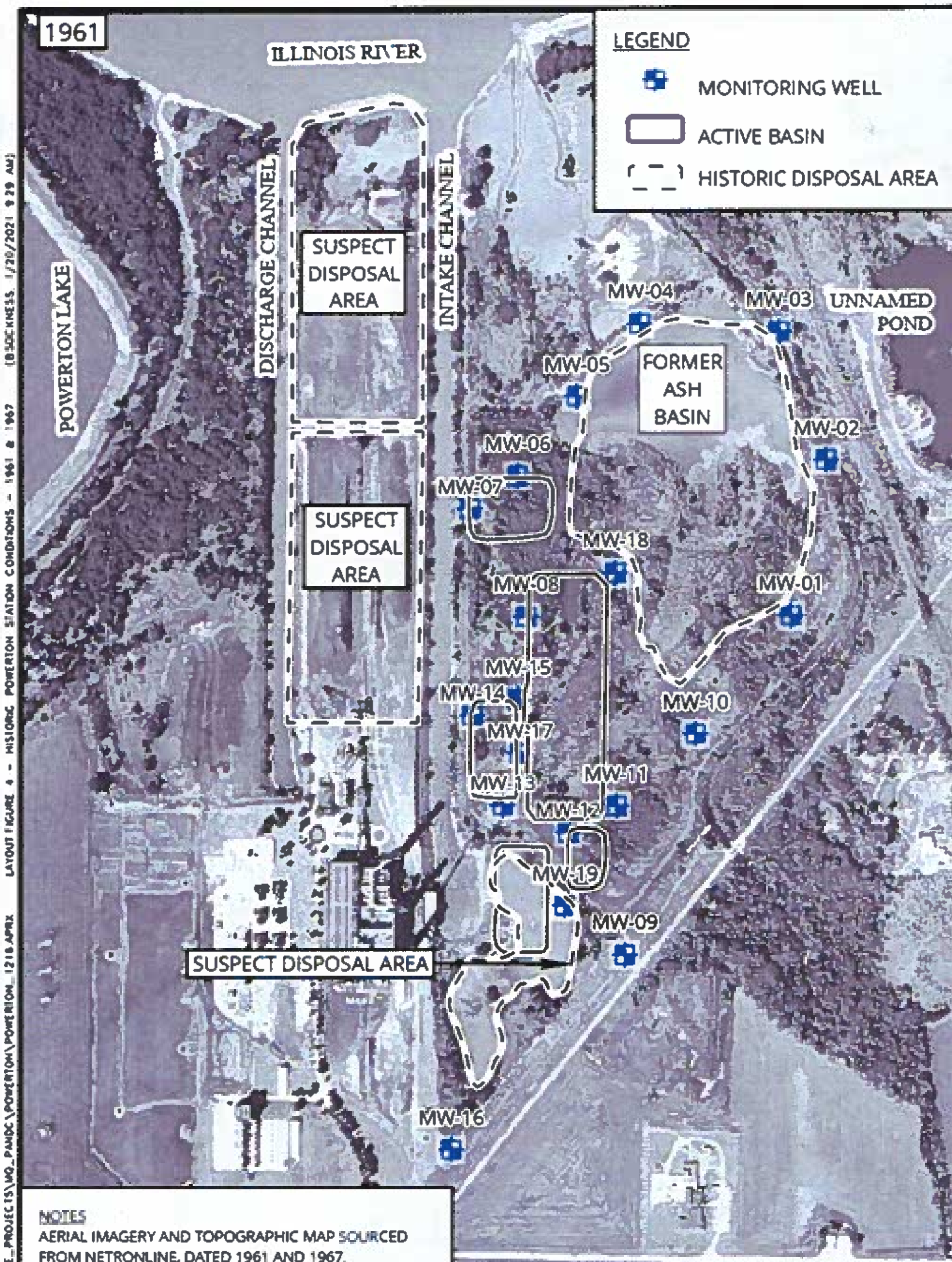


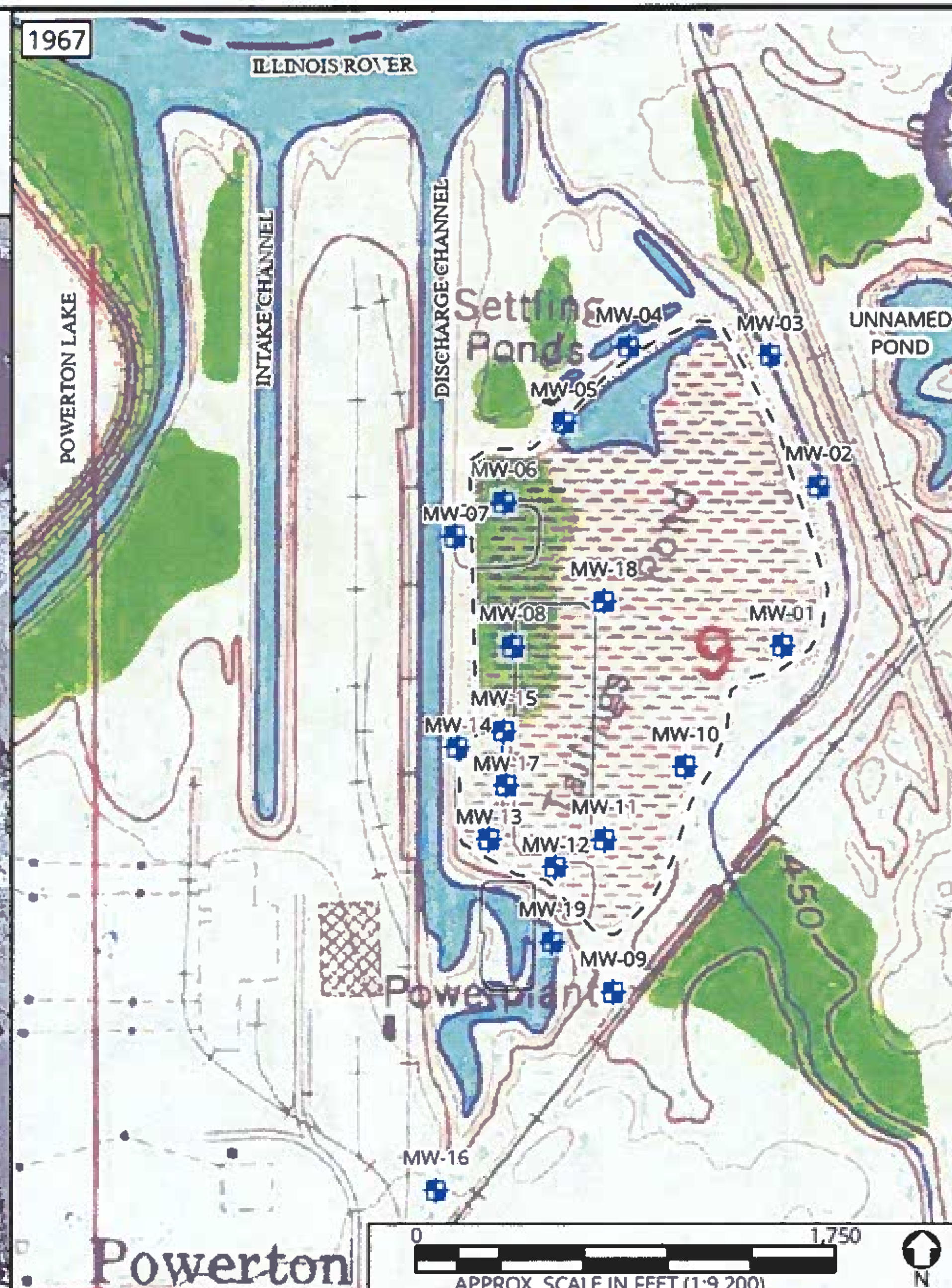
BBJ GROUP

PROJECT NO:	R2011900
CREATED BY:	BGS 12.18.2020
CHECKED BY:	MQ 12.18.2020
APPROVED BY:	MQ 01.20.2021

CURRENT CONDITIONS
POWERTON STATION

FIGURE
3





NOTES

AERIAL IMAGERY AND TOPOGRAPHIC MAP SOURCED FROM NETRONLINE, DATED 1961 AND 1967, RESPECTIVLEY

BASIN AND MONITORING WELL LOCATIONS AND NAMES SOURCED FROM KPRG QUARTERLY GROUNDWATER MONITORING REPORT, DATED JULY 2020

LOCATIONS ARE APPROXIMATE, SHOULD NOT BE USED FOR SURVEYING PURPOSES.

BBJ GROUP

PROJECT NO:	R2011990
CREATED BY:	BGS 12.17.2020
CHECKED BY:	MQ - 12.18.2020
APPROVED BY:	MQ 01.20.2021

HISTORIC POWERTON STATION CONDITIONS - 1961 & 1967

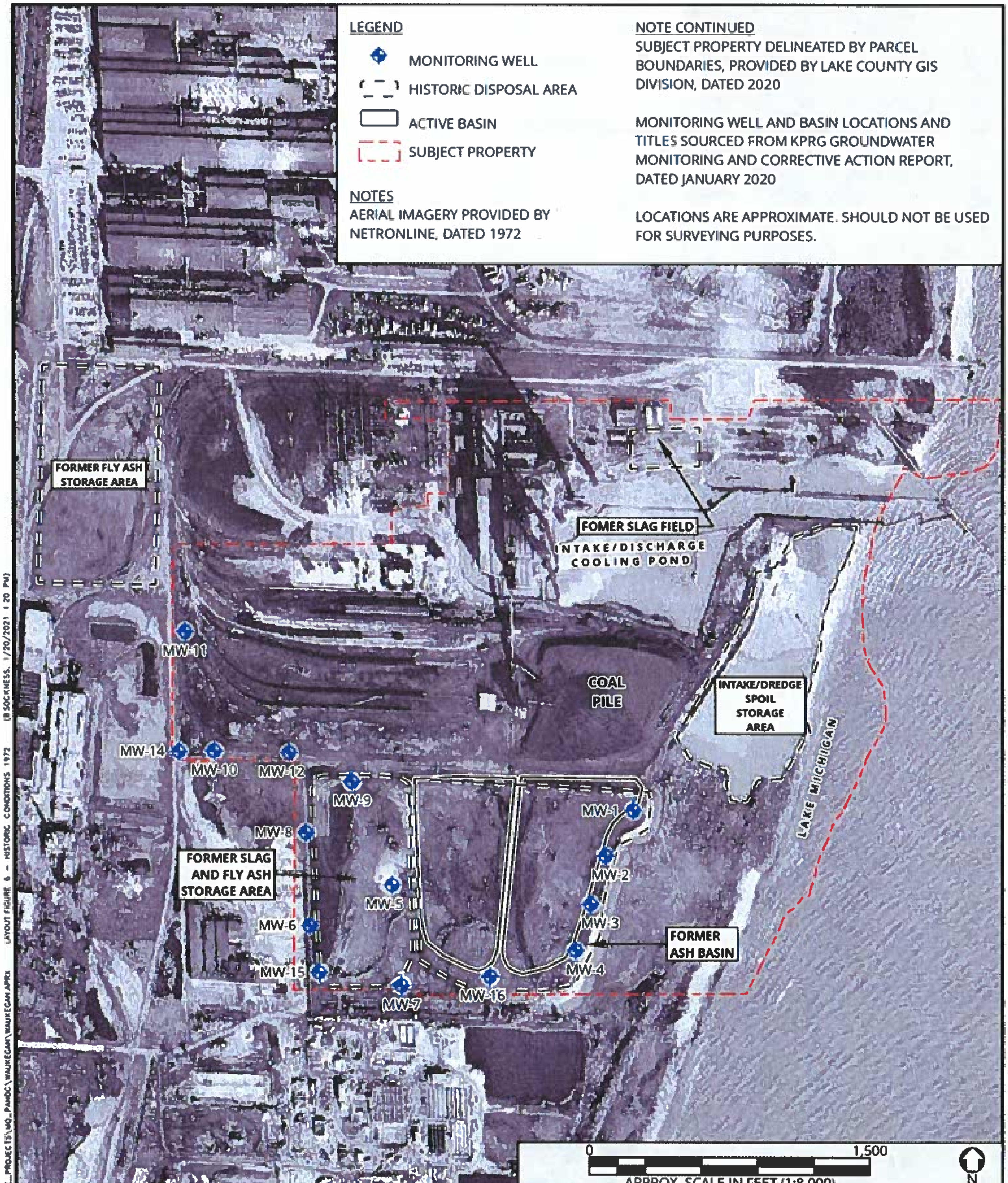
FIGURE 4

BBJ GROUP

PROJECT NO:	R2011900
CREATED BY:	BGS 12.18.2020
CHECKED BY:	MQ 12.18.2020
APPROVED BY:	MQ 01.20.2021

CURRENT CONDITIONS
WAUKEGAN STATION

FIGURE 5

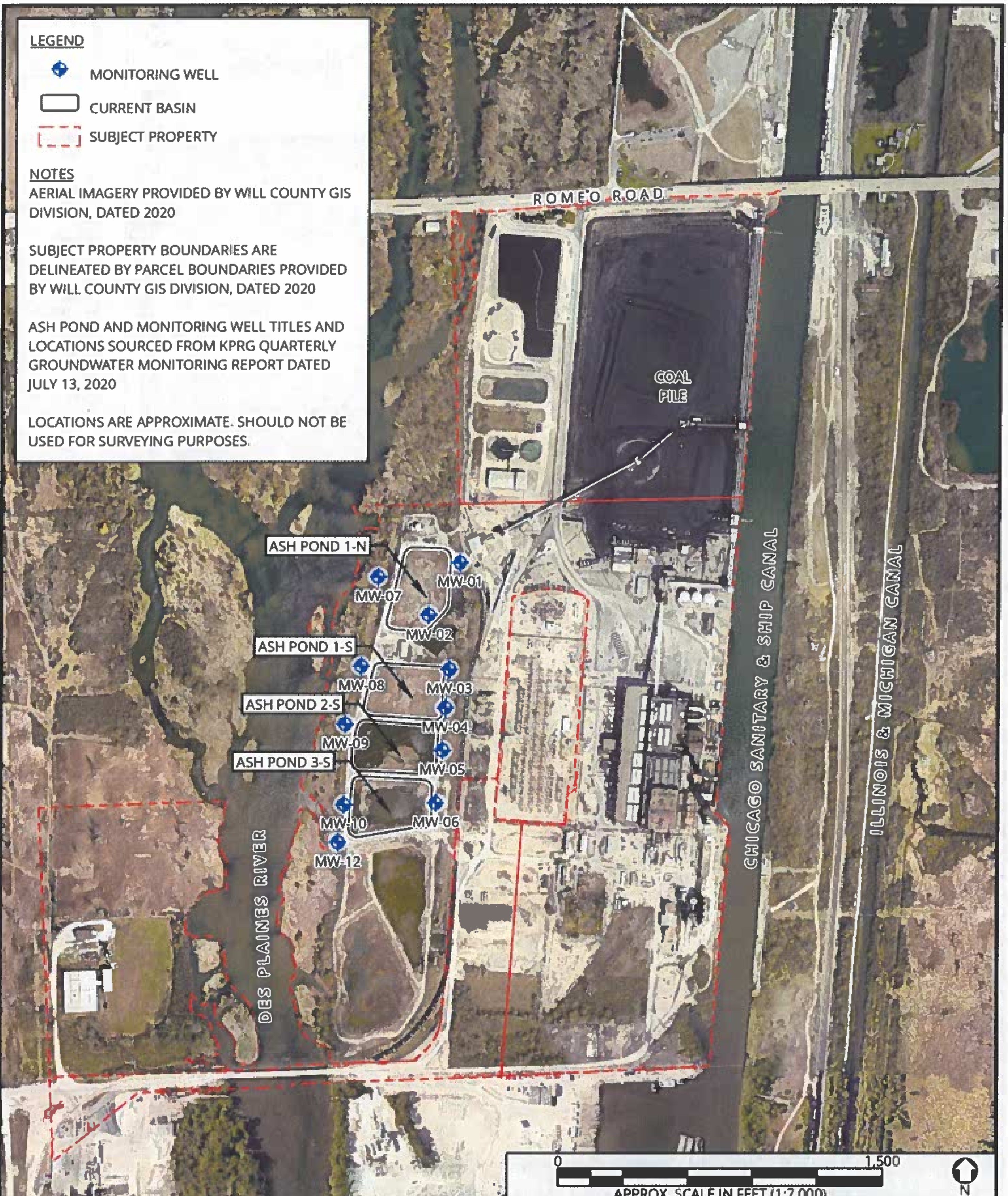


BBJ GROUP

PROJECT NO:	R2011900
CREATED BY:	BGS 12.18.2020
CHECKED BY:	MQ 12.18.2020
APPROVED BY:	MQ 01.20.2021

HISTORIC SITE CONDITIONS - 1972
WAUKEGAN STATION

FIGURE 6

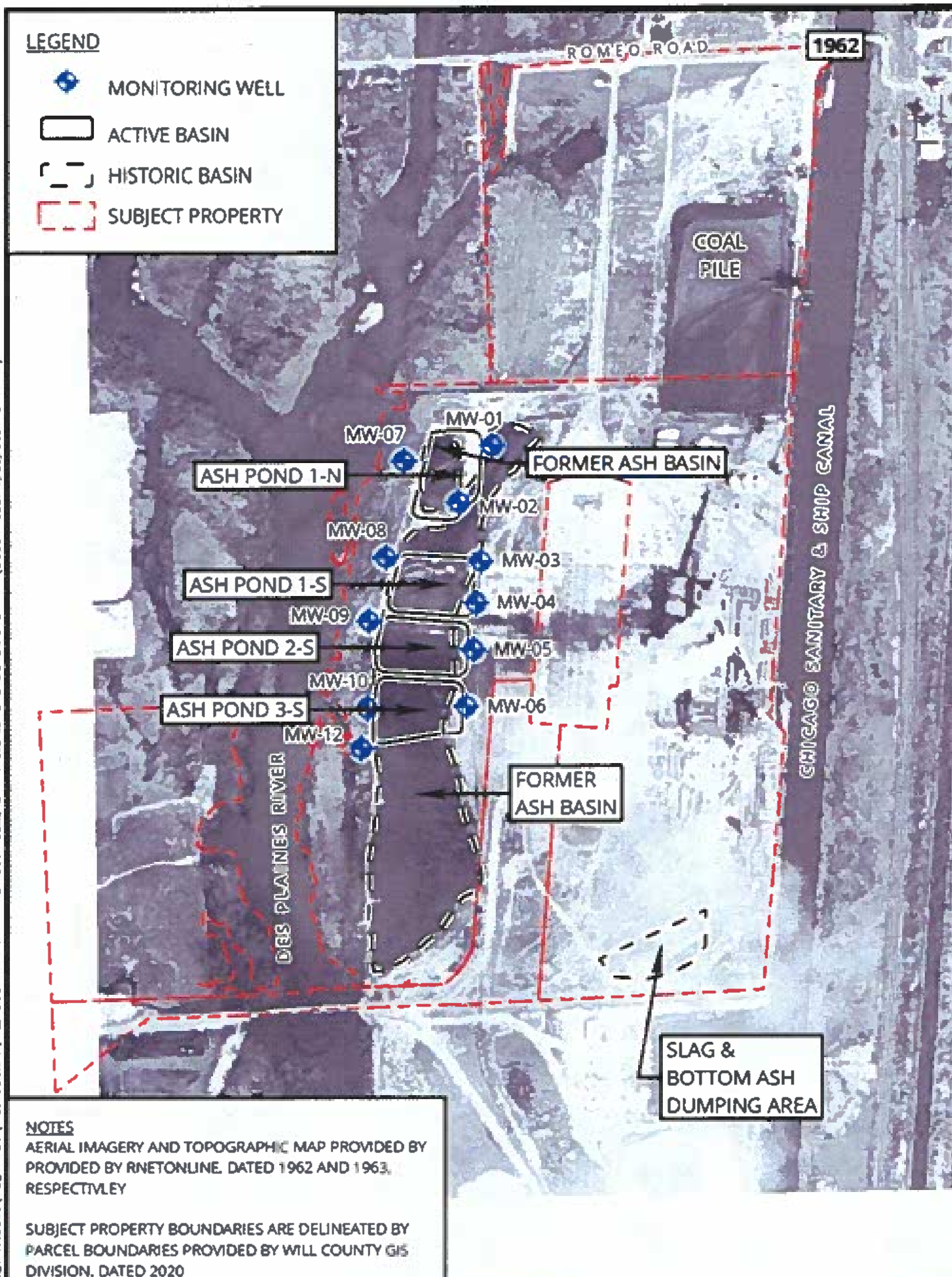


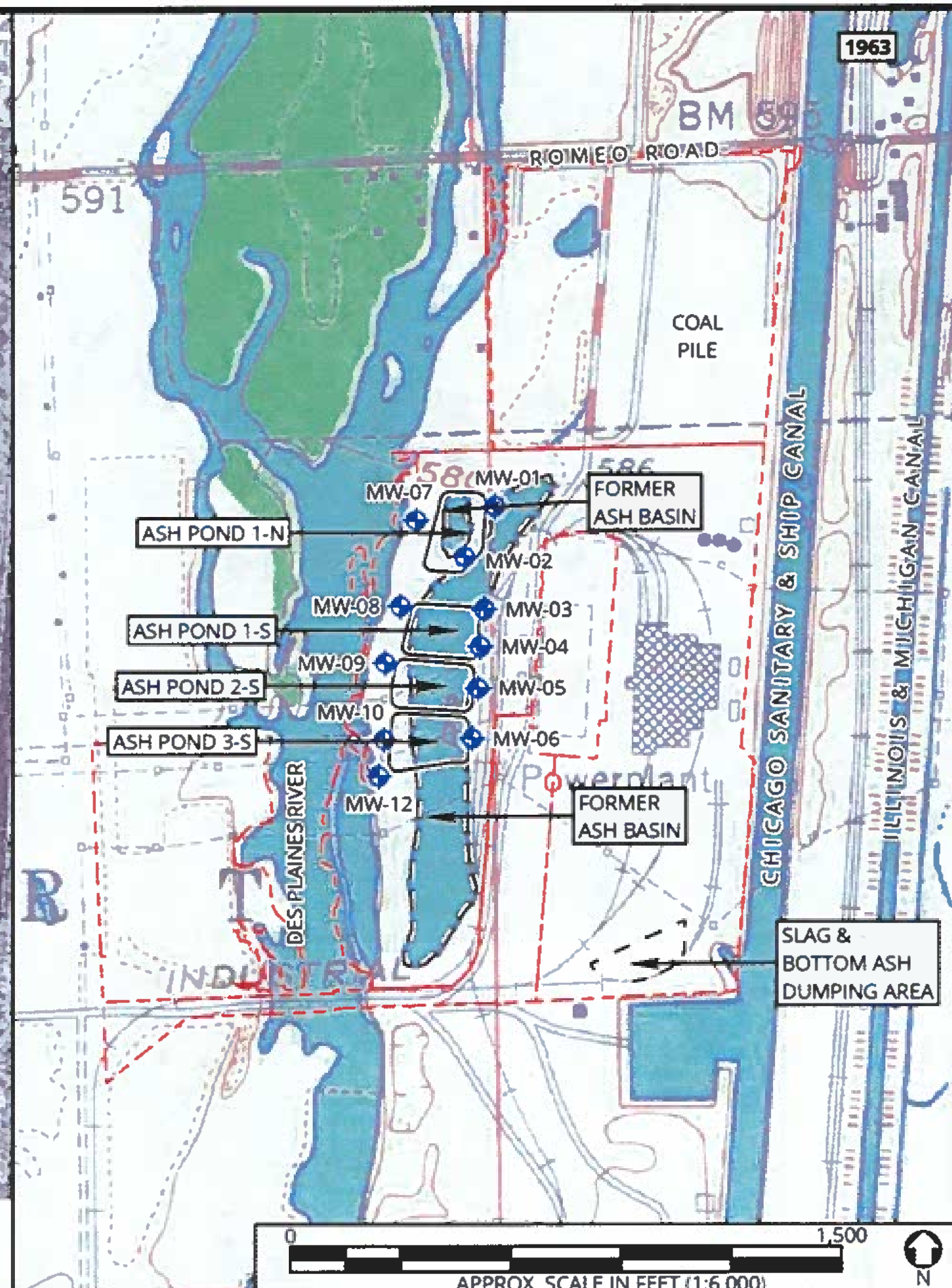
BBJ GROUP

PROJECT NO:	R2011900
CREATED BY:	BGS 12.18.2020
CHECKED BY:	MQ 12.18.2020
APPROVED BY:	MQ 01.20.2021

CURRENT CONDITIONS
WILL COUNTY STATION

FIGURE 7





LEGEND

- MONITORING WELL
- ACTIVE BASIN
- HISTORIC BASIN
- SUBJECT PROPERTY

NOTES

AERIAL IMAGERY AND TOPOGRAPHIC MAP PROVIDED BY PROVIDED BY RNETONLINE. DATED 1962 AND 1963, RESPECTIVLEY

SUBJECT PROPERTY BOUNDARIES ARE DELINEATED BY PARCEL BOUNDARIES PROVIDED BY WILL COUNTY GIS DIVISION. DATED 2020

ASH POND AND MONITORING WELL TITLES AND LOCATIONS SOURCED FROM KPRG QUARTERLY GROUNDWATER MONITORING REPORT, DATED JULY 13, 2020

LOCATIONS ARE APPROXIMATE. SHOULD NOT BE USED FOR SURVEYING PURPOSES.

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APPROX. SCALE IN FEET (1:6,000)
N

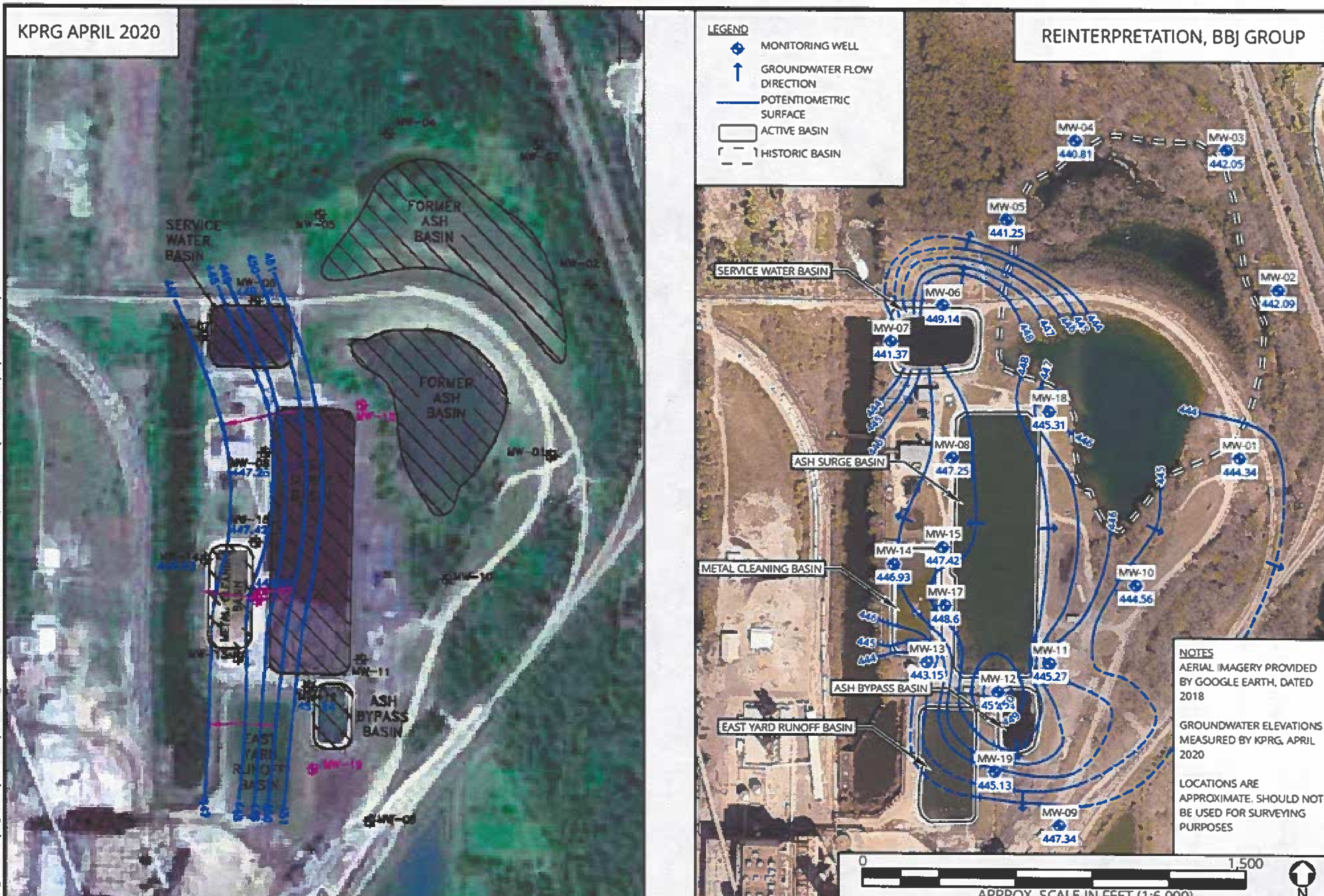
BBJ GROUP

PROJECT NO:	R2011900
CREATED BY:	BGS 12.18.2020
CHECKED BY:	MQ 12.18.2020
APPROVED BY:	MQ 01.20.2021

HISTORIC SITE CONDITIONS - WILL COUNTY STATION 1962 & 1963

FIGURE 8

FILE: I:\22_ARCGIS_DATA\ACTIVE_PROJECTS\MQ_PANDC\WILL COUNTY\WILL COUNTY.APRX LAYOUT FIGURE 8 - HISTORIC SITE CONDITIONS (BSOCKNESS 1/20/2021 3:14 PM)



BBJ GROUP

PROJECT NO:	R2011900
CREATED BY:	BGS 12.18.2020
CHECKED BY:	MQ 12.18.2020
APPROVED BY:	MQ 01.20.2021

ACTIVE ASH BASIN POTENTIOMETRIC SURFACE APRIL 2020 - POWERTON STATION

FIGURE 9

FILE: I:\ZZ_ARCGIS_DATA\ACTIVE_PROJECTS\MQ_PANDC\POWERTON\POWERTON_1216.APRX LAYOUT FIGURE 9 - POWERTON GW (BSOCKNESS 1/20/2021 9:27 AM)

BBJ GROUP

PROJECT NO:	R2011900
CREATED BY:	BGS 12.18.2020
CHECKED BY:	MQ 12.18.2020
APPROVED BY:	MW 01.20.2021

POTENTIAL GROUNDWATER DISCHARGE RECEPTOR AREA
WAUKEGAN STATION

FIGURE 10

Table 1

Example Coal Ash Removal Action Sites

Name of Plant or Site	Operator	CCR Unit	Closure Status	Closure Method per CCR Rule Closure Plan (Actual if Closed)	State
Joliet #29 Generating Station	NRG	Ash Pond 2	Open	Removal	IL
Powerton Generating Station	NRG	Ash By-pass Basin	Open	Removal	IL
Powerton Generating Station	NRG	Ash Surge Basin	Open	Removal	IL
Waukegan Station	NRG	East Ash Pond	Open	Removal	IL
Waukegan Station	NRG	West Ash Pond	Open	Removal	IL
Will County Station	NRG	Ash Pond 2 South	Open	Removal	IL
Will County Station	NRG	Ash Pond 3 South	Open	Removal	IL
Limestone Electric Generating Station	NRG	Bottom Ash Cooling Pond	Open	Removal	TX
Limestone Electric Generating Station	NRG	E Pond (Unit 019)	Open	Removal	TX
Limestone Electric Generating Station	NRG	Secondary E Pond Unit (Unit 003)	Open	Removal	TX
Limestone Electric Generating Station	NRG	ST-18 Unit	Open	Removal	TX
Limestone Electric Generating Station	NRG	Stormwater Pond (Unit 002)	Open	Removal	TX

Name of Plant or Site	Operator	CCR Unit	Closure Status	Closure Method per CCR Rule Closure Plan (Actual if Closed)	State
W.A. Parish Electric Generating Station	NRG	Air Preheater Pond	Open	Removal	TX
W.A. Parish Electric Generating Station	NRG	FGD Emergency Pond	Open	Removal	TX
William C. Gorgas Electric Generating Plant	Alabama Power	Gypsum Pond	Notice of Intent to Close	Removal	AL
White Bluff Plant	Entergy	Recycle Pond A	Notice of Intent to Close	Removal	AR
Cherokee Station	Xcel Energy	Center Ash Pond	Closed	Removal	CO
Cherokee Station	Xcel Energy	Cooling Tower Retention Pond	Closed	Removal	CO
Cherokee Station	Xcel Energy	East Ash Pond	Closed	Removal	CO
Cherokee Station	Xcel Energy	West Ash Pond	Closed	Removal	CO
Pawnee Station	Xcel Energy	Ash Water Recovery Pond	Closed	Removal	CO
Pawnee Station	Xcel Energy	Bottom Ash Storage Pond	Closed	Removal	CO
Valmont Station	Xcel Energy	CCR Impoundment 3A	Closed	Removal	CO
Valmont Station	Xcel Energy	CCR Impoundment 3B	Closed	Removal	CO
Valmont Station	Xcel Energy	EPRI Ash Settling Pond	Closed	Removal	CO
Big Bend Power Station	TECO Energy	Economizer Ash and Pyrite Pond System	Notice of Intent to Close	Removal	FL
Big Bend Power Station	TECO Energy	West Slag Disposal Pond	Notice of Intent to Close	Removal	FL

Name of Plant or Site	Operator	CCR Unit	Closure Status	Closure Method per CCR Rule Closure Plan (Actual if Closed)	State
Crystal River Energy Complex	Duke Energy	Backup FGD Blowdown Treatment Pond	Notice of Intent to Close	Removal	FL
Crystal River Energy Complex	Duke Energy	Primary FGD Blowdown Treatment Pond	Notice of Intent to Close	Removal	FL
Plant Jack McDonough	Georgia Power Company	Ash Pond 2	Closed	Removal	GA
Plant McIntosh	Georgia Power Company	Ash Pond 1	Notice of Intent to Close	Removal	GA
Plant McManus	Georgia Power Company	AP-1, inactive	Notice of Intent to Close	Removal	GA
Plant Yates	Georgia Power Company	Ash Pond 1	Closed	Removal	GA
Plant Yates	Georgia Power Company	Ash Pond A	Closed	Removal	GA
Plant Yates	Georgia Power Company	Ash Pond B	Notice of Intent to Close	Removal	GA
Ottumwa Generating Station	Interstate Power and Light Company	Zero Liquid Discharge Pond	Notice of Intent to Close	Removal	IA
Prairie Creek Generating Station	Interstate Power and Light Company	Beneficial Use Storage Area	Closed	Removal	IA
Prairie Creek Generating Station	Interstate Power and Light Company	PCS Beneficial Use Storage Area	Closed	Removal	IA
Hennepin Power Station	Luminant (formerly Dynegy Inc.)	Hennepin Old West Polishing Pond	Notice of Intent to Close	Removal	IL
Cayuga Generating Station	Duke Energy	Secondary Ash Settling Pond	Notice of Intent to Close	Removal	IN
Gibson Generating Station	Duke Energy	East Settling Basin	Notice of Intent to Close	Removal	IN

Name of Plant or Site	Operator	CCR Unit	Closure Status	Closure Method per CCR Rule Closure Plan (Actual if Closed)	State
Gibson Generating Station	Duke Energy	North Settling Basin	Notice of Intent to Close	Removal	IN
Gibson Generating Station	Duke Energy	South Settling Basin	Notice of Intent to Close	Removal	IN
Michigan City Generating Station	Northern Indiana Public Service Company	Michigan City Boiler Slag Pond	Notice of Intent to Close	Removal	IN
Michigan City Generating Station	Northern Indiana Public Service Company	Primary Settling Pond 2	Notice of Intent to Close	Removal	IN
Lawrence Energy Center	Westar Energy	Area 2 Pond	Notice of Intent to Close	Removal	KS
Lawrence Energy Center	Westar Energy	Area 3 Pond	Notice of Intent to Close	Removal	KS
Lawrence Energy Center	Westar Energy	Area 4 Pond	Notice of Intent to Close	Removal	KS
Nearman Creek Power Station	Kansas City Board of Public Utilities	Bottom Ash Pond	Notice of Intent to Close	Removal	KS
Tecumseh Energy Center	Westar Energy	Bottom Ash Settling Pond	Notice of Intent to Close	Removal	KS
Big Sandy Plant	American Electric Power, Kentucky Power Co.	Bottom Ash Pond	Closed	Removal	KY
East Bend Electric Plant	Duke Energy	Ash Basin	Notice of Intent to Close	Removal	KY
Ghent Generating Station	Kentucky Utilities Company	Gypsum Stack	Notice of Intent to Close	Removal	KY
Ghent Generating Station	Kentucky Utilities Company	Reclaim Pond/Gypsum	Notice of Intent to Close	Removal	KY

Name of Plant or Site	Operator	CCR Unit	Closure Status	Closure Method per CCR Rule Closure Plan (Actual if Closed)	State
		Stack Surge Pond			
Mill Creek Generating Station	Louisville Gas & Electric Company	Clearwell Pond	Notice of Intent to Close	Removal	KY
Mill Creek Generating Station	Louisville Gas & Electric Company	Construction Runoff Pond	Notice of Intent to Close	Removal	KY
Mill Creek Generating Station	Louisville Gas & Electric Company	Dead Storage Pond	Notice of Intent to Close	Removal	KY
Mill Creek Generating Station	Louisville Gas & Electric Company	Emergency Pond	Notice of Intent to Close	Removal	KY
Brayton Point Power Station	Brayton Point LLC	Basin A	Closed	Removal	MA
Brayton Point Power Station	Brayton Point LLC	Basin B	Closed	Removal	MA
Brayton Point Power Station	Brayton Point LLC	Basin C	Closed	Removal	MA
BC Cobb Power Plant	Consumers Energy Co.	Bottom Ash Pond	Notice of Intent to Close	Removal	MI
BC Cobb Power Plant	Consumers Energy Co.	Ponds 0-8	Notice of Intent to Close	Removal	MI
DE Karn Power Plant	Consumers Energy Co.	Bottom Ash Pond	Notice of Intent to Close	Removal	MI
James DeYoung Power Plant	Holland Board of Public Works	Ash Pond 1	Closed	Removal	MI
James DeYoung Power Plant	Holland Board of Public Works	Ash Pond 2	Closed	Removal	MI
James DeYoung Power Plant	Holland Board of Public Works	Ash Pond 3	Closed	Removal	MI
JC Weadock Power Plant	Consumers Energy Co.	Bottom Ash Pond	Notice of Intent to Close	Removal	MI
JH Campbell Power Plant	Consumers Energy Co.	Unit 3 North & 3 South	Notice of Intent to Close	Removal	MI

Name of Plant or Site	Operator	CCR Unit	Closure Status	Closure Method per CCR Rule Closure Plan (Actual if Closed)	State
JH Campbell Power Plant	Consumers Energy Co.	Units 1-2 North and 1-2 South	Notice of Intent to Close	Removal	MI
St. Clair Power Plant	DTE Electric Co.	Scrubber Impoundment	Notice of Intent to Close	Removal	MI
Black Dog Plant	Xcel Energy	Inactive Ash Pond 1	Closed	Removal	MN
Black Dog Plant	Xcel Energy	Inactive Ash Pond 2	Closed	Removal	MN
Black Dog Plant	Xcel Energy	Inactive Ash Pond 3	Closed	Removal	MN
Boswell Energy Center	Minnesota Power	Old Bottom Ash Surface Impoundment	Notice of Intent to Close	Removal	MN
Fox Lake Generating Station	Interstate Power and Light Company	Inactive Surface Impoundment	Closed	Removal	MN
Columbia Municipal Power Plant	City of Columbia	More's Lake Surface Impoundment	Notice of Intent to Close	Removal	MO
Iatan Generating Station	KCP&L	North Ash / South Ash Impoundment	Notice of Intent to Close	Removal	MO
James River Power Station	City Utilities of Springfield	East Pond	Closed	Removal	MO
James River Power Station	City Utilities of Springfield	West Pond	Closed	Removal	MO
John Twitty Energy Center	City Utilities of Springfield	East Pond	Closed	Removal	MO
John Twitty Energy Center	City Utilities of Springfield	West Pond	Closed	Removal	MO
Thomas Hill Energy Center	Associated Electric Coop.	Cell 2 West	Notice of Intent to Close	Removal	MO
Lewis & Clark Station	Montana-Dakota Utilities Co.	Temporary Storage Pad	Notice of Intent to Close	Removal	MT
Asheville Steam Electric Plant	Duke Energy	1982 Ash Basin	Closed	Removal	NC

Name of Plant or Site	Operator	CCR Unit	Closure Status	Closure Method per CCR Rule Closure Plan (Actual if Closed)	State
Buck Steam Station	Duke Energy	Additional Primary Pond (Ash Basin 1)	Notice of Intent to Close	Removal	NC
Buck Steam Station	Duke Energy	Primary Pond (Ash Basin 2)	Notice of Intent to Close	Removal	NC
Buck Steam Station	Duke Energy	Secondary Pond (Ash Basin 3)	Notice of Intent to Close	Removal	NC
Cliffside Steam Station	Duke Energy	Inactive Units 1 - 4 Basin	Notice of Intent to Close	Removal	NC
Dan River Steam Station	Duke Energy	Primary Ash Basin	Notice of Intent to Close	Removal	NC
H.F. Lee Energy Complex	Duke Energy	Active Ash Basin	Notice of Intent to Close	Removal	NC
L.V. Sutton Energy Complex	Duke Energy	1971 Ash Basin	Notice of Intent to Close	Removal	NC
L.V. Sutton Energy Complex	Duke Energy	1984 Ash Basin	Notice of Intent to Close	Removal	NC
W.H. Weatherspoon Power Plant	Duke Energy	1979 Ash Basin	Notice of Intent to Close	Removal	NC
Coyote Station	Otter Tail Power Company	Nelsen Pond	Notice of Intent to Close	Removal	ND
Coyote Station	Otter Tail Power Company	Slag Pond	Notice of Intent to Close	Removal	ND
Coyote Station	Otter Tail Power Company	Sluice Outfall	Notice of Intent to Close	Removal	ND
B.L. England Generating Station	RCCM	Slag Ponds	Notice of Intent to Close	Removal	NJ
Hudson Generating Station	PSEG Power LLC	Bottom Ash Pond	Closed	Removal	NJ

Name of Plant or Site	Operator	CCR Unit	Closure Status	Closure Method per CCR Rule Closure Plan (Actual if Closed)	State
Hudson Generating Station	PSEG Power LLC	North Fly Ash Pond	Closed	Removal	NJ
Hudson Generating Station	PSEG Power LLC	South Fly Ash Pond	Closed	Removal	NJ
Mercer Generating Station	PSEG Power LLC	North Fly Ash Pond	Closed	Removal	NJ
Mercer Generating Station	PSEG Power LLC	South Fly Ash Pond	Closed	Removal	NJ
Four Corners Power Plant	Arizona Public Service Co.	Upper Retention Sump	Notice of Intent to Close	Removal	NM
Reid Gardner Generating Station	NV Energy	SI B-1	Notice of Intent to Close	Removal	NV
Reid Gardner Generating Station	NV Energy	SI B-2	Notice of Intent to Close	Removal	NV
Reid Gardner Generating Station	NV Energy	SI B-3	Notice of Intent to Close	Removal	NV
Reid Gardner Generating Station	NV Energy	SI E-1	Notice of Intent to Close	Removal	NV
Muskogee Generating Station	OG&E Energy Corp.	Emergency Ash Basin	Notice of Intent to Close	Removal	OK
Brunner Island Steam Electric Station	Talen Energy	Ash Basin No. 6	Notice of Intent to Close	Removal	PA
New Castle Generating Station	GenOn	North Ash Pond	Closed	Removal	PA
Cross Generating Station	Santee Cooper	Gypsum Pond	Closed	Removal	SC
W.S. Lee Steam Station	Duke Energy	Secondary Ash Basin	Notice of Intent to Close	Removal	SC

Name of Plant or Site	Operator	CCR Unit	Closure Status	Closure Method per CCR Rule Closure Plan (Actual if Closed)	State
Wateree Generating Station	South Carolina Electric & Gas	Ash Pond	Notice of Intent to Close	Removal	SC
Winyah Generating Station	Santee Cooper	Slurry Pond 2	Closed	Removal	SC
Big Stone Plant	Otter Tail Power Company	Slag Pond Area	Closed	Removal	SD
Big Stone Plant	Otter Tail Power Company	Temporary Storage Area	Closed	Removal	SD
Bremo Power Station	Dominion Energy	East Ash Pond, Inactive	Notice of Intent to Close	Removal	VA
Bremo Power Station	Dominion Energy	West Ash Pond, Inactive	Notice of Intent to Close	Removal	VA
Chesterfield Power Station	Dominion Energy	Lower Ash Pond	Notice of Intent to Close	Removal	VA
Possum Point Power Station	Dominion Energy	Pond A	Notice of Intent to Close	Removal	VA
Possum Point Power Station	Dominion Energy	Pond B	Notice of Intent to Close	Removal	VA
Possum Point Power Station	Dominion Energy	Pond C	Notice of Intent to Close	Removal	VA
Possum Point Power Station	Dominion Energy	Pond E	Notice of Intent to Close	Removal	VA
Columbia Energy Center	Wisconsin Power & Light Co.	Secondary Pond	Notice of Intent to Close	Removal	WI
Nelson Dewey Station	Wisconsin Power & Light Co.	WPDES Pond	Closed	Removal	WI
Mount Storm Power Station	Dominion Energy	Low Volume Waste Sedimentation Ponds	Notice of Intent to Close	Removal	WV

Appendix A

CV, Mark A Quarles, P.G.

Mark Quarles, P.G.
Senior Geologist, Nashville Branch Manager

Education

MBA Vanderbilt – Owen Graduate School of Management, 2001

B.S., Environmental Engineering Technology, Western Kentucky University, 1985

Professional Registration

Professional Geologist – Tennessee (#3834)

Professional Geologist – New York (#779)

Professional Geologist – Georgia (#2266)

Water Pollution Control Operator (Class II) - Massachusetts

GENERAL CAREER BACKGROUND

Mr. Quarles has provided consulting services for a variety of local, state, US EPA, and international regulatory programs for a diverse list of clients — including industrial manufacturers, law firms, municipal governments, commercial developers, and non-profit organizations. He has served as Client Manager, Project Manager, and Senior Geologist for projects in multiple states and has managed teams of geologists, chemists, natural resource specialists, environmental engineers, and environmental scientists.

Coal combustion waste experience has included investigations for over 100 coal combustion waste disposal sites across the United States, with a particular emphasis on these states: Alabama, Florida, Georgia, Illinois, Iowa, Kentucky, New York, North Carolina, South Carolina, and Tennessee. The work has evaluated disposal site designs, operation and monitoring programs, and closure plans relative to the US EPA RCRA Subtitle D, Coal Combustion Residuals Rule ("CCR Rule"), and state-equivalent programs.

In addition to coal combustion wastes, Mr. Quarles has experience with environmental compliance programs associated with US EPA and state-equivalent standards for voluntary Brownfield programs, hazardous wastes (RCRA Subtitle C), corporate environmental audits, Superfund (CERLCA), municipal and industrial landfill siting and design (RCRA Subtitle D), due diligence property transactional standards (ASTM), wastewater and stormwater discharges (Clean Water Act), potable water supply (Safe Drinking Water Act), oil storage (Oil Pollution Control Act), threatened and endangered species (Endangered Species Act), dredge and Fill (404 Permits), sediment contamination, stream alternation permits, and wetlands.

Mr. Quarles has testified as a subject matter expert in Federal and State Courts, administrative hearings, and public hearings.

REPRESENTATIVE CCR PROGRAM EXPERIENCE

General CCR Rule Compliance

Mr. Quarles has evaluated site conditions and compared them to the technical standards associated with the CCR Rule and state-equivalent programs, in addition to standards established by the Electric Power Research Institute. The services have included expert opinion technical reports, expert testimonies, and comments at public hearings regarding Environmental Impact Statements, CCR Rule compliance, proposed investigations to define the nature and extent of contamination, proposed closure plans, and proposed corrective action measures.

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Electric Power Industry and Governmental Research

Mr. Quarles has used historical research dating to the 1970s by the Electric Power Research Institute, the US EPA, internal utilities, peer-reviewed publications, and governmental research organizations to determine coal-fired power plant operational standards and known risks to water quality.

Forensic Analyses

Mr. Quarles has reviewed historical reports, topographic maps, and aerial photographs to determine where historical disposal operations occurred, the likelihood of wastes being placed below the seasonal high groundwater table, and when groundwater contamination mostly likely occurred.

Utility Rate Case Support

Mr. Quarles has testified at rate case hearings regarding compliance with the CCR Rule and state-equivalent programs. Services have included reviewing proposed investigations to identify legacy waste disposal activities, estimating when groundwater contamination most likely occurred, reviewing investigations to determine the nature and extent of contamination, and reviewing proposed groundwater corrective actions.

REPRESENTATIVE CCR PROJECT EXPERIENCE

CCR Rate Case Hearings – Raleigh, North Carolina

Served as Senior Geologist associated with rate casing hearings before the North Carolina Utilities Commission. Services included an extensive review of historical internal documents and discovery, proposed closure plans for landfills and surface impoundments, and groundwater monitoring plans relative to the CCR Rule and the Coal Ash Management Act.

CCR Compliance - Georgia

Served as Senior Geologist for reviewing draft closure plans for surface impoundments. Proposed closure methods included closure-by-removal and closure-in-place with an engineered cap. The plans were reviewed relative to the CCR Rule, Georgia EPD regulations and standards, and draft permit conditions.

CCR Compliance and Litigation – Gallatin, Tennessee

Served as Senior Geologist and litigation subject matter expert regarding CCR contamination of groundwater, surface and groundwater used as public drinking water supplies, connectivity of groundwater to surface waters, off-site contamination of river sediments, and leaching of constituents with the proposed cap-in-place closure. Forensic investigations demonstrated that wide-spread karst conditions of sinkholes and sinking streams existed beneath the impoundments,

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impounded conditions raised the localized groundwater, wastes were submerged in groundwater, and continued leaching would occur with the proposed cap-in-place.

CCR Rule Compliance – Multiple Sites, Iowa
Served as Senior Geologist to review surface impoundment and landfill historic construction documents, groundwater monitoring reports, alternate source determinations, and / or proposed groundwater remedies at eight power plants.

CCR Compliance and Litigation – Kingston, Tennessee
Served as Senior Geologist and field sampling team member in response to a dike failure that released 5.4 million cubic yards of coal combustion wastes into the Emory, Clinch, and Tennessee Rivers. Services included reviewing defendant discovery documents and field sampling results, completing surface water and private property sampling (including polarized microscopic analyses), and preparing written testimonies.

CCR NPDES Permit Comments – Ithaca, New York
Reviewed a proposed NPDES permit for a leachate and stormwater collection pond associated with a Part 360 landfill permit.

CCR Environmental Impact Statement – Kingston, Tennessee
Reviewed an EIS associated with a proposed bottom ash dewatering system. Compared the proposed plan to other utility-owned power plants and systems for water minimization, waste avoidance, and land disposal.

CCR Compliance and Litigation – Eden, North Carolina
Served as Senior Geologist and litigation subject matter expert regarding the nature and extent of contamination due to the failure of an unlined CCR surface impoundment. Services included an extensive review of historical industry practices and defendant discovery documents regarding construction, operation and maintenance, inspections, and the life expectancy of the underlying corrugated metal pipe that ultimately failed. Private property sampling was also completed.

Flue Gas Desulfurization (FGD) Landfill – Gallatin, Tennessee
Reviewed the Part 1 / 2 permit application for a proposed Subtitle D CCR landfill. The services included a review of the hydrogeologic characterization plan, the proposed groundwater monitoring system, and the proposed landfill design regarding separation from the uppermost aquifer and leachate control.

CCR Impoundment Dewatering Plans – Multiple Locations, Georgia
Served as Senior Geologist to review dewatering plans associated with

closure of surface impoundments. The work included research regarding changes in water quality associated with standing water in the impoundments, pore water within the submerged solid wastes, and groundwater. Those results were then compared to the NPDES permits to understand likely compliance, expected changes in water quality over time, and protection of the receiving streams.

CCR-RELATED LEGAL TESTIMONIES

Application of Duke Energy Progress, LLC for Adjustment of Rates and Charges Applicable to Electric Service in North Carolina before the North Carolina Utilities Commission on behalf of the Sierra Club. Written and oral testimonies. April 2020.

Application of Duke Energy Carolinas, LLC for Adjustment of Rates and Charges Applicable to Electric Service in North Carolina before the North Carolina Utilities Commission on behalf of the Sierra Club. Written and oral testimonies. February 2020.

Michael Beck et al versus Duke Energy Carolinas and Duke Energy Business Services. North Carolina State Court. Written testimony regarding the Dan River Plant spill and damage to private property and the Dan River. 2019.

Application of Duke Energy Carolinas, LLC for Adjustment of Rates and Charges Applicable to Electric Service in North Carolina before the North Carolina Utilities Commission on behalf of the Sierra Club. Written and oral testimonies. January 2018.

Application of Duke Energy Progress, LLC for Adjustment of Rates and Charges Applicable to Electric Service in North Carolina before the North Carolina Utilities Commission on behalf of the Sierra Club. Written and oral testimonies. October 2017.

SELC on behalf of the Tennessee Clean Water Network and Tennessee Scenic Rivers Association versus Tennessee Valley Authority, US District Court, Middle District of Tennessee. Written and oral testimonies. 2017.

Chesney versus Tennessee Valley Authority – US District Court. Written testimony. 2011.

PEER-REVIEWED PUBLICATIONS

Quarles, M. and Chris Groves, "Forensic Hydrogeology: Evaluating a Karst Critical Zone Enormously Altered by Coal Combustion Residuals," Geologic Society of America conference, Denver, Colorado, September 2016.

Quarles, M., "A Case Study in Karst Hydrogeology and Contaminant Fate and Transport," National Groundwater Association 51st Annual Convention and Exposition, December 1999.

Quarles, M. and Allen P. Lusby, "Enhanced Biodegradation of Kerosene-Affected Groundwater and Soil," 1994 Annual Conference of the Academy of Hazardous Materials Managers, October 1994.

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