Coal Ash at A.B. Brown & Public Health

Aerial photo of the A.B. Brown power generating station and ash disposal sites (© 2016 BlairPhotoEVV)

Hoosier Environmental COUNCIL

April 18, 2016

Credits and Acknowledgements

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The authors wish to gratefully acknowledge the assistance of the following reviewers:
Wendy Bredhold, Allison Fisher, Jesse Kharbanda, Tim Maloney, Jodi Perras, and Matt Skuya-Boss.

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Executive Summary

Coal ash is the by-product that is left over after coal is burned. More than 100 million tons are generated in the U.S. each year. Coal ash is stored in open-air pits and surface waste ponds, many of which lack adequate safeguards, leaving nearby communities at risk from potential large-scale disasters. Coal ash contains arsenic, lead, mercury, selenium, cadmium, and chromium. If there is prolonged exposure, these toxic substances can cause cancer, heart damage, lung disease, kidney disease, reproductive problems, gastrointestinal illness, impaired bone growth in children, and neurological disorders.

Vectren Corporation has a coal-burning power plant called A.B. Brown in Posey County, Indiana, near the border with Vanderburgh County and a half mile from the Ohio River. A.B. Brown makes 284,000 tons of coal ash each year. For comparison, the average American produces 4.4 pounds per day of trash plus recycled or composted waste. That means it would take the entire city of Evansville, IN, (population 120,300) nearly 3 years to make as much waste as A.B.Brown produces in one year.

Of the coal ash produced at A.B. Brown, 27% gets used in cement, 59% is stored in a landfill and the rest goes into unlined ash ponds. The two ponds were created by building an earthen dam across an existing ravine next to the plant in 1978, and then 24 years later building a second dam further upstream in the ravine. Water is used to rinse the ash into the ponds. The ponds' combined surface area is 156 acres, and at their deepest point the ash/water mix is 5 to 6 stories high (62 feet). As of October of 2016, the two ponds held a total of 6.8 million cubic yards of mixed water and ash. That's enough to fill 2,080 olympic-sized swimming pools.

Brown's landfill contains another 6.8 million cubic yards of coal combustion waste, but in a dry form. As of October, 2015, 61% of the landfill was covered with soil and vegetation, and approximately half of that also had an impermeable cover called geomembrane in addition to soil. In the active area, 18% of the landfill lacked any cover. The landfill permit requires cover annually. Vectren uses other methods, as necessary, to control fugitive dust.

Coal ash can be a threat to humans through contamination of water or inhalation of airborne dust or, if a dam bursts, through a spill of the ash and water mixture.

<u>Impact on ground water:</u>

There is already ground water contamination by coal ash at the A.B. Brown dry landfill. Vectren has been required to monitor it for more than 20 years and take corrective action. Ground water contamination is also likely from the ponds, though it has not been tested. A hydrogeologist evaluated the data on A.B. Brown's ash along with data on the local geology and concluded that contaminants from Brown's

coal ash ponds are likely moving into the ground water in several directions. People using wells within a mile of the ash ponds or landfill for drinking or cooking should have their water tested for metals, sodium and sulfate.

Impact on the Ohio River:

A.B. Brown has a permit to discharge wastewater to the Ohio River. Their discharge report from August, 2015, showed that Brown was releasing 2.88 million gallons per day with an arsenic concentration slightly above the US drinking water standard. The discharge also carries selenium and dissolved solids which are harmful to aquatic life.

Airborne Dust:

Dry coal combustion waste at A.B. Brown could produce fugitive dust either where it is being loaded onto barges or from the dry waste landfill. Neighbors have described occasional incidents of wind-blown, gray ash covering their yards and homes. Inhalation of fine particles in the dust can irritate the lungs, worsen lung diseases including asthma, and increase the risk of cardiovascular disease. As of fall 2015, Vectren has a fugitive dust control plan in place at A.B. Brown. If there are future incidents of fugitive dust, they should be reported to

- Indiana Department of Environmental Management Office of Air Quality at (317) 233-5674 and ask for the appropriate county inspector
- or the IDEM complaint line at (800) 451-6027 ext.24464
- or by email to CCR_inquiries@vectren.com

Spill risk:

Both dams at AB Brown were rated 'significant hazard' by the EPA, meaning if the dam failed, there would not be loss of life, but it could cause significant economic and environmental damage. As to whether the dams could fail, the EPA rated the upper dam in 'satisfactory' structural condition. The lower dam was rated in 'fair' condition, meaning acceptable performance is expected, but minor deficiencies may require repair or further investigation. In February of 2016, Vectren published plans to disassemble parts of the upper dam and strengthen the lower dam.

The A.B. Brown compliance reports including the fugitive dust plan and inspection reports are available at:

https://www.vectren.com/Community/Environmental_Stewardship/CCR_Rule_Compliance_Data_and_Information.jsp

Background

When coal is burned for electricity, the combustion and pollution control processes generate fly ash, bottom ash, flue gas desulfurization sludge, and boiler slag. Together they are commonly referred to as coal ash, and in the regulations they are called coal combustion residuals or CCR.

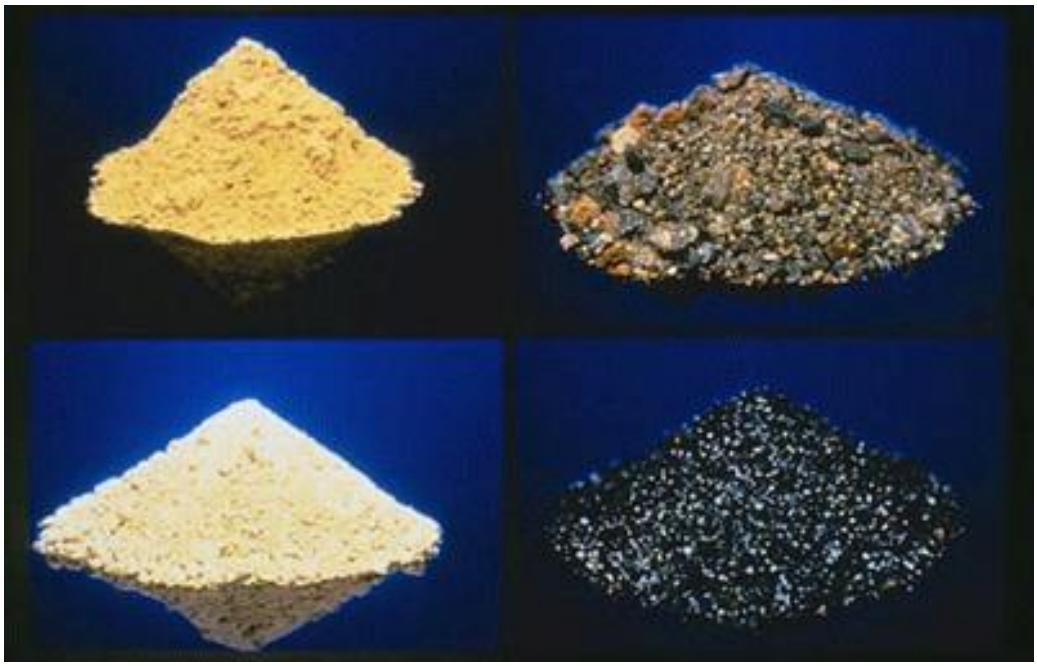

Figure 1. Top left to bottom right: fly ash, bottom ash, flue gas desulfurization material, boiler slag From American Coal Council (2010)

Coal is composed predominantly of carbon most of which is released when coal is burned. This leaves other elements more concentrated in the ash than they were in the coal. Residual, unburned carbon accounts for 1 to 20% of coal ash by weight. More than 90% of the non-carbon portion of the ash consists of oxides of silicon, aluminum, iron and calcium, similar to material found in soil. A number of toxic elements are also present in low concentrations, but enough to be a public health concern if the ash is not handled appropriately (Table 1)(Electric Power Research Institute (EPRI), 2009a).

	Range in coal ash
Arsenic	2.6 – 260 mg/kg
Cadmium	Undetectable to 3.7 mg/kg
Chromium	27 – 1100 mg/kg
Iron	34,000 - 160,000 mg/kg
Lead	8.1 – 230 mg/kg
Manganese	85 - 890 mg/kg
Mercury	Undetectable to 0.51 mg/kg
Nickel	39 - 440 mg/kg
Selenium	Undetectable to 18 mg/kg
Sodium	1,600 - 17,000 mg/kg
Strontium	270 - 3100 mg/kg
Thallium	Undetectable to 45 mg/kg
Uranium	Undetectable - 19 mg/kg
Vanadium	Undetectable - 360 mg/kg

Table 1. Minor constituents of fly and bottom ash. Data from Electric Power Research Institute (2009a)

The United States produces over 100 million tons of coal ash per year. Approximately 40% is beneficially used including use in cement and wallboard. The remainder is disposed of in landfills if it is dry or in coal ash ponds if it is mixed with water (Amer Coal Ash Assoc, n.d.).

Coal ash becomes a health issue if the toxic metals in the ash contaminate water or if dust from dry ash becomes airborne where it could be inhaled. Since coal ash is stored in quantities reaching millions of tons, it can also threaten health if there is an avalanche-like spill from one of the storage facilities like the Kingston ash spill in Tennessee in 2008.

This report will examine the coal ash storage at the A.B. Brown power plant in Posey County, Indiana, and its potential for impacting local public health.

Site Description

The A.B. Brown facility, owned and operated by Vectren Power Supply, is a Southern Indiana Gas & Electric Company (SIGECO) power generation station located eight miles

east of Mt Vernon – considered part of the Evansville metropolitan area – in Posey County, Indiana. Along with Vectren's other power plants, the facility supplies electricity to seven counties in Southwestern Indiana. Two of the four generating units at Brown burn bituminous coal and have a combined operating capacity of 461 megawatts (MW) (Vectren Corporation, 2014; US Energy Information Administration, n.d., b). A.B. Brown produces 284,000 tons of coal combustion waste per year (US Energy Information Administration, n.d., a). The ash and other wastes generated are used in cement or go into a restricted waste landfill and two coal ash ponds (ATC Group Services, 2016a and 2016b).

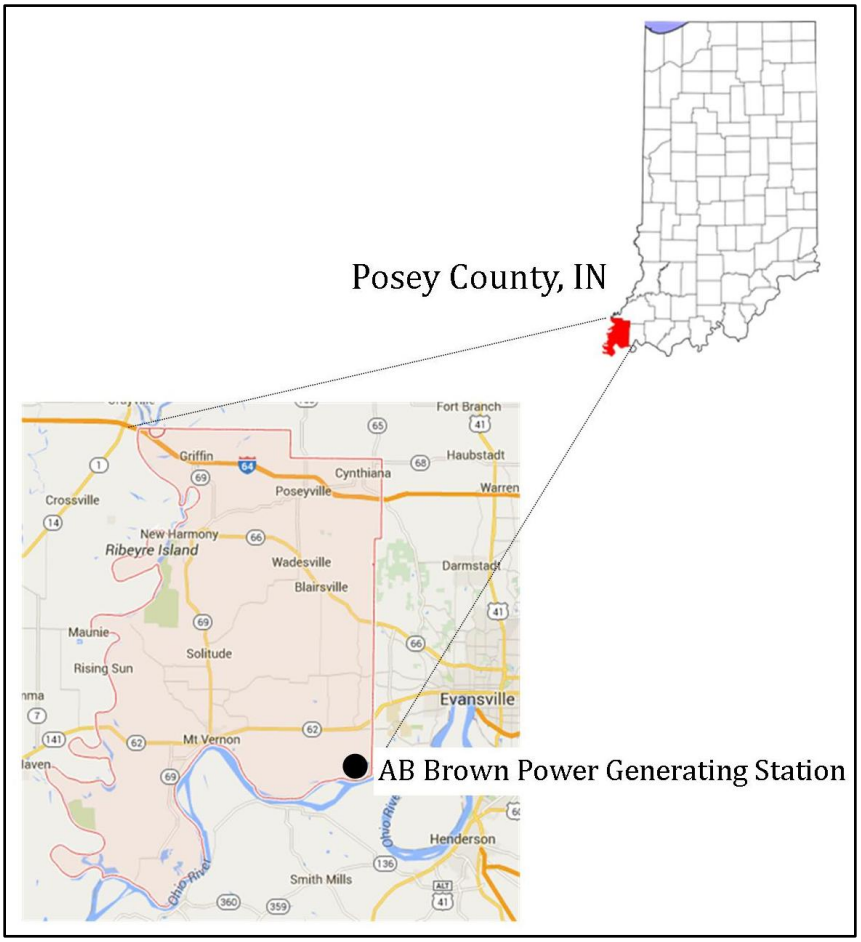

Figure 2. Map Data 2016 (c) Google and NationalAtlas.gov

Coal Ash Ponds

Power plants often use water to move coal ash out of the plant and into an impoundment. These impoundments can also be referred to as 'ponds' or 'lagoons'. Since Vectren's own reports refer to their coal ash storage structures as 'ponds', this report will use the same term to avoid confusion. However, these are massive collections of mixed ash and water that dwarf the size of many lakes.

A.B. Brown has two coal ash ponds that were constructed by blocking off a natural ravine located a half mile north of the Ohio River. A small, unnamed stream used to drain the ravine. It now starts below the Lower Dam, heads west one third of a mile, then turns south and into the Ohio River.

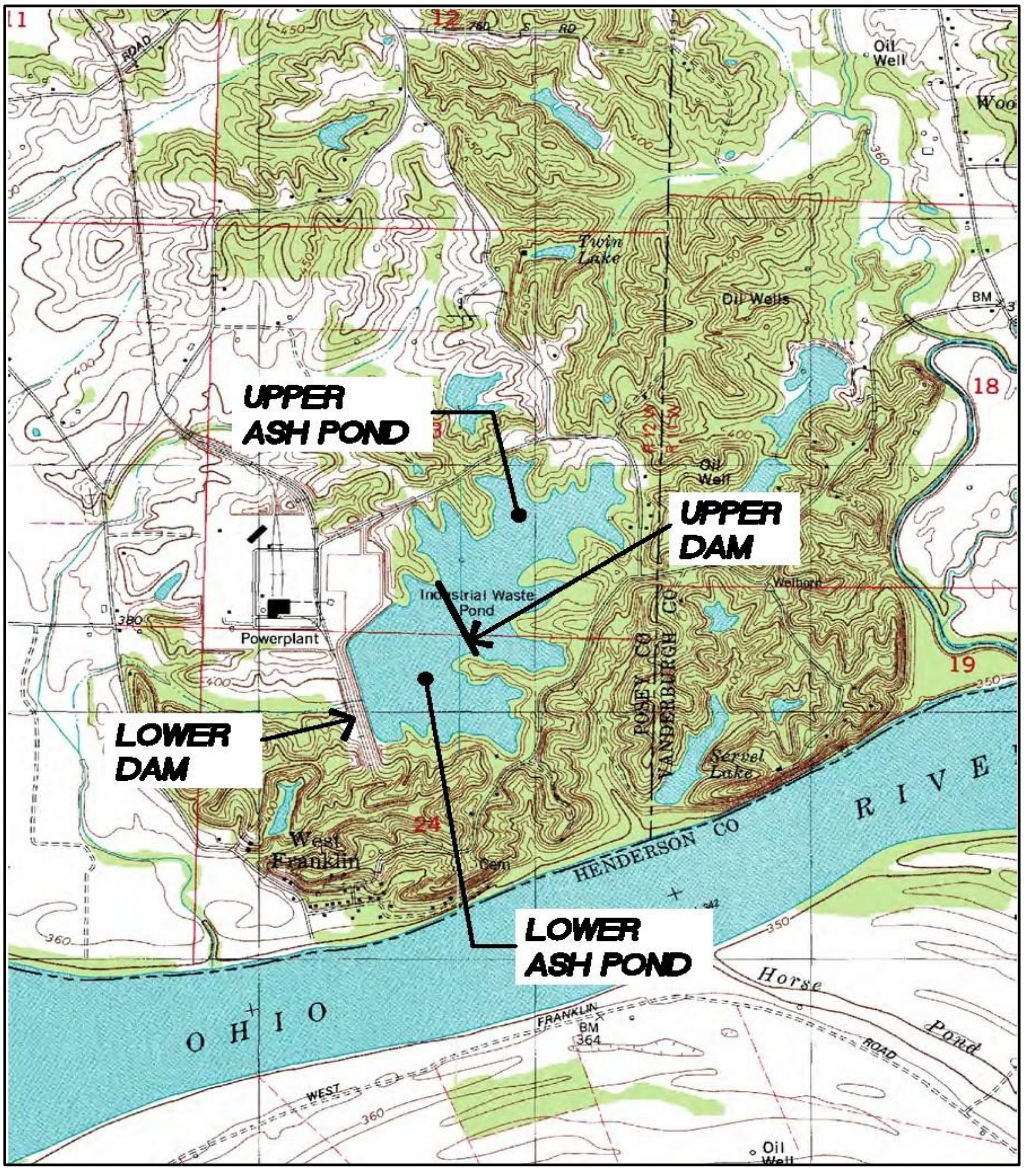

Figure 3. Map of the upper and lower ash ponds and proximity to the Ohio River (ATC Group Services, 2016a).

Both of A.B. Brown's ponds are unlined. They cover 156 acres, with approximately 53 acres impounded in the Lower Ash Pond and the remaining 103 acres impounded in the Upper Ash Pond (Figure 3) (Wilson, 2009). The Lower Dam became operational in 1978 and since then no significant amount of material has been removed (Retherford, 2009).

The Upper Dam was constructed in 2002 to better manage the separation of water and solids within the ponds. The Upper Pond is used to store liquid wastes that include: fly ash, bottom ash, boiler slag, boiler chemical cleaning wastes (once per 7-8 years), flue gas deposits, flue gas desulfurization(FGD) belt filter wash down, water sump wastes, pyrites, material removed from the coal pile runoff pond (once per year), plant floor drain wash down, reverse osmosis system reject and rainfall/runoff from the area surrounding the pond (Lockheed Martin, 2009b). The Lower Ash Pond is used for storage of scrubber and water treatment blowdown as well as any discharge from the Upper Pond (Lockheed Martin, 2009a). In 2009, Vectren reported that the fly ash and bottom ash had been disposed of exclusively in the Upper Ash Pond since 2002 (Retherford, 2009).

In October, 2015, the lower pond was approximately 53 feet deep and the upper pond was 62 feet, the height of a 5 - 6 storey building. The lower pond surface was at an elevation of 442.3 feet above sea level and the upper pond surface was at 458.3 feet (ATC Group Services, 2016a). The Ohio River bank lies downhill from AB Brown at 350 feet above sea level (US Geologic Survey, n.d.).

A professional licensed engineer from the environmental consulting firm ATC performed a visual inspection of the ponds in the fall of 2015. The inspector estimated that the Upper Pond held a total of 4.2 million cubic yards (500,000 cubic yards of water and 3.7 million cubic yards of ash) and the lower pond held 2.6 million cubic yards (300,000 cubic yards of water and 2.3 million cubic yards of ash) (ATC Services Group, 2016a).

Upper Dam

The Upper Dam at AB Brown is 20 feet high reaching an elevation of 464 feet. The crest is 1100 feet long and 25 feet wide. If the Upper Dam failed, it would release the Upper Pond contents into the Lower Pond.

Assessments of the Upper Dam have rated it a high hazard if it were to fail, but found that it was in good structural condition and unlikely to fail. In 2009, Lockheed Martin recommended that the Upper Dam should be classified as a 'Significant Hazard' because that is how the Lower Dam was classified, and there had been no analysis of how well the Lower Dam would hold if the Upper Dam failed (Lockheed Martin, 2009b).

After the 2008 coal ash spill in Tennessee, the EPA contracted with dam safety experts to assess the potential hazard and structural integrity of dams holding coal ash at 235 sites in 33 states (EPA, March 2016). The EPA assessment designated the Upper Dam's potential hazard as 'significant' meaning "failure or mis-operation results in no probable loss of human life, but can cause economic loss, environment damage, disruption of lifeline facilities, or impact other concerns". The EPA rated the structural condition of the Upper

Dam as 'satisfactory' meaning "no existing or potential management unit safety deficiencies are recognized. Acceptable performance is expected under all applicable loading conditions (static, hydrologic, seismic) in accordance with the applicable criteria." (EPA, 2013). Similarly, engineering firm ATC Group Services inspected the Upper Dam in 2015 and classified it as 'high hazard' (ATC Services Group, 2016a).

On February 10, 2016, Vectren filed a public notice with the Indiana Department of Natural Resources of its intent to decommission the Upper Dam at A.B. Brown. The word 'decommission' refers to any dam that is going to be removed or changed so it will no longer function as a dam. The plan for dam decommissioning, written by environmental consulting firm ATC, would not completely remove the upper dam. It would build a 10-foot wide trapezoidal breach in the southern end of the Upper Dam with a breach elevation of 455 feet above sea level. The plan describes other steps they would take to lower the upper pond and allow it to drain into the Lower Pond (ATC Group Services, Feb 2016). Given that the upper pond surface is currently at 458.3 feet and its maximum depth is 62 feet, it appears that much of the upper pond's contents would be left in place after the pond lowering measures and construction of the breach.

The decommissioning plan includes construction of an additional buttress on the lower dam to "provide reinforced stability for the Lower Ash Pond". The buttress would make the lower dam thicker, but not higher. The plan states that these changes are needed "in order to meet stringent CCR criteria", referring to the EPA's rule for Coal Combustion Residuals (ATC Group Services, Feb 2016). As mentioned above, the Lower Pond already holds more than its estimated maximum volume, so it is not clear how it will hold the additional material from the Upper Pond after the Upper Dam is decommissioned.

Lower Dam

The Lower Dam at A.B. Brown is an earthen embankment that was constructed across a ravine in the 1970s. It is 70 feet high at its maximum bringing the crest to an elevation of 450.9 feet above sea level. The dam is 20 feet wide at the crest and 1,540 feet long. The crest is lined with crushed stone. The Lower Dam is connected to the Upper Dam at the North East end. The water level is maintained by pumping the water back for reuse at the facility (ATC Group Services, 2016a; Lockheed Martin, 2009a). The Lower Dam is permitted by the state of Indiana, State ID#65-7, permit# D-4405, rev 1 (Retherford, 2009).

Assessments of the Lower Dam have rated it a high hazard if it were to fail, and its structural condition was rated 'fair'. The Indiana Department of Natural Resources (IDNR) designated the Lower Dam as a Significant Hazard, meaning no human life is likely to be lost in the event of the dam failing, "but potential economic or environmental impacts could result at downstream facilities". (Lockheed Martin, 2009a). The EPA assessment also

designated the hazard potential for the Lower Dam as 'Significant', similar to the Upper Dam, but its condition was rated one degree lower than the Upper Dam as 'fair', meaning "Acceptable performance is expected under all required loading conditions (static, hydrologic, seismic) in accordance with the applicable safety regulatory criteria. Minor deficiencies may exist that require remedial action and/or secondary studies or investigations." (EPA, 2013).

As with the Upper Dam, the Engineering firm ATC Group Services classified the Lower Dam as 'high hazard' (ATC Services Group, 2016a). The inspector entered that classification on the federal inspection form for the CCR Rule. The form defines high hazard as "A structure the failure of which may cause the loss of life and serious damage to homes, industrial and commercial buildings, public utilities, major highways, or railroads." The inspector did not indicate which persons or structures would be at risk. On a topographic map of the area it appears that the coal/water mixture would spill to the west if the Lower Dam failed, along the continuation of the ravine (figure 4). A spill to the south appears unlikely, given the terrain. If it were to happen, the Ohio River is only a half mile away downhill along with approximately 20 houses in the unincorporated town of West Franklin.

The 2009 assessment of the Lower Pond by Lockheed Martin raised the concerns about the Lower Dam including:

- Saturated areas on the lower portion of the downstream slope from seepage
- Ponding of water on the berm surface showing that the berm did not have adequate drainage
- Vegetation and tree growth on the lower portion of the downstream slope that could damage the dam if they were uprooted during a storm
- Minor leakage at the outlet end of the principal spillway

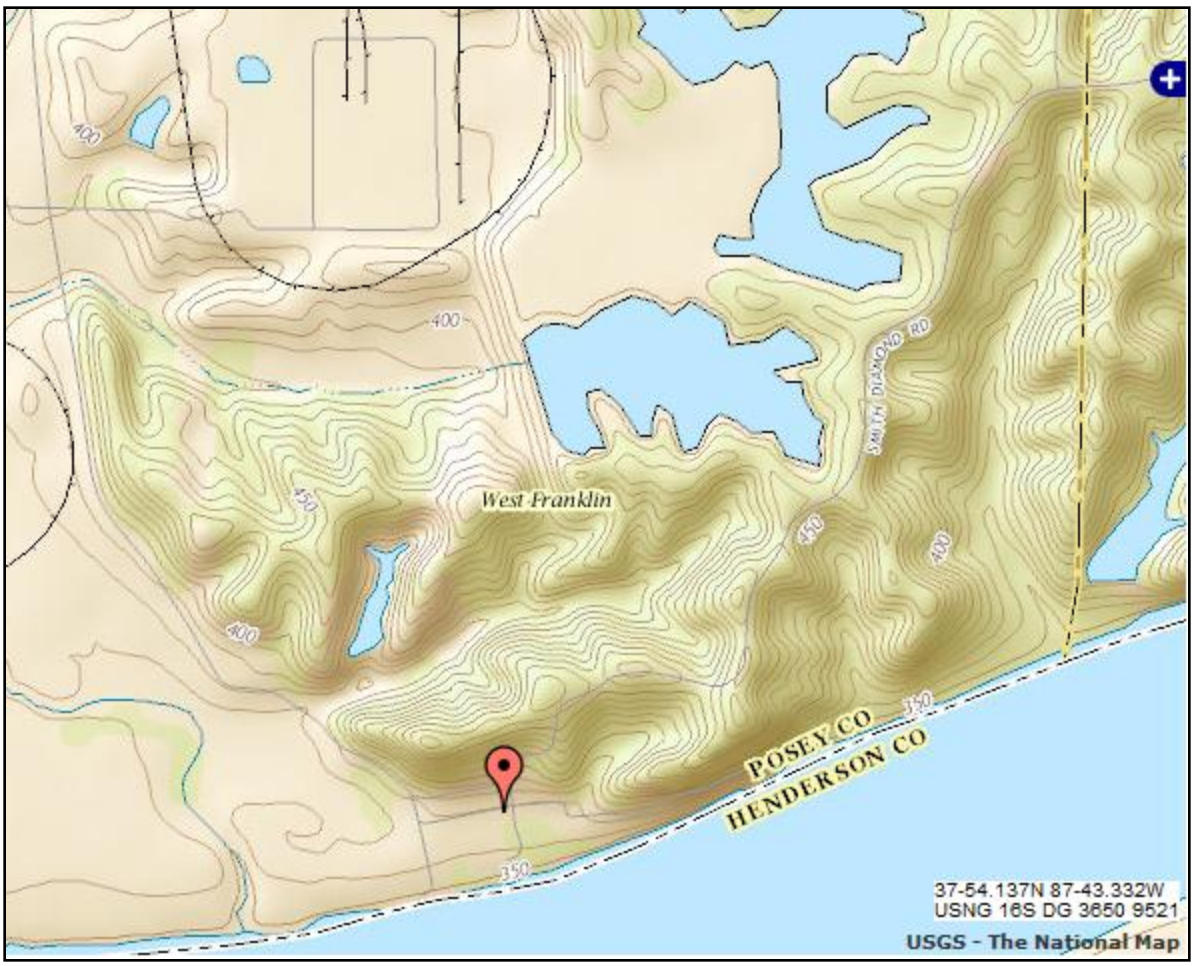

Figure 4. Topographic map of region around A.B. Brown and West Franklin, Indiana.

The Lockheed Martin assessment report made the following recommendations:

- Create a concrete operation and maintenance plan
- Document a full chronology of efforts to mitigate seepage
- Consider constructing a drain outlet system to address seepage by draining the Seepage Collection Zone in the dam
- Consider regrading the berm surface
- Perform an hydraulic evaluation of the capacity of the Lower dam's spillway system to safely pass the flow that would result from a failure of the Upper Dam
- Use piezometers should to measure ground water flow within the embankment.
- Sample soil from the dam to look for zones where seepage would be likely
- Develop a plan for operations, maintenance and inspections

ATC Group Services LLC, reviewed the pond records and performed a visual inspection of both the dams on October 7, 2015 and noted that the overall condition of the

facility's pond system was satisfactory. The inspection report included this question: "Previous recommendations for maintenance, repairs, and upgrades: Have they been performed". The ATC inspector checked the answer 'yes', but gave no explanation (ATC Group Services, 2016a, pg 4). However, the ATC report noted that there was still a slow leakage (less than one gallon per minute) from the joints and minor cracks in the piping associated with the Lower Dam Principal Spillway Outlet and recommended that the leak needs to be monitored weekly and the outlet repaired if it increases or looks cloudy.

The 2015 inspection report by ATC referred to an inspection by Stantec in October, 2014, that showed "some staining and spalling" of a concrete pipe in the principle spillway system, but it was in satisfactory operating condition. Spalling refers to crumbling of concrete due to freeze - thaw cycles. The 2015 inspection was strictly visual and did not recheck the spillway pipes. It did not include video, nor did it include any "test drilling, testing of materials, precise physical measurements . . .or other engineering analyses". (ATC Group Services, 2016a)

In its current condition, the Lower Dam might not withstand an earthquake. There is a fault two miles northwest of AB Brown. An analysis in 1982 determined that the area around Brown is in a seismic 'zone 3' and could experience major damage if an earthquake occurred. AECOM, a company from Cleveland, OH, analyzed the Lower Dam for seismic stability in 2015, and their report is incorporated in ATC Group Service's decommissioning plan (Feb 2016). AECOM took multiple borings into the lower dam to analyze the soil and fill comprising the dam. They concluded " . . the analyses indicate that the Lower Dam in its existing configuration will not satisfy requirements for post-earthquake stability. . . As a result, a stabilizing soil buttress has been proposed."

The plan to decommission the Upper Dam includes a proposal to strengthen the Lower Dam. The plan would build up a 200-foot wide plateau of fill material or 'soil buttress' below the Lower Dam, essentially increasing its thickness. The proposed addition will not change the height of the Lower Dam or the capacity of the Lower Ash Pond (ATC Group Services, Feb 2016, pp 7) (see figure 5).

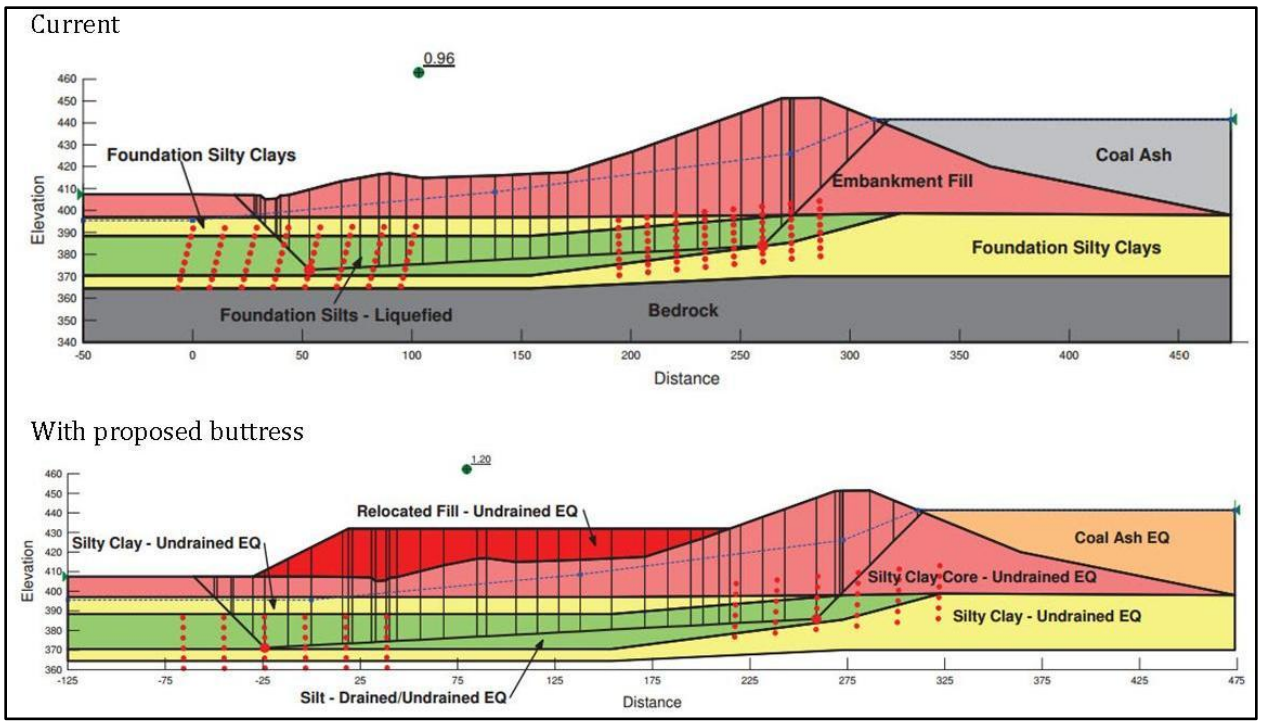

Figure 5. Proposed change to the lower dam at A.B. Brown (cross-section A). From post-liquefaction stability analysis performed by AECOM and included in ATC Group Services, (2016, Feb 17)

Restricted Waste Landfill

The restricted waste landfill at A.B. Brown is located immediately north of the ash ponds (figure 6). It began operation in 1979 and was expanded in 1992. The original landfill was unlined. The expansion has a compacted clay liner as required for type III restricted waste landfills (EPRI, 2009b; Indiana Department of Environmental Management, n.d.). The old and new landfills together cover 85.5 acres of which 70.5 acres has undergone closure or partial closure with a cover of soil or soil and geomembrane, which is a man-made liner for preventing water from getting through. In this case, the geomembrane will help prevent rain or snowmelt from seeping into the landfilled waste. As of October, 2015, 28 acres of the 85 acre landfill had the geomembrane cap (ATC Group Services, 2016b). A 15-acre active section lacks any cover (ATC Group Services, 2016b). In the landfill's permit, cover is required on an annual basis (Breyenton, 2015).

The A.B. Brown landfill holds approximately 6.8 million cubic yards of dry coal combustion residuals, primarily waste from flue gas desulfurization (FGD). FGD removes sulfur from the power plant's air emissions and at A.B. Brown the FGD waste is mostly calcium sulfite (EPRI, 2009b), but FGD wastes also contain heavy metals (EPRI, 2006). In 2014, Vectren landfilled 167,000 tons of FGD material at AB Brown (US Energy Information Administration, 2015). The most recent land disposal report Vectren submitted stated that

44,687.43 tons of FGD waste were added in the third quarter of 2015 (Vectren, October, 2015).

An inspection of the landfill in 2015 found focal issues requiring repair or modification. There was 'significant erosion' around downdrain pipes at the southeast corner of the landfill and some sparsely vegetated and eroded areas on the sideslopes. Vegetation was obstructing some downdrain pipes. Storm water management and drainage issues were noted focally. There were several seeps along the south slope with a total flow of approximately 1 gallon per minute that was directed to a separate wastewater pond (ATC Group Services, 2016b). Issues of fugitive dust and ground water contamination from the landfill are described in separate sections below.

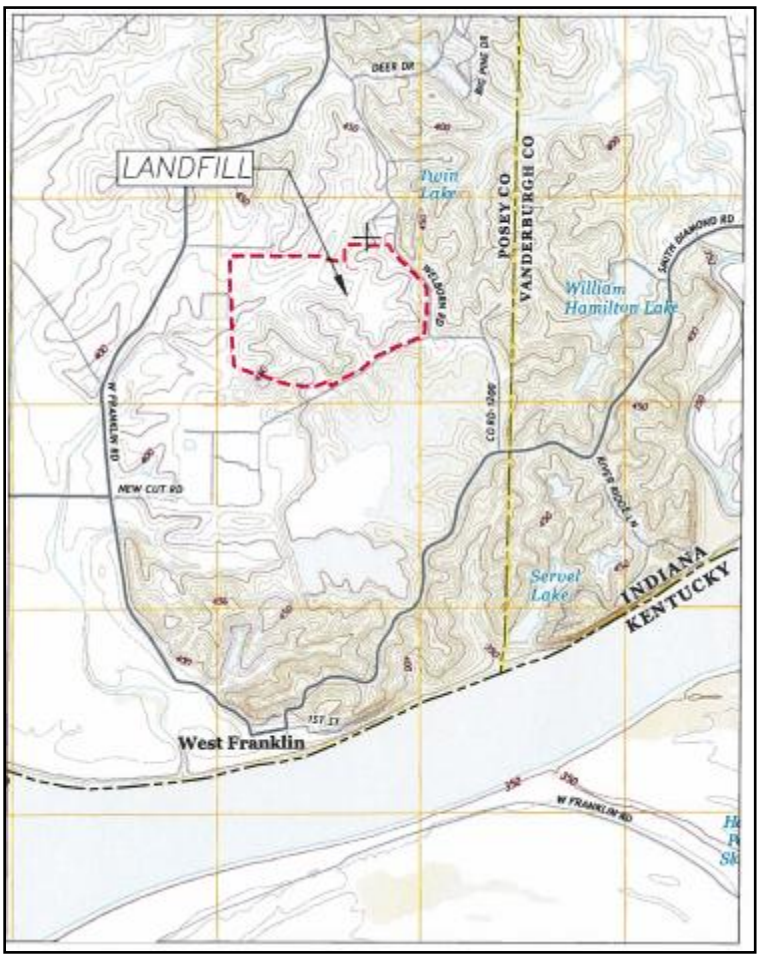

Figure 6. Map of the restricted waste landfill. (ATC Group Services, 2016b)

Fugitive Dust

Fugitive dust could be generated at the A.B. Brown facility by any dry coal handling or ash handling activities, but the dry fly ash handling system and the on-site landfill are the most likely sources. Dry fly ash is pneumatically moved from the power generating station via a piping system meant to reduce dust to a silo at a barge loading facility on the Ohio River. The silo has been in operation since 2009 and since then the majority of fly ash at A.B. Brown is diverted to this silo. Since February, 2010, most of the fly ash processed through the silo is being sent via a river barge loader to a cement processing plant in St Genevieve, Missouri. When the dry ash handling system is unavailable, the fly ash is rinsed into the coal ash pond with water, in a process called sluicing (Bryenton, 2015; Vectren Corporation, 2014). In 2014, A.B. Brown reported 77,000 tons of fly ash sent for use offsite, which was 73% (US Energy Information Administration, n.d. a). Neighbors living near A.B. Brown have noted occasional episodes of fugitive dust (personal communication) (figure 7).

Figure 7. Coal ash at a residence east of A.B. Brown, January, 2015.

The air permit for A.B. Brown requires recording visible emissions daily for the lime and soda ash transfer points, and weekly from barge loading of the fly ash and points where the coal is transferred via railcar or truck. An inspection February 26, 2015, found no dust violations, though many of the activities that might generate dust were not in operation at the time of the inspection. The inspection did find a record keeping violation

that the facility failed to record visible emission notations for the barge loading from November, 2014 to February 2015 (IDEM, Feb 26, 2015).

Fugitive dust can also be generated when the FGD waste is trucked and stored at the onsite restricted waste landfill. As the waste is moved by a dragline excavator on a daily basis and 15 acres of the landfill lack cover, the likelihood of dust generation is very high. (ATC Group Services, 2016b; Bordenkecher, 2015).

Vectren's Fugitive Dust Control Plan states that the FGD waste is conditioned with water to reduce dust prior to transport to the landfill. After it has dried, dust is controlled by spraying with water, fogging, using a wind barrier, compaction, vegetative cover, or using a commercial dust control product. Depending on weather conditions and the condition of the landfill, Vectren also has operational procedures for minimizing waste disturbance by traffic and for delaying movement of the ash by the excavator (Breyenton, 2015). Under provisions of the facility's air permit, dust generation is controlled during coal transfers from railcars or trucks by using a water mist curtain (IDEM, Feb 26, 2015).

The finest dust in coal ash can be as small as 1 micrometer (EPRI, 2009). Particles that small can get deep into the lungs and even be absorbed into the blood. Exposure to airborne fine particles increases the risk of cardiovascular disease and reduces life expectancy. The longer a person has been exposed, the more the risk, but even exposures of hours to days have a measurable impact (Brook, et al., 2010). Fine particles irritate the lungs and worsen lung diseases like asthma (Bell & Samet, 2005).

Impact on the Ohio River

The AB Brown plant has an IDEM permit (# IN 0052191) to discharge process and cooling water into the Ohio River under the National Pollutant Discharge Elimination System (NPDES). The current permit, set to expire on 9/30/2016, requires the facility to measure and report the concentrations of 20 different constituents including arsenic, boron, cadmium, mercury and selenium in the discharge, but the permit only sets a limit on the discharge of mercury. The permit limits the discharge of mercury to no more than 12 nanograms per liter (ng/L) for a monthly average concentration and no more than 20 for a daily maximum (Vectren, Sept 2015).

The A.B. Brown Discharge Monitoring Report for August 2015 reported that the plant discharged 2.88 million gallons of waste water per day with an arsenic concentration of 0.0101 mg/L and selenium of 0.0489 mg/L. The arsenic concentration was just above the maximum allowed in drinking water, 0.010 mg/L, and selenium was just under the drinking water limit of 0.05. Total chromium was present at 0.00306 mg/L, well below the maximum concentration of chromium allowed in drinking water which is 0.1 mg/L. However, the more toxic form, hexavalent chromium (chromium VI), is more common in

coal ash leachate and it has no drinking water standard. Cadmium and mercury were not detectable in the discharge (Vectren, Sept 2015).

A.B. Brown added procedures in 2014 to reduce mercury in its wastewater. Two chemical-precipitation water treatment systems at the AB Brown plant were added towards the end of 2014 to comply with its NPDES permits and ORSANCO standards including a 12 nanogram/liter (parts per trillion) discharge limit for mercury. The treatment system receives leachate from the landfill. (Vectren Corporation, 2014; ORSANCO, 2015).

The US Environmental Protection Agency (EPA) finalized new Effluent Limit Guidelines and Standards (ELGS) on September of 2015 that set additional requirements for wastewater discharge from processes or by-products that include flue gas desulfurization, fly ash, bottom ash, flue gas mercury control and gasification of fuels such as coal and petroleum coke. The final rule establishes (EPA, 2015):

- Phased implementation of more stringent requirements that limit effluent discharge of mercury, selenium, arsenic and nitrogen in FGD wastewater from wet scrubber systems.
- Incorporation into a plant's NPDES permit a zero discharge limit of pollutants in ash transport water. Affected plants are given until 2023 to meet even more stringent standards for FGD wastewater and total dissolved solids based on new evaporation technology.
- "Zero discharge pollutant limits for flue gas mercury control wastewater and stringent limits on arsenic, mercury, selenium and total dissolved solids in coal gasification wastewater."

Depending on when a new plant needs to renew its Clean Water Act permit, compliance is expected between 2018 and 2023. If IDEM issues a new permit by September 30, 2016, Vectren will need to comply with the new water pollution protections within five years, or 2021. The current permit is set to expire in September of 2016.

Impact on Ground water

Contaminants from coal ash can be carried by water downward through the soil to the ground water in a process known as 'leaching'. Where ground water beneath coal ash ponds has been tested, contamination has been common. In 2007, the EPA reported on a total of 54 coal ash sites around the US where ground water contamination had been documented. Since the EPA's report, advocacy groups have documented additional cases (Stant, 2010). As of February, 2014, the group Earthjustice reported a total of 208 cases of known ground water contamination or spills of coal ash in the US (Earthjustice, 2014). In

2015, reports were published in North Carolina detailing additional instances of ground water contamination. In North Carolina, 313 private water wells close to 14 unlined coal ash ponds were tested. 291 of them (93%) failed at least one North Carolina drinking water standard, most of those for contaminants associated with coal ash (Southern Environmental Law Center, 2015; North Carolina DHHS, 2015).

When there is leaching from coal ash, some contaminants leach more readily than others. A study by the Electric Power Research Institute (EPRI) analyzed 81 leachate samples from 29 coal ash sites (2006). They found that the contaminants that can leach in the highest concentrations were aluminum, boron, chromium VI, iron, lithium, manganese, molybdenum, silicon, sulfate, strontium, and vanadium.

Table 2 lists many of the substances that can leach from coal ash in high enough concentration to potentially contaminate ground water and pose a threat to health. For each substance the range of concentrations that can be found in leachate from fly ash and FGD waste is listed. The US drinking water standards are listed for comparison. Leachate is the water that has been in direct contact with the ash. Coal ash leachate can have concentrations that are higher than the US safe drinking water standards, but if coal ash leachate contaminates ground water, it is diluted before it reaches wells, so these are not the concentrations that would be seen in wells.

The possible health effects listed in table 2 are those that could occur from eating or drinking a low dose over a long period of time. They are not the high dose effects or the effects from inhalation. The health effects for all of these substances depend on how a person was exposed, how much they were exposed to, and for how long. There is not room in this report for complete toxicological information.

A.B. Brown is located in Posey County which has a single bedrock aquifer, the McLeansboro Group Aquifer System. This aquifer system is believed to be formed mostly from shale and sandstone formations (Unterreiner, 2006). Within that system the Inglefield Sandstone Member (50 – 65 feet thick) is the principal bedrock aquifer in the county. (Robinson, 1977). The sidewalls of the ravine that holds the A.B. Brown ash ponds are outcrops of the Inglefield Sandstone Member. A 1979 soil survey of Posey County documented that the soil lining the ravine is a well-drained type formed from the sandstone and known as the Wellston soil series (US Department of Agriculture, 1979). Thus, the saturated coal ash in the ponds lies in direct contact with permeable soils and sandstone.

	Possible Health Effects	Drinking Water Standard or Health Advisory (mg/L)	Range in Coal Ash Leachate mg/L
Arsenic	warty skin growths, fetal damage arsenic is a known carcinogen (liver, bladder, lung, skin)	0.010	0.0014 - 1.38
Cadmium	kidney damage probable carcinogen	0.005	BDL - 0.065
Chromium VI	stomach ulcers, sperm damage known carcinogen (lung, stomach)	NA	BDL - 5.09
Iron	liver & heart damage in patients with hemochromatosis	0.3	BDL - 25.6)
Manganese	nervous system damage	0.3	BDL - 4.17
Nickel	allergic reactions, stomach ache, kidney damage some forms are carcinogenic	0.1	BDL - 0.597
Selenium	selenosis (hair loss, numbness & abnormal sensations)	0.05	0.000071 - 2.36
Sodium	high blood pressure, cardiovascular disease	20	3.8 - 4,630
Strontium	impaired bone growth	4	0.030 - 16.9
Uranium	kidney damage	0.02	BDL - 0.061
Vanadium	nausea, diarrhea possible carcinogen (lung)	NA	BDL - 5.02

Table 2. Data obtained from Electric Power Research Institute (2006); Agency for Toxic Substances and Disease Registry (n.d.); and US Environmental Protection Agency (2012)

Ground water does not stand still. It generally travels through the ground from locations where the water table is at a higher elevation above sea level toward a location where it is lower. A difference in the elevation of ground water between two locations is called 'hydraulic head'. The surfaces of the A.B. Brown ash ponds are at elevations of 442.3 and 458.3 feet above sea level, while ground water elevations all around the pond are lower creating a hydraulic head such that water would be expected to move from the ponds outward. North of the ponds ground water is between 407 and 459.48 feet (ATC Group Services, 2016c). Ground water in the mass of earth comprising the lower dam on the west side of the ponds was measured at 406 and 424 feet above sea level (ATC Group Services, Feb 2016, pp 87). To the south, the Ohio River is at 350 feet above sea level (US Geologic Survey, n.d.). Well logs from east of the upper pond show ground water at 452 and 455 feet (Indiana Department of Natural Resources, n.d.).

There are many factors that point to there being a high risk that leachate from the A.B. Brown coal ash ponds is contaminating ground water. They are unlined, and they sit on permeable soil and sandstone. The coal ash mixed with water has been stored there for nearly 40 years, and there is a hydraulic head to push water from the ponds outward to the north, west, east and south. The extent of ground water impact is not certain since the ground water around the ponds has not been tested. Twin Lakes just northeast of AB Brown and the stream below the Lower Dam may also be impacted by the coal ash.

Coal ash at the A.B. Brown landfill has already contaminated ground water. This was discovered in the early 1990s. At that time the ground water exceeded the secondary US standards for sulfate, pH, total dissolved solids and chloride (EPA, 2007). Since then, the Indiana Department of Environmental Management (IDEM) has required Vectren to install monitoring wells and periodically test samples of the ground water. The monitoring wells are on the AB Brown property immediately to the north and east of the landfill. IDEM also required a corrective action plan. Vectren has constructed a slurry wall around the northeast corner of the RWS and in 2012 they began adding a geomembrane cap over the landfill (ATC Group Services, 2016c).

	Highest Result at Brown for Nov, 2015 [well ID]	**Drinking Water Standard or Health Advisory**	**Number of wells that exceeded standard/advisory**
sulfate	8340 mg/L [MW-4.3B]	500 mg/L (health advisory)	7
boron	13.5 mg/L [MW-4.3B]	3 mg/L (child health advisory)	3
sodium	4350 mg/L [MW-4.3B]	20 mg/L (health advisory)	9
arsenic	10.7 ug/L [MW-4.1A]	10 ug/L	1
cadmium	5.3 ug/L [MW-4.1A]	5 ug/L	1
mercury	0.0022 mg/L [MW-4.1A]	0.002 mg/L	1
chromium	1.0 mg/L [MW-4.1A]	0.1 mg/L	1

Table 3. Constituents in ground water at the A.B. Brown restricted waste landfill, November, 2015 (ATC Group Services, 2016c)

Over the past 20 years of monitoring near the landfill in A.B. Brown's monitoring wells, the ground water has repeatedly shown contamination by sulfate, boron, and sodium, which are among the constituents that leach most easily from coal ash. One of the monitoring wells has repeatedly failed the Indiana ground water standard for arsenic. The

most recent ground water monitoring in November of 2015 showed that nine of the wells failed one or more of the US drinking water standards or health advisories, see table 3 (ATC Group Services, 2016c). Seven wells were tested for 13 constituents, while 4 others, including the 3 furthest from the north edge of the landfill, were tested for just sulfate, boron and sodium. None of the wells was tested for the full list of possible constituents of coal ash leachate. Exceedances were not found in the three furthest wells, which are located 70 to 400 feet to the north of the landfill. It is possible that A.B. Brown's extraction wells just south of them (EW-1, EW-2, and EW-3) could be creating a cone of depression that prevents the contaminated ground water from reaching them.

There are also privately owned water wells near A.B. Brown. According to the Indiana Department of Natural Resources (IDNR), there are close to a hundred water wells within 3 miles of A.B. Brown, mostly used for domestic purposes (figure 8). Most of these wells are in the city of West Franklin, and range in depth from 18 to 318 feet (IDNR, n.d.). As of this writing, none are known to have been tested for coal ash contaminants.

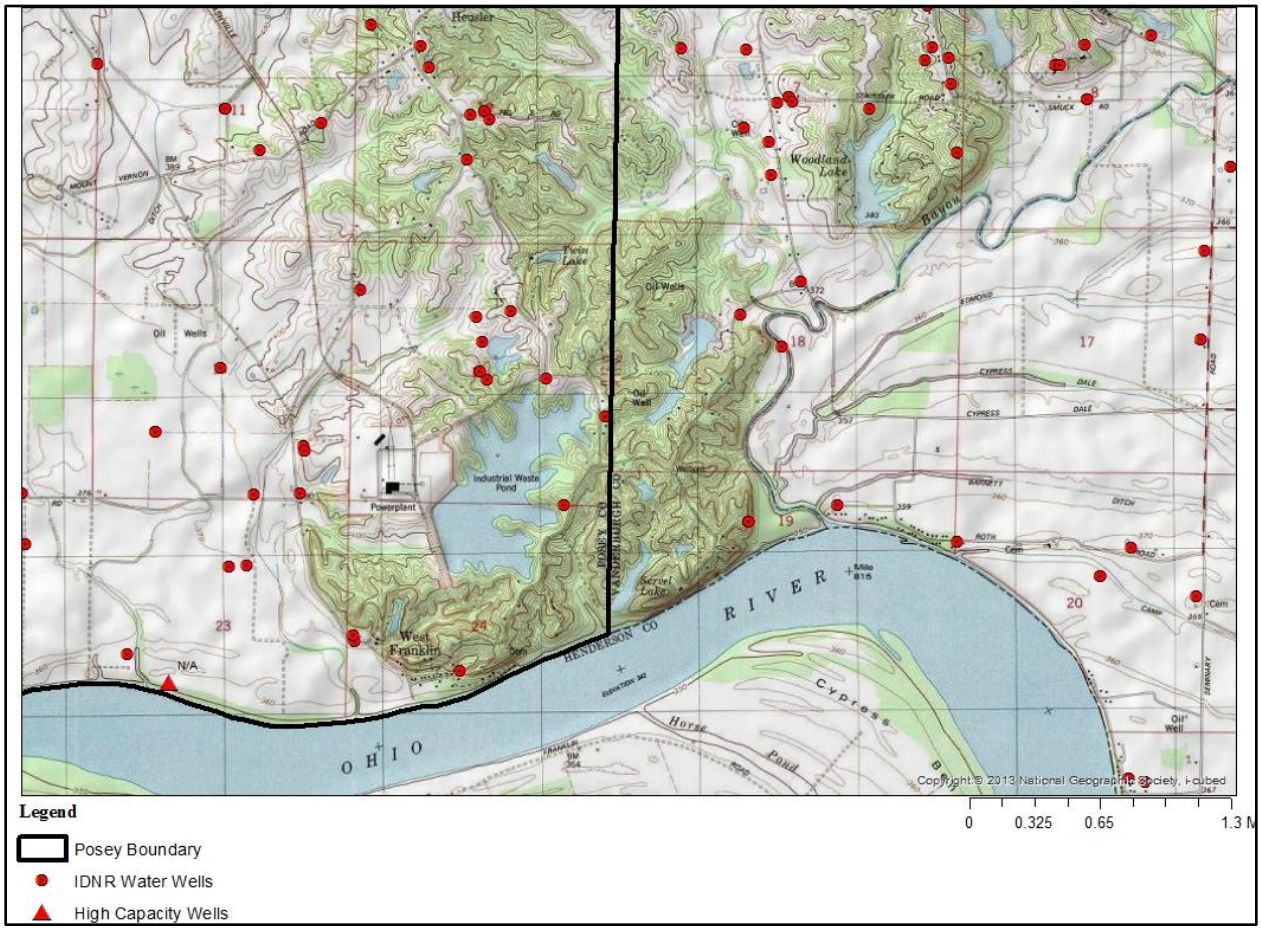

Figure 8. Wells within 3 miles of A.B. Brown. From the Indiana Department of Natural Resources Water Well Record Database

Conclusion

The coal ash ponds and landfill at the A.B. Brown power generating station contain massive amounts of ash that have the potential to impact the health of the local community via spill, airborne dust, contamination of ground water, and contamination of the Ohio River. The ponds contain an estimated 6.8 million cubic yards of mixed coal ash and water, and the landfill contains another 6.8 million cubic yards of dry coal combustion waste.

A coal ash spill from the A.B. Brown ponds appears to be unlikely. A recent inspection rated the Upper Dam in satisfactory structural condition. The Lower Dam was rated in fair condition, but there is a plan to strengthen it. If there were a spill, it would send a slurry of coal ash and water downstream and westward along the uninhabited ravine in which the dams were built.

Fugitive dust may be generated from barge loading and the dry handling of flue gas desulfurization waste at the A.B. Brown landfill. Coal ash dust contains fine particles (less than 2.5 micrometers) that can irritate the lungs, trigger asthma attacks, worsen other lung diseases, and contribute to cardiovascular disease. Exposure to fine particulate is known to shorter life expectancy. People living near A.B. Brown have complained of occasional dust incidents. Vectren published a dust control plan in October of 2015.

A.B. Brown's wastewater discharge to the Ohio River contains detectable arsenic and selenium, though in concentrations nearly acceptable in drinking water and once in the river they are diluted further. Cadmium and mercury were not detectable. There does not appear to be a threat to human health via drinking water from the current effluent, but this report includes only a limited review of the discharge monitoring and has not assessed the impacts to aquatic life. A more thorough review is warranted as the discharge permit is renewed: the permit is set to expire in September, 2016.

There is a high risk of ground water contamination near the A.B. Brown coal ash ponds for the following reasons:

- the ponds are unlined
- the underlying soil is permeable
- the ponds contain millions of cubic yards of coal ash slurry
- there is an hydraulic head pushing the pond water outward in all directions
- the ash has been there for more than 30 years
- the adjacent landfill has been impacting ground water since the early 1990s.

The ground water surrounding the coal ash ponds at the A.B. Brown facility and in drinking water wells within one mile should be tested for all of the contaminants that can leach from coal ash in concentrations that can impact health: arsenic, cadmium, chromium (VI), iron, manganese, nickel, selenium, sodium, sulfate, strontium, thallium, uranium, and vanadium.

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