Global Environmental, LLC
Environmental Consulting

October 15, 2019

Georgia Power Company

Preliminary Analysis of Closure Permit Applications
and Federal and State CCR Compliance
for the Sierra Club

Plants Bowen, Hammond, McDonough, Scherer, Wansley and Yates

SUMMARY

I completed a preliminary analysis of coal combustion residual ("CCR") disposal areas at the above-referenced coal-fired power plants owned and operated by Georgia Power Company. In particular, I specifically evaluated:

1. Coal-fired power plant waste disposal and management practices that were commonly used by the industry during the time that Georgia Power constructed and operated its waste management units.
2. The groundwater monitoring systems that Georgia Power uses to collect groundwater samples to determine whether or not releases of contaminants have occurred and if corrective measures are required.
3. The methods Georgia Power has proposed to close existing CCR surface impoundments in-place ("closure-in-place") at coal-fired power plants and the environmental conditions that are likely to exist going forward after the closure-in-place construction has been completed.
4. Site conditions at each location that might affect the proposed closure method in terms of whether Georgia Power can meet the closure performance standards established by the Georgia Environmental Protection Division ("EPD", Rule 391-3-4.10) in its State CCR Rule and also the U.S. Environmental Protection Agency in its Final Rule for Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities (codified at 40 C.F.R. Part 257).

My analysis included a review of documents provided by the Sierra Club and other information obtained through publicly-available sources, including those provided by Georgia Power on its

CCR Compliance Data & Information website.[1] I focused my research on the following Plants as being representative of Georgia Power's overall CCR closure strategy throughout Georgia: Plant Bowen, Plant Hammond, Plant McDonough, Plant Scherer, Plant Wansley, and Plant Yates. The focus of my review was to gather information regarding site conditions as they may affect selection of closure-in-place —with a particular focus on portions of reports that describe, for example, geologic and hydrogeologic conditions; methods to control or treat contaminated groundwater; depth of ash and depth of saturated ash; local and area groundwater flow; surface water flow patterns; interaction of groundwater with surface waters; and the presence of saturated CCRs post-closure. Throughout this report, I cite to certain documents which I have used as references to form my opinions, conclusions, and recommendations. Those references are included as attachments to this preliminary report. The specific page numbers of the citations are given as PDF page numbers of the actual file.

The following are the major conclusions from my preliminary analysis:

- Groundwater contamination is present due to the leakage of unlined surface impoundments that Georgia Power constructed from the early 1950s through the 1970s, and up until 1982—despite the electric power industry trend of constructing lined impoundments starting in the 1970s.
- Georgia Power's closure plans are based upon permit applications and not actual permits issued by the Georgia Environmental Protection Division ("EPD"). In fact, Georgia Power has already completed or initiated closures at Plants Hammond, McDonough, and Yates prior to receiving permits.
- Georgia Power's groundwater monitoring systems are not compliant with the Federal or Georgia CCR Rules.
- The proposed closure plans are inconsistent with State and Federal Laws because the plans do not meet the required technical standards for closure-in-place.
- According to Georgia Power's groundwater predictive modeling results for Plants Scherer and Wansley, Georgia Power's closure-in-place plans are non-compliant with the Federal or State CCR Rule performance standards since they will continue to leave CCRs saturated in groundwater even after closure is complete and without other measures (e.g. slurry walls, groundwater pumping wells) to prevent on-going leaching to groundwater or prevent contaminated groundwater from migrating away from the impoundments. Such predictive models for all Plants are necessary to demonstrate compliance.
- Georgia Power's closure plans will not resolve on-going groundwater contamination, and the nature and extent of contamination has not been determined for each Plant.
- Georgia Power's closure plans failed to model or predict how long groundwater will remain contaminated into the future, how much, if any, groundwater quality will improve over time, or when Georgia and EPA water quality standards will be met.

[1] https://www.georgiapower.com/company/environmental-compliance/ccr-rule-compliance-data/ccr-rule-compliance-plant-list.html

TECHNICAL COMMENTS

1.0 BACKGROUND ON COAL COMBUSTION RESIDUALS

Coal Combustion Residuals ("CCRs") are solid wastes created by the preparation and burning of coal to produce electricity. The primary solid wastes that are generated during that process include bottom ash, fly ash, pyrite / mill rejects, and synthetic gypsum. Bottom ash is heavier and consists of larger particles of ash that are generated during combustion and fall to the bottom of the furnace (hence the name "bottom ash"). Fly ash is the smaller, fine-particle ash that forms during combustion and is carried out of the boiler by the flue gases and is then collected by the air pollution control dust collection system. Synthetic gypsum is created when flue gas desulfurization ("FGD") air pollution control technology is used to scrub air emissions. Metals such as aluminum, arsenic, boron, calcium, cobalt, iron, lithium, magnesium, manganese, selenium, silicon, strontium, and sulfur are common in CCRs and are also commonly found in leachate and / or groundwater at leaking disposal areas. Sulfate is a compound that is also commonly present, and total dissolved solids ("TDS") concentrations of surface water and groundwater are usually higher when CCR constituents are present.

CCR constituents can leach from the solid waste when it comes into contact with water, such as sluice water, groundwater, precipitation, or contact stormwater run-off. The risks to the water environment originate when those constituents are leached from the solid CCRs and are then transported away from the disposal area in groundwater and surface water. Constituent risks vary by each constituent—with risks to humans, fish, and aquatic life being common.

Solubility depends upon numerous factors such as the pH of the solid-to-water mixture and the geochemical conditions under which the CCRs exist. Those conditions can change over time after closure, allowing constituents that had not previously migrated from a disposal unit to become mobile in the future. These changes have serious long-term implications for closure—especially for closure-in-place where wastes remain in contact with groundwater, as discussed further in my testimony.

Geochemical conditions such as pH can also vary vertically and laterally within the same impoundment. Some constituents leach regardless of groundwater pH (e.g. high or low pHs, calcium, boron, sulfate) while others leach at near neutral, acidic (low pH), and / or basic (high pH) conditions. Arsenic for example, leaches more at near neutral pH. Leachability can be so quick that some constituents might not even be currently present in pore water of saturated impoundments because the constituents may have already migrated from the disposal unit and into groundwater.

Human health exposures from CCRs are generally associated with water exposure pathways such as dermal contact, ingestion, and inhalation. Humans can also consume fish and mammals that have bio-accumulated the contaminants through the food chain when such animals are exposed to CCR contaminants. Fish and aquatic life can be affected when groundwater discharges into receiving streams and CCR constituents are present in the water and in sediments at the bottom. Fish and aquatic life are vulnerable to sediment contamination because CCR constituents can accumulate in solid form (e.g. fly ash that has been released) or when dissolved-phase constituents (e.g. boron, arsenic) adheres to sediment where organisms live.

2.0 STATE AND FEDERAL CCR RULES

2.1 Groundwater Monitoring

The Georgia CCR Rule and the EPA CCR Rule both have performance standards for groundwater monitoring systems. The fundamental purpose of a groundwater monitoring well system is to detect contamination due to leakage from disposal areas and to enable corrective actions in a timely manner. The monitoring system should be an "early" warning prior to contamination flowing away from the disposal area.

According to the 1991 Georgia Environmental Protection Division Manual for Groundwater Monitoring, "a key part of the operation of any land treatment, storage, or disposal facility should be a monitoring program which is designed to assess the impact of the system on ground-water resources."[2] Further, a monitoring system is "required…to detect and quantify contamination, as well as measure the effectiveness of engineered disposal systems, and the effectiveness of corrective action for improperly sited or poorly operated sites." The EPD has concluded these important facts:

- "Poorly constructed wells and careless sample collection and analysis can yield widely varying test results."[3]
- "Downgradient wells must be located, screened, and sufficiently numerous to provide a high level of certainty of constituents from the waste management unit(s) to the uppermost aquifer will be immediately detected."[4]
- "There are situations where the owner / operator should have multiple wells at the same location" where the uppermost aquifer is heterogeneous with multiple interconnected aquifers, variable lithology, and discrete fracture zones, as examples.[5] These multiple-depth well configurations are called "cluster" wells.

In a similar manner, the CCR Rule[6] specifies the performance standard for a groundwater monitoring system where the owner "must install a groundwater monitoring system that consists of a sufficient number of wells, installed at appropriate locations and depths, to yield groundwater samples from the uppermost aquifer that:

- "Accurately represent the quality of background groundwater that has not been affected by leakage from a CCR unit."

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[2] Manual for Groundwater Monitoring, Georgia EPD, September 1991 at 5 ("EPD 1991 Groundwater Manual").
[3] EPD 1991 Groundwater Manual at 5.
[4] EPD 1991 Groundwater Manual at 8.
[5] EPD 1991 Groundwater Manual at 10.
[6] 40 CFR Part 257.91

- "Accurately represent the quality of groundwater passing the waste boundary of the CCR unit."

Groundwater monitoring wells do not always provide an accurate indication of the contaminants in groundwater. Wells are only capable of monitoring at discrete intervals (e.g. 10 feet) of an aquifer in one horizontal location; which means they can be installed in such a way as to miss the contamination—depending on where the well was located and how deep the well was drilled. The Georgia EPD recognized this fact in its 1991 guidance document.[7]

Wells should be screened to collect groundwater nearest to the bottom of the disposal area, in addition to deeper portions of the aquifer if a downward hydraulic gradient exists (i.e. cluster wells). Contamination due to leakage can be worse (i.e. higher concentrations and / or more constituents) the closer those wells are screened to the bottom of the disposal unit. As a result, wells that are screened too deep in the uppermost aquifer can miss CCR-related contamination or under-report the highest concentrations. Groundwater wells should also be located along preferential pathways in the dike (e.g. excavated soils used to build the dike versus natural ground), along original stream valleys that are now covered by man-made dikes, and within discrete preferential flow fractures in bedrock.

Wells also need to be properly screened because "pockets" of high pH (basic) or low pH (acidic) groundwater, for example, can vary spatially and vertically within an impoundment, and as such, metal leachability from CCRs into groundwater can vary. A metal that might not be present in the deeper, near-neutral pH groundwater might exist at a much higher concentration shallower in the uppermost aquifer. "Red water" seeps—examples of shallow discharges—are near-ground surface discharges of leachate that are common around leaky impoundments. As illustrated below (confidential Midwest U.S. location), wells that are screened deeper in the aquifer along a stream would likely miss the shallow "red water" groundwater contamination that discharges into the receiving stream:

The quality of leachate and pore water within the CCRs can vary over time. As such, groundwater monitoring programs must be capable of detecting long-term changes and engineers and geologists must understand these potential changes when selecting closure options,

[7] EPD 1991 Groundwater Manual at 10.

determining the need for groundwater corrective actions, and determining if CCRs are the cause of groundwater contamination. Some constituents can quickly become soluble when CCRs are initially sluiced into an impoundment and can leach from the CCRs into groundwater. Some constituents leach from the CCRs regardless of water pH (e.g. boron, calcium, and sulfate). Some may not even be currently present in high concentrations in the shallow pore water within the CCRs because they have already leached from the CCRs and have migrated laterally or vertically.

Leachate and groundwater concentrations are also affected by the type of CCR present (e.g. fly ash, bottom ash, gypsum); the origin of the source coals burned over the life of the impoundment; the age of the CCRs; the type(s) of air pollution controls used to capture the CCRs; and the degree that the CCRs are submerged in groundwater, as examples.

Sampling baseline groundwater conditions can misrepresent the presence (or absence) of contamination caused by CCRs. The reason for "baseline" monitoring at CCR disposal sites is for CCR Rule compliance and to determine the baseline to which future sampling results are compared in order to determine if a disposal unit is leaking and whether or not future assessments and corrective actions are necessary. The challenge is that Georgia Power has already been operating unlined surface impoundments for decades and groundwater contamination likely began early in their operational life. Secondly, surface impoundments and their "wet" sluicing processes "mound" the groundwater, producing radial, 360-degree groundwater flow patterns that can vary drastically from "natural," pre-impoundment conditions. For example, instead of groundwater always flowing from a topographically high area towards and into a stream, groundwater can sometimes flow "backwards" and away from a stream in some areas. As a result, a designated "upgradient" well in a monitoring system may in fact be hydraulically "downgradient" from an impoundment and show signs of contamination; therefore, making future comparisons of sample results possibly meaningless to determine if a disposal area is currently leaking.

Groundwater quality can also worsen over time after a surface impoundment is closed-in-place with an engineered cap to limited infiltration of precipitation into the waste. The Electric Power Research Institute (EPRI) recognizes that closure-in-place is not always effective as a groundwater corrective action. A 2001 EPRI study concluded that groundwater quality did not improve when an engineered cap was built over the CCRs that were submerged in groundwater.[8] Further, EPRI concluded that constituent concentrations in the groundwater actually increased because the contact time between the CCRs and groundwater increased when the groundwater velocity slowed due to the elimination of precipitation infiltration into the wastes.[9] As such, construction of a cap over CCRs submerged in groundwater resulted in unintended, worsened consequences. This fact should be carefully considered when selecting a long-term closure strategy such as closure-in-place.

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[8] Evaluation and Monitoring of Cap Alternatives at Three Unlined Coal Ash Impoundments, EPRI Technical report, September 2001 at 9, available at https://www.epri.com/#/pages/product/1005165/?lang=en-US. ("EPRI 2001")
[9] EPRI 2001 at 64 and 69.

2.2 Disposal Site Suitability

Georgia has had specific criteria for evaluating site suitability for solid waste disposal units since at least 1972 with the passage of the Solid Waste Management Act of 1972 when "site selection for municipal solid waste landfills became a rigorous application of both engineering and geology."[10] Although not specific to CCR disposal units, similar key site evaluation criteria would have applied to CCR units because the risk due to leakage and groundwater contamination remains the same, if not greater for CCR units. As will be discussed later in this analysis, Georgia Power constructed unlined disposal units adjacent to rivers and streams and in areas with shallow groundwater.

In 1991, Georgia EPD summarized specific site selection criteria for municipal and industrial landfills in its Criteria for Performing Site Acceptability Studies for Solid Waste Landfills in Georgia.[11] In 1992, Georgia EPD also published a Ground-Water Pollution Susceptibility Map to identify areas that were especially vulnerable to pollution from land disposal activities.[12] The 1991 site selection manual required the following criteria to apply to CCR disposal units in order to protect groundwater:

- CCRs are industrial wastes and a landfill for CCR disposal is considered to be an "industrial" landfill.[13]
- If an industrial landfill is located within a Most Significant Ground-Water Recharge Area, the same acceptability criteria applicable for a municipal solid waste landfill applies to a CCR landfill (except proximity to an airport). As such, any CCR landfill located within that Recharge area must have a synthetic liner and a leachate collection system.[14]
- Owners or operators of new industrial landfill units, existing industrial landfill units, and lateral expansions located in an unstable area "must demonstrate that the engineering measures have been incorporated into the landfill unit's design to ensure that the integrity of the structural components of the landfill unit will not be disrupted." An example of an "unstable area" is karst terrain characterized by sinkholes and rapid conduit groundwater flow.[15]

3.0 HISTORICAL INDUSTRY PRACTICES AND KNOWLEDGE OF RISKS

EPA issued reports in 1980 and 1988 documenting its concerns about leaking, unlined CCR disposal units. EPA based its conclusions on industry-provided data on waste disposal practices from at least the mid-1970s. This historical industry research indicated that Georgia Power knew

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[10] Criteria for Performing Site Acceptability Studies for Solid Waste Landfills in Georgia, Circular 14 Georgia EPD, 1991 at 4 ("EPD 1991 Circular 14").
[11] EPD 1991 Circular 14.
[12] Ground-Water Pollution Susceptibility Map of Georgia, Hydrologic Atlas, Georgia EPD, 1992 at 20 ("EPD 1992 Hydrologic Atlas").
[13] EPD 1991 Circular 14 at 26.
[14] EPD 1991 Circular 14 at 5, 26.
[15] EPD 1991 Circular 14 at 28.

or should have known about CCR contamination of groundwater shortly after disposal began, given its disposal of CCRs into unlined impoundments; their close proximity to shallow groundwater; and their construction of impoundments over streams.

In response to "leaky" impoundments, disposal into lined disposal units ("wet" and "dry") was commonplace in the mid-1970s to help mitigate those risks – yet Georgia Power continued to build unlined impoundments and continues to dispose of CCRs into unlined impoundments with its current plans for closure-in-place. Key conclusions from the 1980 and 1988 EPA reports include:

- **"**Ash deposited in the bottom of the ash pond may continue to leach where the ash is in contact with groundwater if the surrounding environment is changed to anaerobic and low-pH conditions."[16]
- "The most significant potential problems associated with ash disposal in ponds are . . . quantities of trace metals in groundwater leachate."[17]
- "The primary concern regarding the disposal of wastes from coal-fired power plants is the potential for waste leachate to cause groundwater contamination."[18]

Disposal of municipal and industrial solid wastes in engineered disposal units (e.g., designed with a liner, leachate collection system, etc.) has been commonplace since the mid-1970s. The 1988 EPA report stated that the trend was for more disposal units to be constructed with some sort of clay or composite liner to protect groundwater. Key conclusions and statistics of that report included:

- Fly ash, bottom ash, boiler slag, and flue gas desulfurization (FGD) wastes warranted continued regulation as a solid waste under RCRA Subtitle D because of the potential to contaminate groundwater and the damage it might cause.[19]
- 40 percent of the generating units built since 1975 have liners.[20]
- According to a survey regarding the required use of liners in disposal units, state-required liner use in Southeastern states in the 1980s was common: 6 of the 11 states (55%) that required the use of liners universally or on a case-by-case basis based were located within the Southeastern U.S. (Florida, Kentucky, Alabama, Tennessee, Louisiana, and

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[16] EPA Interagency Energy/Environment R7R Program Report, "Behavior of Coal ash Particles: Trace Metal Leaching and Ash Settling," March 1980 at 20 ("EPA 1980"), available at https://nepis.epa.gov/Exe/ZyNET.exe/20006ME6.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1976+Thru+1980&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C76thru80%5CTxt%5C00000002%5C20006ME6.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL).

[17] EPA 1980 at 16.

[18] EPA Report to Congress, "Wastes from the Combustion of Coal by Electric Utility Power Plants," February 1988 at 14 ("EPA 1988"), available at https://www.epa.gov/sites/production/files/2015-08/documents/coal-rtc.pdf.

[19] EPA 1988 at 14, 17.

[20] EPA 1988 at 14.

Mississippi).[21]

- "Lining is becoming a more common practice, however, as concern over potential ground-water contamination from 'leaky ponds' and, and to a lesser extent, from landfills has increased."[22]
- "Mitigation measures to control potential leaching include installation of liners, leachate collection systems, and ground-water monitoring systems and corrective action to clean up groundwater contamination."[23] As such, groundwater cleanups were required at that time.
- Regarding the trend towards preferred construction of landfills rather than wet impoundments, the EPA concluded that "[t]hese trends in utility waste management methods have been changing in recent years, with a shift towards greater use of disposal in landfills located on-site. For example, for generating units built since 1975, nearly 65 percent currently dispose of coal combustion wastes in landfills, compared to just over 50 percent for units constructed before 1975."[24]
- "Although surface impoundments were once the more common practice, and are still widely used, landfilling has become the more common practice because less land is required, and it is usually more environmentally sound (because of the lower water requirements, reducing leaching problems, etc.)."[25]
- More landfills than surface impoundments were used for CCR disposal in the United States in the 1980s. Specifically, the number of landfills (578) outnumbered surface impoundments (483).[26] Further, landfills were most commonly used in the high coal-consuming areas of the East and Midwest (Regions 3 and 5).[27] Of the total (483) surface impoundments reported in the U.S., nearly 75 percent were located in EPA Region 4 because "in the past" those facilities had "access to abundant, inexpensive supplies of water" making wet sluicing operations "economical to use."[28] The use of surface impoundments, however, decreased as the costs of "wet ponding" increased.[29]
- The trend to build lined landfills for disposal continued through the mid-1990s and early 2000s. "Between 1994 and 2004, the amount and quality of environmental controls used at CCW management units appear to have increased. A trend toward management in landfills (dry handling) and away from surface impoundments (wet handling) is also evident."[30] From 1994 to 2004, "virtually all newly built or expanded units (97% of landfill and 100% of surface impoundments)" were built with liners.[31]

[21] EPA 1988 at 138 -139.
[22] EPA 1988 at 159 -160.
[23] EPA 1988 at 16.
[24] EPA 1988 at 158.
[25] EPA 1988 at 297.
[26] EPA 1988 at 154.
[27] EPA 1988 at 155.
[28] EPA 1988 at 155.
[29] EPA 1988 at 151.
[30] EPA / DOE 2006 at 23, 62.
[31] EPA / DOE 2006 at 97.

Landfills were not necessarily more expensive to construct than surface impoundments in the 1980s. According to the EPA 1988 Report, the total capital and operation and maintenance costs (given in 1980s cost per ton) to construct an unlined surface impoundment was more than the cost to construct a lined landfill. The annualized 1982 cost to construct and operate an unlined surface impoundment ranged from $8.00 to $17.00 per ton, compared to the much less $5.70 to $13.55 per ton for a single clay-lined landfill and $6.45 to $15.15 per ton for a single synthetic-lined landfill.[32]

Similarly, EPA's analysis of capital costs for closure (including cap construction) indicated that landfill versus surface impoundment costs were comparable ($39,000 to $128,000 per acre for a surface impoundment versus $55,000 to $137,000 per acre for a landfill).[33] However, the total annual post-closure care cost of a landfill was much less than a surface impoundment: $1.0 to $2.8 million per year for a surface impoundment versus $0.4 to $0.9 million for a landfill.[34]

Coal ash waste reuse and/or recycling was also a common practice in the 1980s. The EPA reported that an average of 18 percent of all coal ash generated annually was recovered or reused from 1970 to 1980, and that trend increased to 27 percent in 1985.[35] "All types of coal ash are appropriate for use as construction materials, as cement additives, and for several other uses." Further, the EPA reported that coal ash reuse and recovery was the most prevalent in the Southeastern and North Central Unites States.[36]

4.0 GEORGIA POWER'S DISPOSAL OF CCRS AND IMPACTS ON GROUNDWATER

Georgia Power disposed of its CCRs in unlined surface impoundments initially upon plant start-up and continued to construct unlined surface impoundments at least until 1982.[37] All of the original surface impoundments built by Georgia Power were unlined;[38] all of the impoundments planned for closure-in-place were built with bottoms that are within 5 feet of the uppermost aquifer;[39] and all of the planned closures will leave millions of cubic yards of CCRs in the ground in perpetuity.[40] A summary of impoundment construction, CCR volume, and closure methods are identified in **Table 2** below:

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[32] EPA 1988 at 320.
[33] EPA 1988 at 313.
[34] EPA 1988 at 313.
[35] EPA 1988 at 180, 182.
[36] EPA 1988 at 182.
[37] History of Construction reports, available at https://www.georgiapower.com/company/environmental-compliance/ccr-rule-compliance-data/ccr-rule-compliance-plant-list.html.
[38] Liner Design Criteria reports, available at https://www.georgiapower.com/company/environmental-compliance/ccr-rule-compliance-data/ccr-rule-compliance-plant-list.html.
[39] Location Restrictions Reports and Part B Permit Applications submitted to Georgia EPD available at https://www.georgiapower.com/company/environmental-compliance/ccr-rule-compliance-data/ccr-rule-compliance-plant-list.html.
[40] Initial Written Closure Plans, available at https://www.georgiapower.com/company/environmental-compliance/ccr-rule-compliance-data/ccr-rule-compliance-plant-list.html.

Table 2: CCR Impoundments and Closure Methods

Plant Name	Name	Liner	Planned Closure Method
Bowen	AP-1, 1968	Unlined	Excavation, construction of a lined area, consolidation (254 acres to 144 acres), Closure-in-Place (11,410, 260 cubic yards)
Hammond	AP-1, 1952 AP-2, 1969 AP-3, 1977 AP-4, Unknown	Unlined Unlined Unlined Unknown	AP-1, AP-2, and AP-4: Closure-by-Removal to an off-site landfill (Huffaker Road Landfill) AP-3: Already closed, consolidation (25 acres), Closure-in-Place (1,108,000 cubic yards minimum)
McDonough	AP-1, 1963 AP-2, 1968 AP-3, 1969 AP-4, 1972	Unlined Unlined Unlined Unlined	AP-1: completed consolidation of CCR from AP-2 and AP-3, Closure-in-Place (1,400,000 cubic yards) AP-2, AP-3, AP-4: consolidation Closure-in-Place (64 acres, 4,900,000 cubic yards)
Scherer	AP-1, 1982	Unlined	Partial excavation, consolidation to smaller footprint (550 acres to 330 acres), Closure-in-Place (7,757,000 cubic yards)
Wansley	AP-1, 1975	Unlined	Partial excavation, consolidation to smaller footprint (343 acres to 138 acres), Closure-in-Place (14,200,000 cubic yards)
Yates	AP-1, 1950 AP-2, 1966 AP-3, 1976 AP-A, 1976 AP-B, 1976 AP-B', 1977	Unlined Unlined Unlined Unlined Unlined Unlined	AP-1, AP-2, AP-A, and AP-B – excavated, transported, closure-in-place, consolidated at "Ash Management Area" AP-3, AP-B' (approximately 85 acres) – wastes remain and will become the new consolidated Ash Management Area: 650,000 cubic yards AP-1; 855,000 cubic yards AP-2; 1,400,000 cubic yards AP-3; 690,000 cubic yards AP-B; 466,000 cubic yards AP-B'. Total: 4,061,000 cubic yards

Georgia Power vertically expanded impoundment AP-1 at Plant Bowen in 1992 and 2001 by placing "dry" CCRs on top of wastes in the former unlined impoundment. This disposal method is referred to as a "dry stack." The dry stack at Plant Bowen, illustrated on **Figure 1,** is discussed later in this analysis.

4.1 Surface Impoundments Built On / Near Water

In my experience of investigating CCR disposal sites across the United States, with a particular emphasis on the southeastern United States, groundwater and surface water contamination from unlined surface impoundments is quite common. Also, solid CCRs (e.g. fly ash, bottom ash) are sometimes found in rivers and streams adjacent to impoundments due to, for example, past dike failures and inefficient solids removal (i.e. inability to remove floating fly ash) from legacy impoundment spillway / overflow structures.

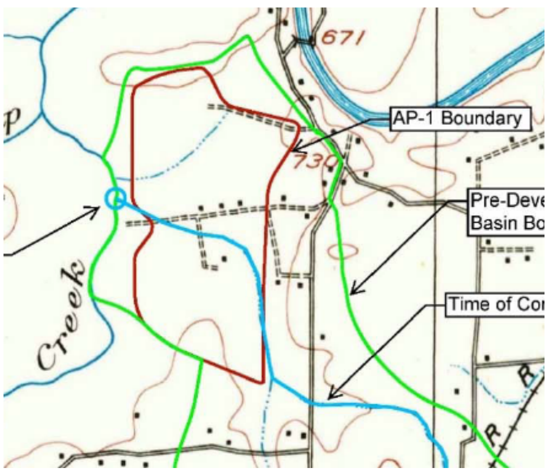
Placing CCRs directly into a stream places the wastes in direct contact with surface water and groundwater because shallow water table aquifers flow from topographically high areas (e.g.

ridges, hills) towards and into streams. Also, soils in the stream valleys are more susceptible to allowing contamination to flow quickly through them because the stream valley and alluvial floodplain soils are typically more porous (i.e. sandy and gravelly). Construction of CCR disposal areas over streams also permanently destroys stream functionality.

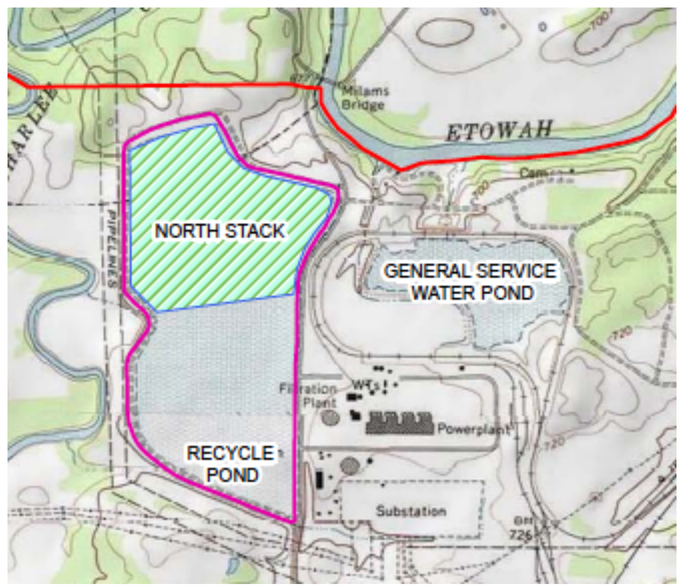
Georgia Power's surface impoundments were constructed over existing streams at Plants Bowen, McDonough, Wansley, Scherer, and Yates. Georgia Power also constructed impoundments adjacent to large rivers and small streams, as illustrated in **Figures 1** through **6** below. At Plant Bowen, Georgia Power constructed the 254-acre impoundment AP-1 (note the vertically expanded "North Stack") over an un-named tributary of Euharlee Creek (blue line within the red area, left diagram) and near the Etowah River, as illustrated in **Figure 1** below.[41]

Figure 1 – Plant Bowen

Before



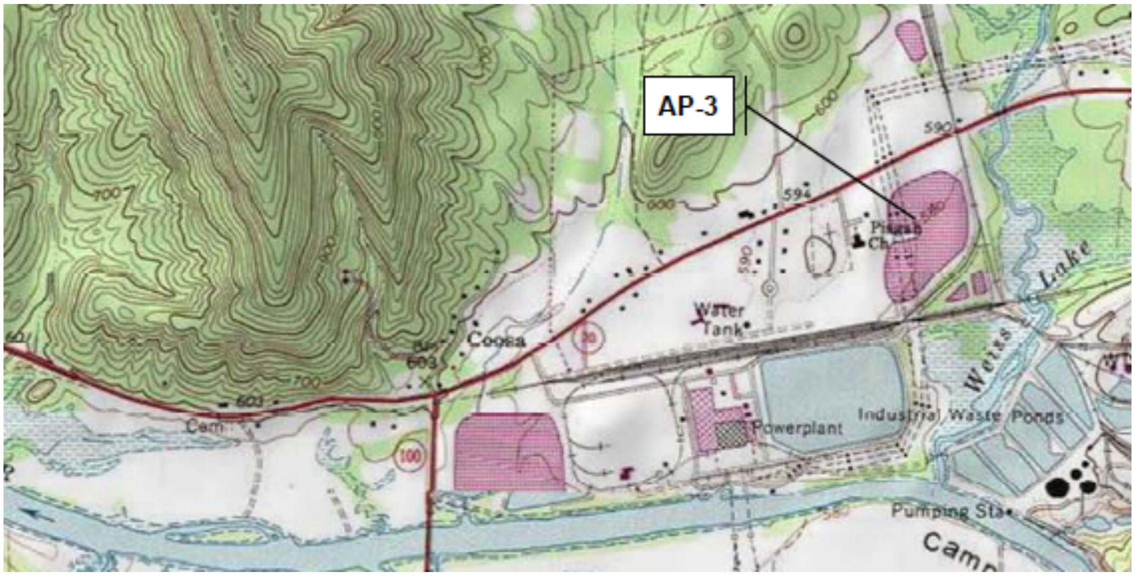
After



At Plant Hammond, Georgia Power constructed AP-3 adjacent to Cabin Creek / Weiss Lake and other impoundments along the Coosa River, as illustrated in **Figure 2**:

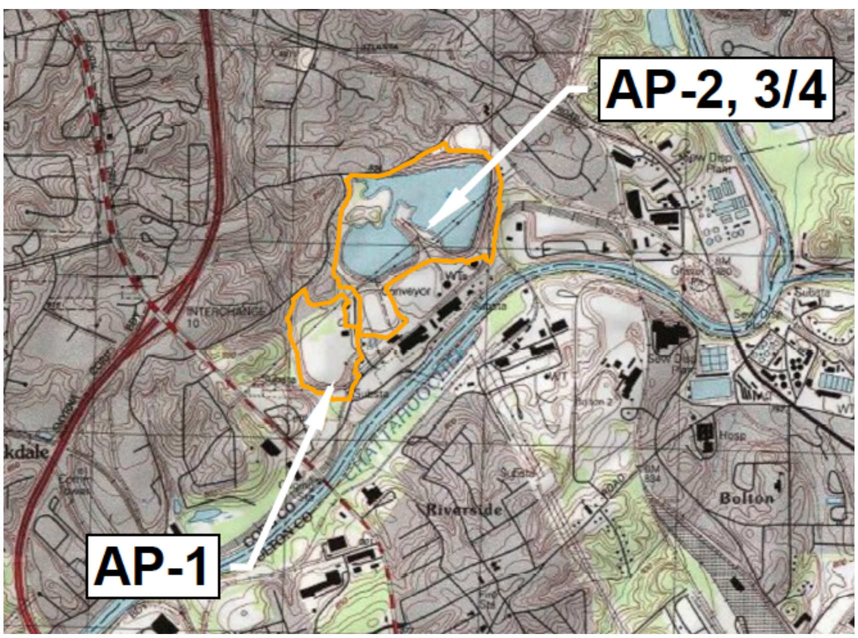
[41] Bowen 2018 Part B Application at 946.

Figure 2 – Plant Hammond



At Plant McDonough, Georgia Power constructed four impoundments (AP-1 through 4). The 41-acre impoundment AP-4 was built over an unnamed tributary of the Chattahoochee River. The stream was re-routed into a 90-inch corrugated metal pipe, and that pipe is located beneath AP-4. The impoundment locations are illustrated in **Figure 3**.

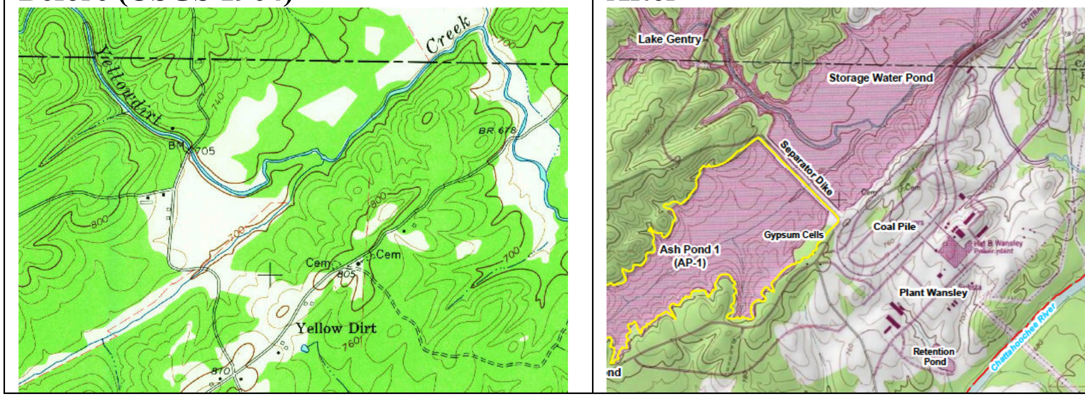
Figure 3 – Plant McDonough



At Plant Wansley, Georgia Power constructed a cross-valley dam across an unnamed tributary of Yellowdirt Creek to form the 243-acre impoundment AP-1, as illustrated in **Figure 4**. The Chattahoochee River is located to the southeast (right diagram).

Figure 4 – Plant Wansley

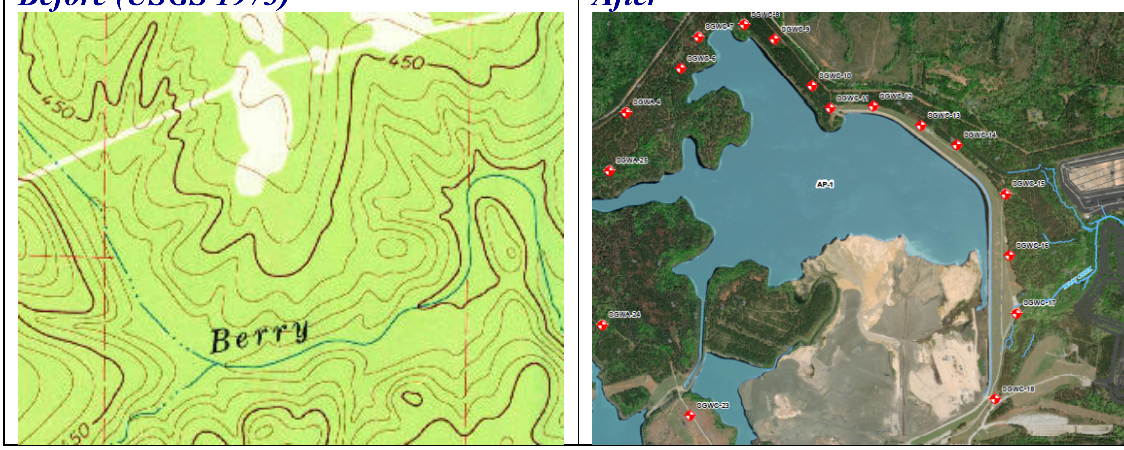
Before (USGS 1964)	**After**



At Plant Scherer, Georgia Power constructed a cross-valley dam across Berry Creek, as illustrated in **Figure 5**.[42] The former stream valley became surface impoundment AP-1.

Figure 5 – Plant Scherer

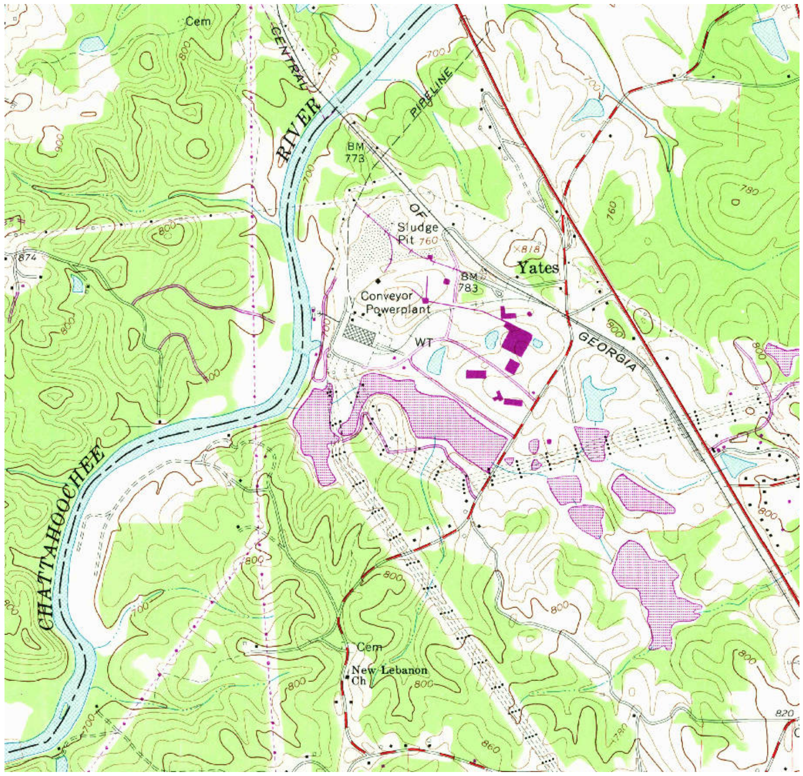
Before (USGS 1973)	***After***



At Plant Yates, Georgia Power constructed dams across multiple unnamed tributary stream valleys to form multiple surface impoundments (purple areas), as illustrated in **Figure 6**.[43]

[42] Scherer 2018 AP-1 Part A.
[43] USGS 1965.

Figure 6 – Plant Yates



In addition to building on or near streams and rivers, Georgia Power also constructed some surface impoundments within or nearby areas designated by the Georgia EPD as Most Significant Groundwater Recharge Areas (pink areas with dashes below) and also within areas that have the highest susceptibility to groundwater pollution (pink areas below), as illustrated in **Figure 7.**[44] Looking at the pink areas with dashes in **Figure 7**, it is clear that Plant Bowen is located within a Significant Recharge Area, and Plant Yates is likely within a Recharge Area. Plant Hammond is located within or very near an area with the highest susceptibility to groundwater pollution, and Plant Scherer is close to a Significant Recharge Area.[45]

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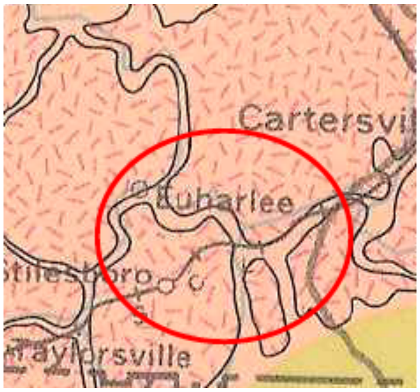
[44] EPD 1992 Hydrologic Atlas 20.

[45] At the scale of the map, it is difficult to precisely determine the disposal area locations compared to the significant contamination potential areas.

Figure 7

Plant Bowen



Plant Hammond

Plant Scherer

Plant Yates

4.2 Surface Impoundments Built in Karst Terrain

Both Plants Bowen and Hammond face significant site closure challenges because both have a history of sinkhole collapses beneath impoundments due to karst terrain and the underlying solution-enlarged carbonate bedrock. The specifics of those sinkhole collapses are as follows:

- **Plant Bowen –** the History of Construction report for AP-1 described two events where sinkholes formed beneath or adjacent to the impoundment; however, numerous more collapses were reported in the 1970s, the early and late 1990s, in 2002, and again in 2008—despite Georgia Power injecting more than 330,000 cubic feet of grout into the subsurface since 1968 in attempts to stabilize the subsurface.[46]

  The July 2002 sinkhole collapse "occurred due to the opening of karst features beneath AP-1" and resulted in a release of CCRs from the impoundment. The 2002 collapse resulted in 11 cubic yards of CCRs flowing through groundwater and being deposited into Euharlee Creek. CCR / groundwater mixtures were also reported in on-site piezometers.[47] A second sinkhole collapse in December 2008 occurred north of the dike abutment but no CCR was released.

  Georgia Power concluded that mounding of groundwater, saturated conditions within the CCRs, and impoundments being constructed without liners may have played a role in sinkhole formation.[48]

- **Plant Hammond** – while the History of Construction report for AP-3 did not describe any past history of sinkhole collapses and concluded that "no structural issues have been observed for AP-3," Georgia Power described an unspecified "seepage" event that occurred one month after the impoundment became operational (July 1977). That seepage event apparently refers to a June 1997 leakage of up to 1 million gallons per day of CCRs due to the collapse of a sinkhole beneath the wastes.[49] Despite the occurrence of that significant leakage due to a sinkhole, Georgia Power was silent on any such unstable conditions in its Part B Permit application to Georgia EPD. Instead, Georgia Power stated that the Location Restrictions Report (that is supposed to describe any unstable geology) would not be prepared until possibly April 16, 2020 because the CCR Rule allows for more time to complete such a report for "inactive" impoundments.[50]

4.3 Surface Impoundments Built in Shallow Water Table Aquifers

Consultants for Georgia Power concluded that shallow, water table aquifer conditions exist at Plants Bowen, Hammond, Scherer, Wansley and Yates, and that the uppermost aquifer begins in the soil nearest the original land surface.[51] My analysis did not determine the specifics of the water table aquifer at Plant McDonough but given its proximity adjacent to the Chattahoochee River, shallow water table conditions are also expected there.

As previously discussed, consultants certified that the surface impoundments at each of those Plants planned for closure-in-place were constructed with less than 5 feet separating the bottom of the wastes and the uppermost aquifer (if not closer). The uppermost aquifer extends into the deeper bedrock at Plants Bowen, Hammond, Wansley, and Yates. The important take-away for

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[46] Bowen Part A Application, Closure Plan, Foundation Improvement Plan at 324-325.
[47] Bowen 2009 Dike Assessment at 7, 10, and 11.
[48] Bowen Part A Application, Closure Plan, Foundation Improvement Plan at 324.
[49] Hammond 2010 Dike Assessment at 62.
[50] Hammond Part B Permit Application at 5.
[51] 2018 Part B Applications, Hydrogeologic Assessment or Characterization Reports at each facility.

these Plants is that groundwater first occurs in the shallow soil in which impoundments were constructed—without the currently-required 5-foot separation between the CCRs and groundwater.

Georgia Power consultants collected groundwater elevations prior to each sampling event and used that data to produce diagrams commonly referred to as "groundwater contour maps" or "potentiometric surface diagrams." The consultants concluded, using those diagrams, that groundwater flows towards and into adjacent streams along the bank (e.g. Euharlee Creek, Berry Creek, Cabin Creek) and large river (e.g. Coosa and Chattahoochee Rivers). As a result, constituents in groundwater are expected to discharge into receiving streams. "Mounding" of groundwater can also occur if free standing water or saturated CCRs exist in a leaking impoundment, and that mounding can create a radial, 360-degree flow pattern. Potentiometric surface diagrams produced by Georgia Power consultants and reported in the most recent 2019 groundwater reports for Plants Bowen, Hammond, McDonough, Scherer, Wansley, and Yates are illustrated in **Figures 8** through **13**.[52] Groundwater flow directions are depicted by the blue or green arrows on some figures. Note the mounded, radial flow conditions reported below for Plant Bowen and how the groundwater flows southward away from the Etowah River and towards Georgia Power-designated "upgradient" wells (BGWA-29 and BGWA-2).

[52] 2019 Groundwater Reports for each Plant, available at https://www.georgiapower.com/company/environmental-compliance/ccr-rule-compliance-data/ccr-rule-compliance-plant-list.html.

Figure 8 - Plant Bowen (2019 Report, Figure 3, note radial mounding)

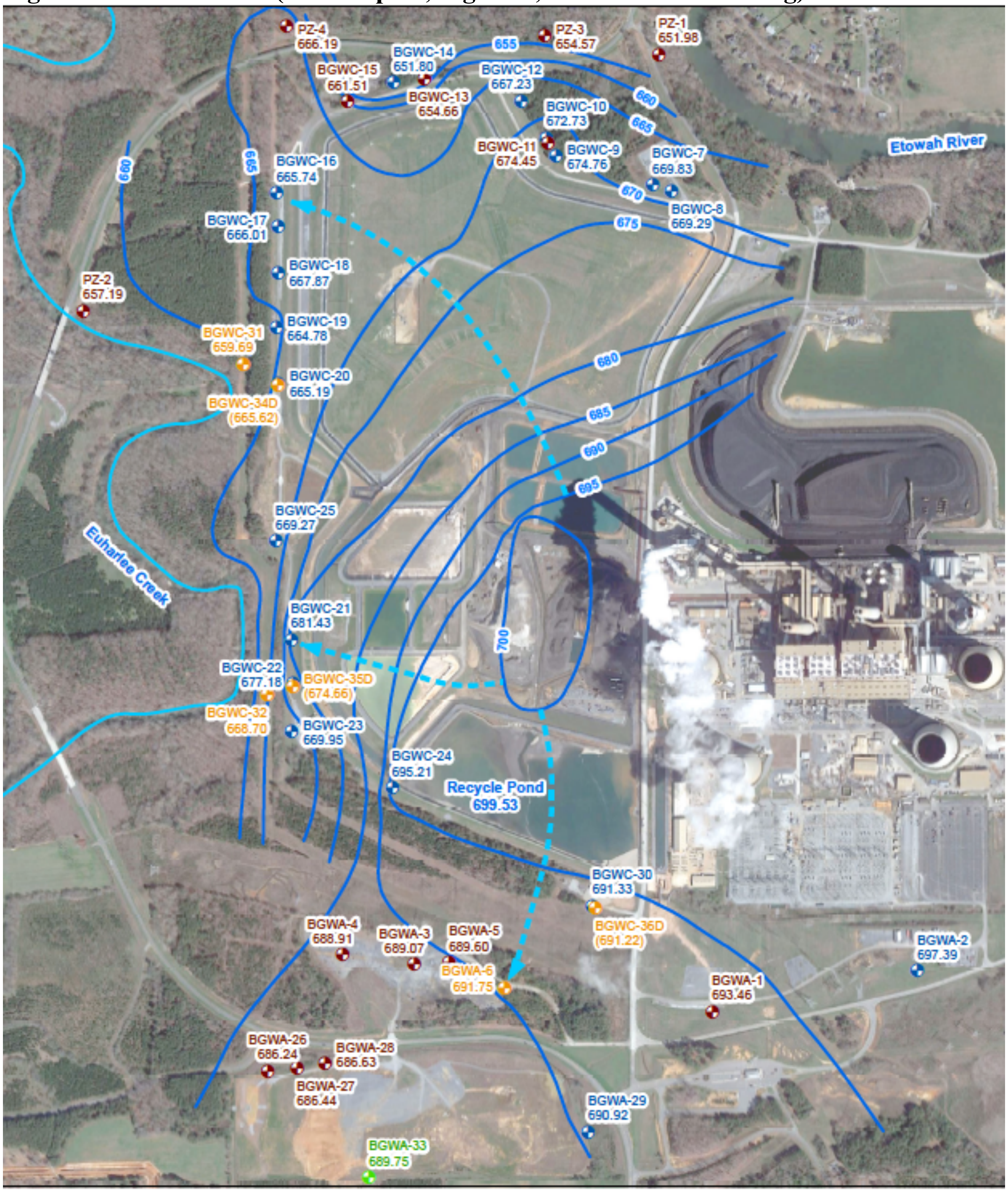


Figure 9 - Plant Hammond (2019 Report, Figure 3)

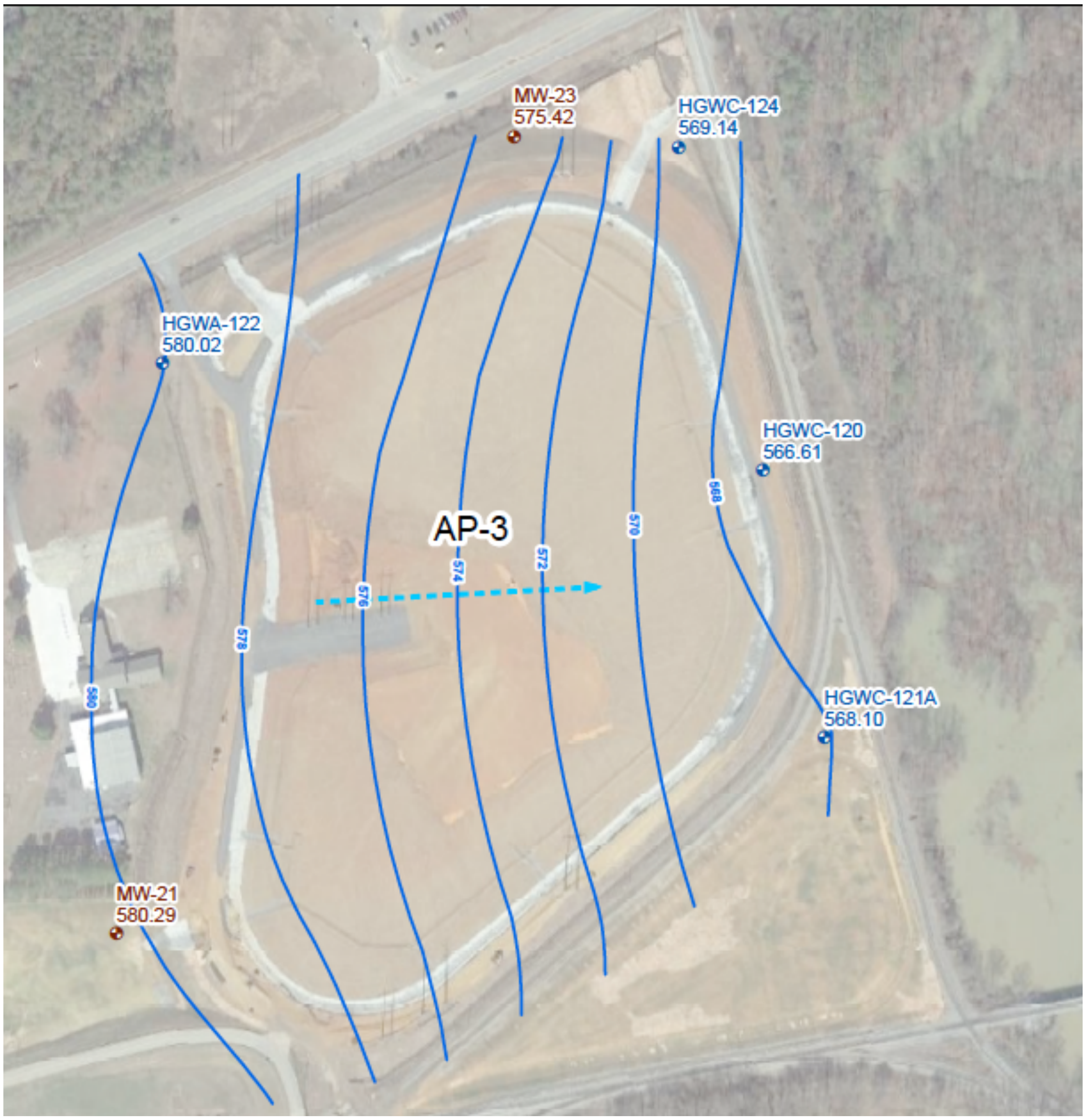


Figure 10 - Plant McDonough (2019 Report, Figure 3)

Figure 11 - Plant Scherer (2019 Report, Figure 3)

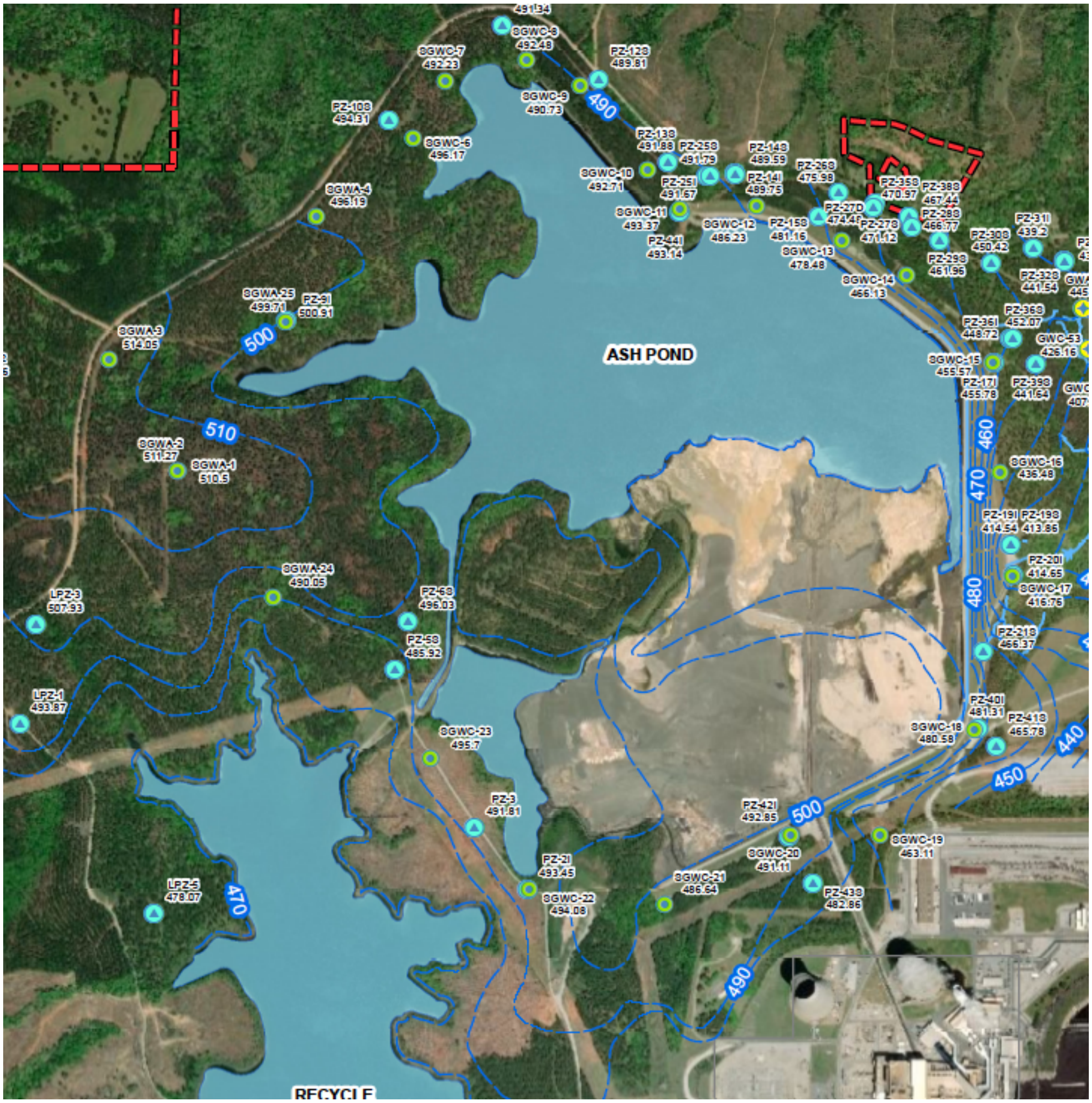


Figure 12 - Plant Wansley (2019 Report, Figure 3)

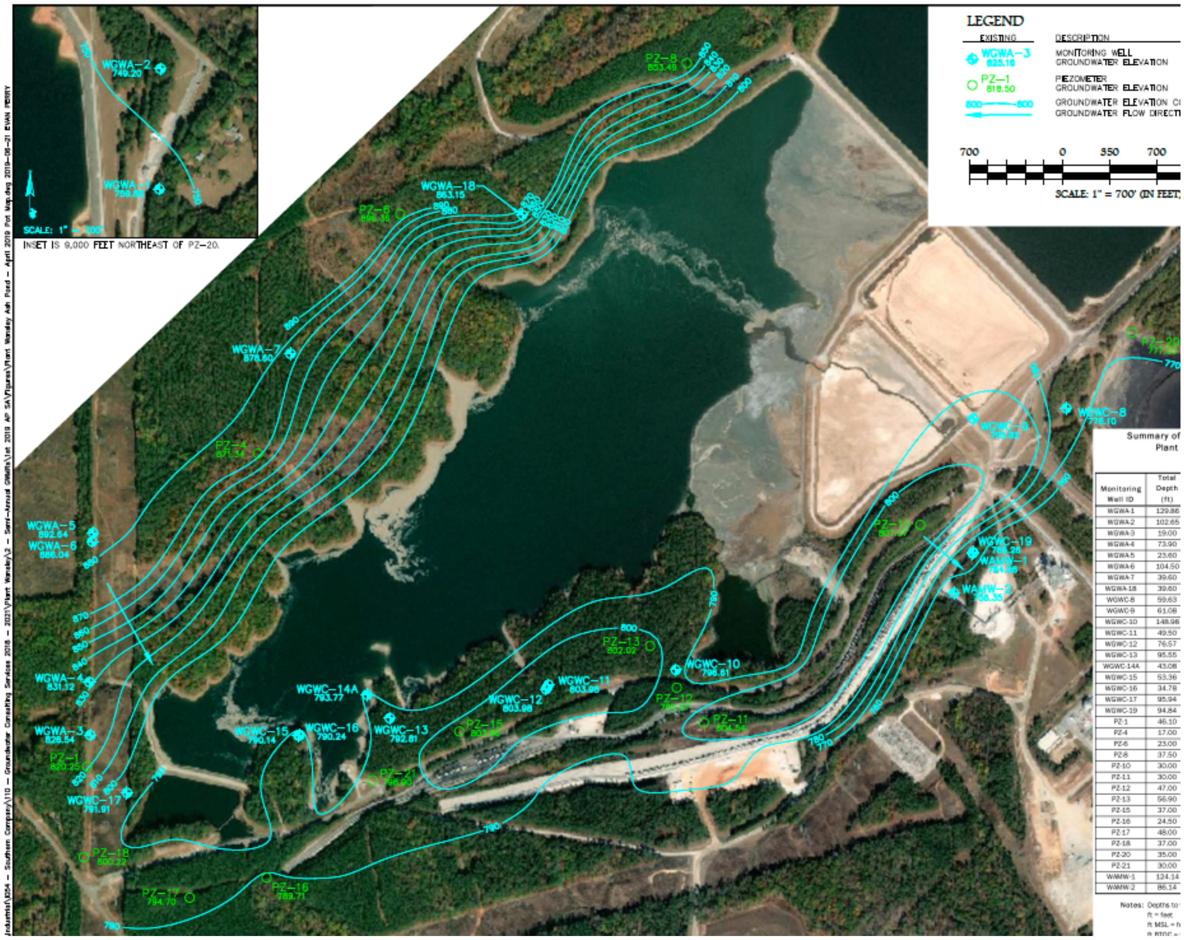
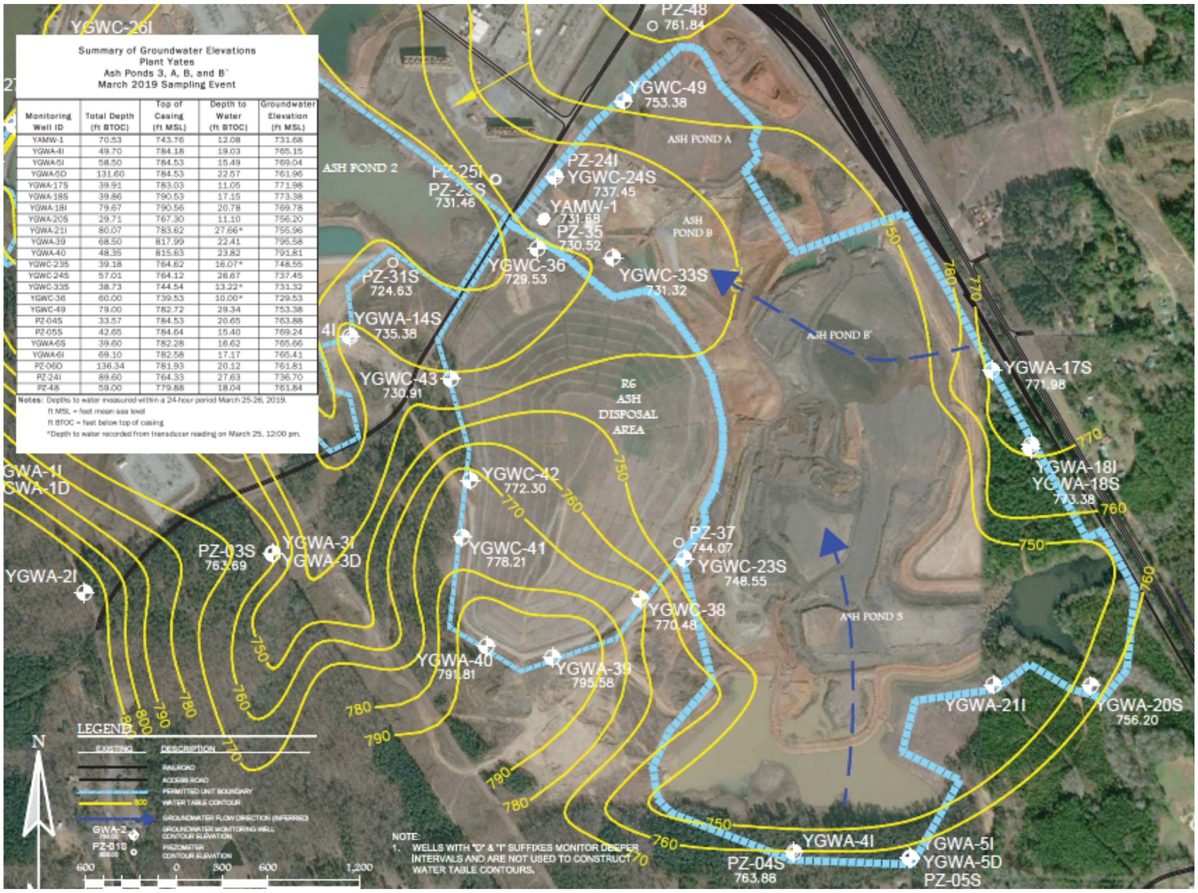


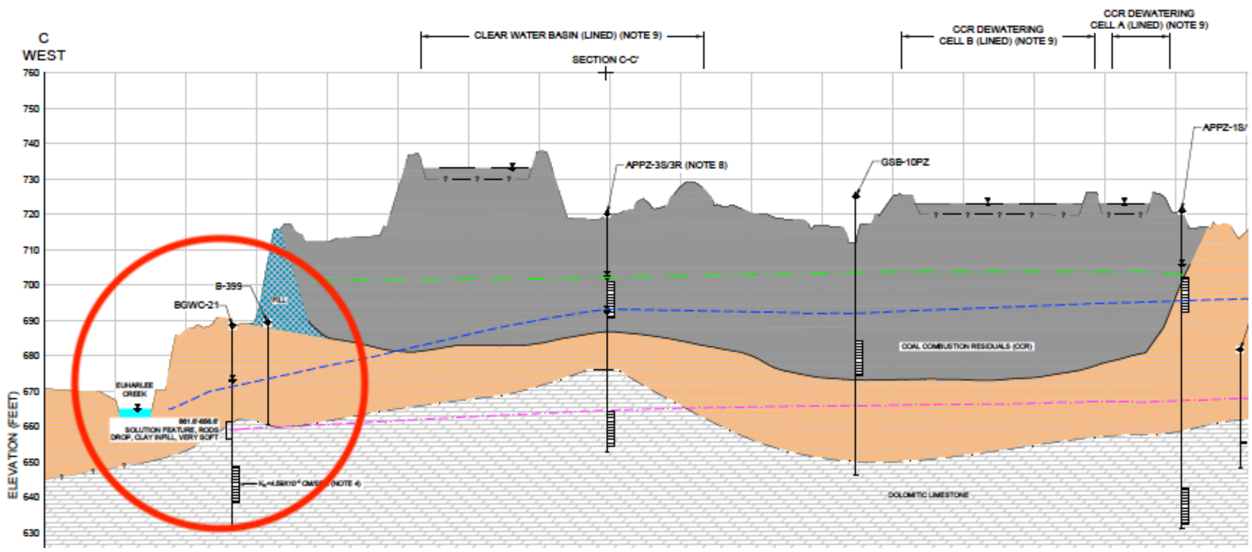
Figure 13 - Plant Yates (2019 Report, Figure 3)



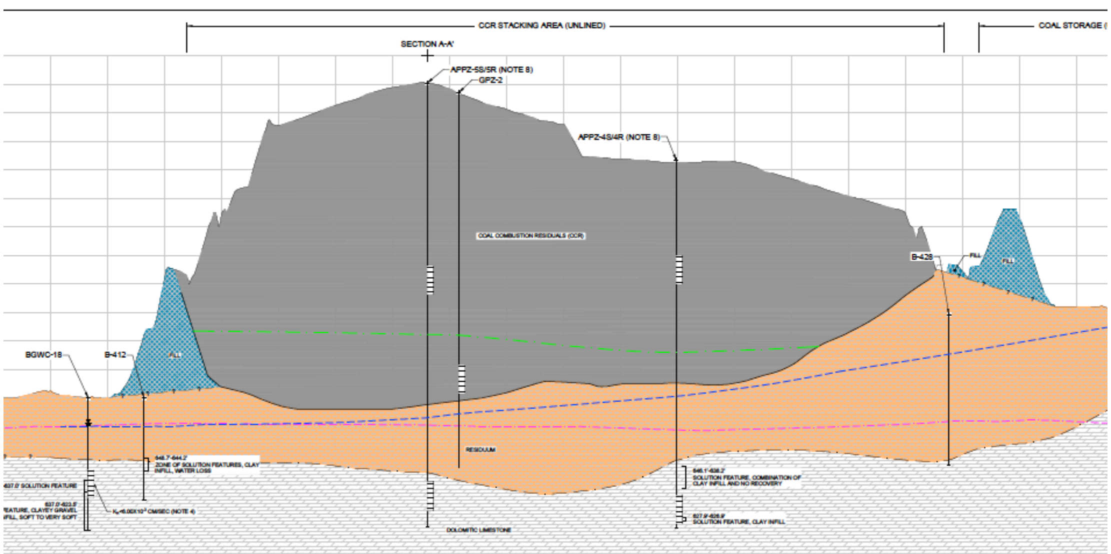
4.4 CCRs are Submerged in Groundwater

CCRs in surface impoundments have been submerged in groundwater in the uppermost aquifers. Reports prepared on behalf of Georgia Power (Part B Applications, Hydrogeologic Assessment Report, each Plant) describe and illustrate CCRs that are submerged in the uppermost aquifer (depicted by the dashed line and blue triangles on each figure) at Plants Bowen, Plant Hammond, Plant Scherer, and Plant Wansley, as illustrated in **Figures 14** through **18**.

Figure 14 - Plant Bowen - West-East Section (saturated waste below green line, Part B, Figure 4C)



Plant Bowen - West-East Section – (Part B, Figure 2-4B)



Plant Bowen - North-South Section – saturated waste below green line (Part B, Figure 2-4A)

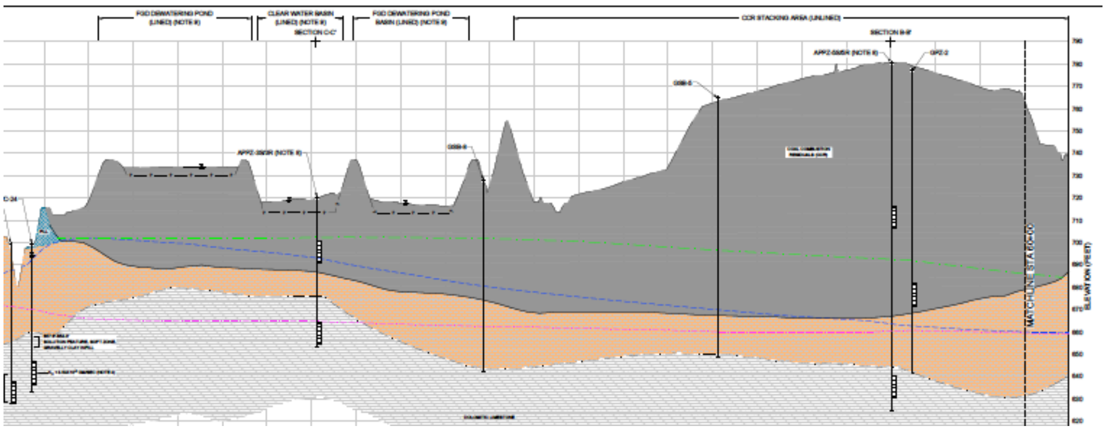
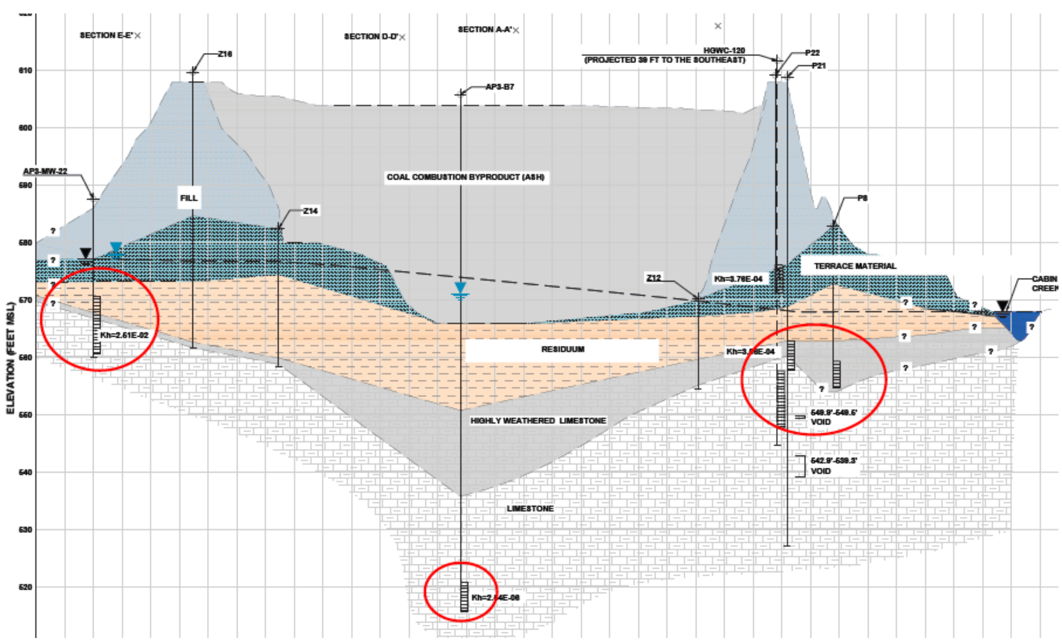


Figure 15 - Plant Hammond

West-East Section (saturated wastes below black dashed line, Part B, Figure 2-3B



Plant Bowen - North-South Section (Part B, Figure 2-3A)

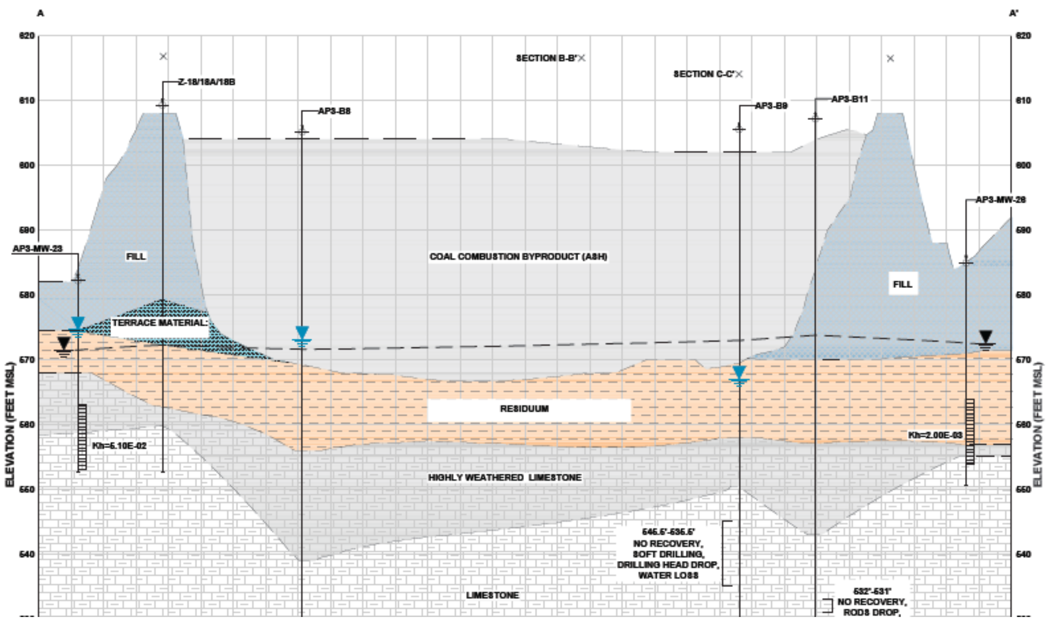
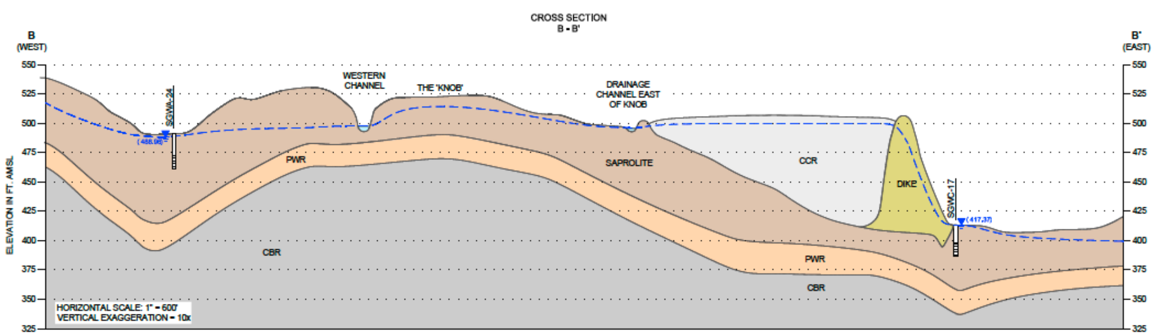


Figure 16 - Plant Scherer

West-East Section (saturated wastes below the dashed blue line, Part B, Figure 5)



North-South Section (Part B, Figure 4)

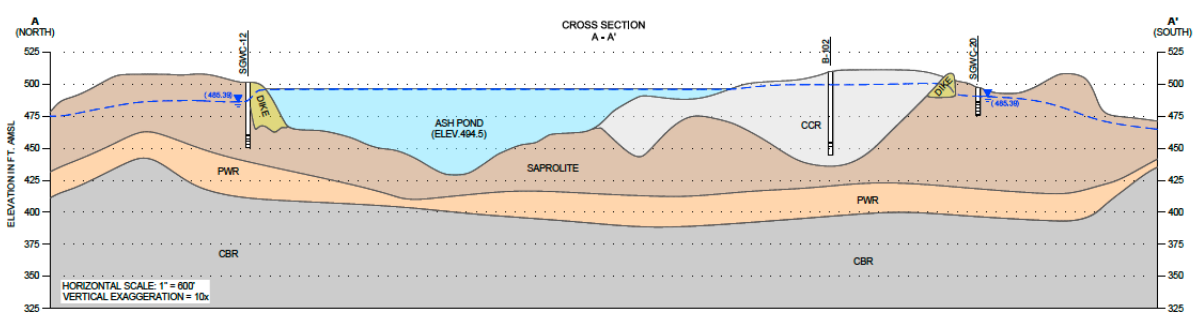


Figure 17 - Plant Wansley

Northwest to Southeast - (saturated below the dashed blue line, Part B, Figure 3.3)

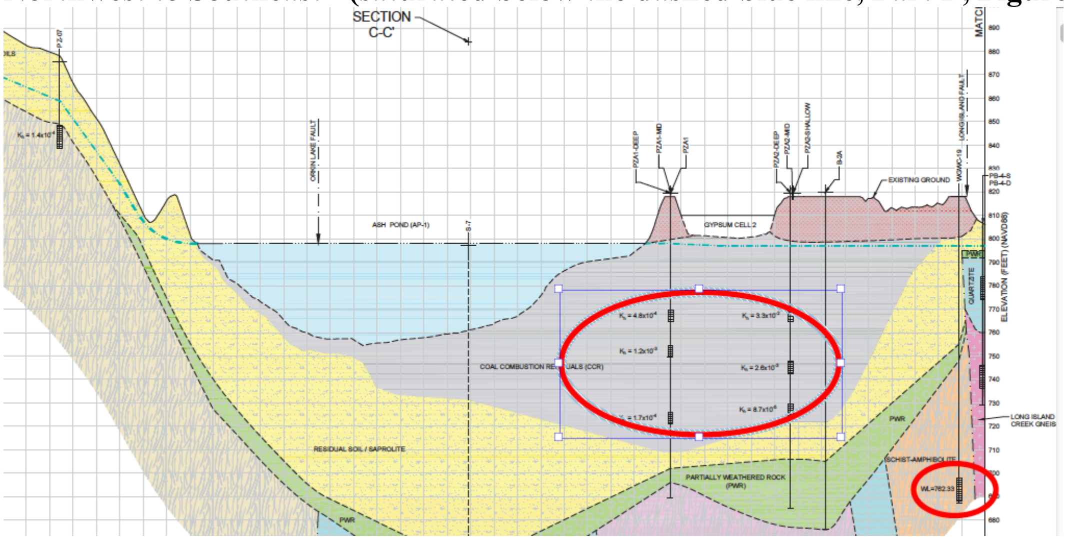
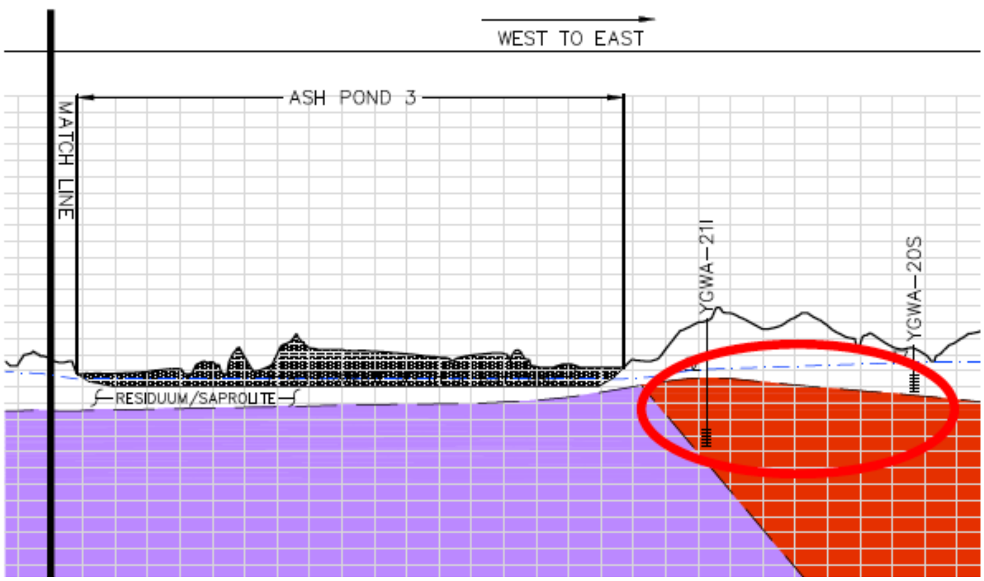
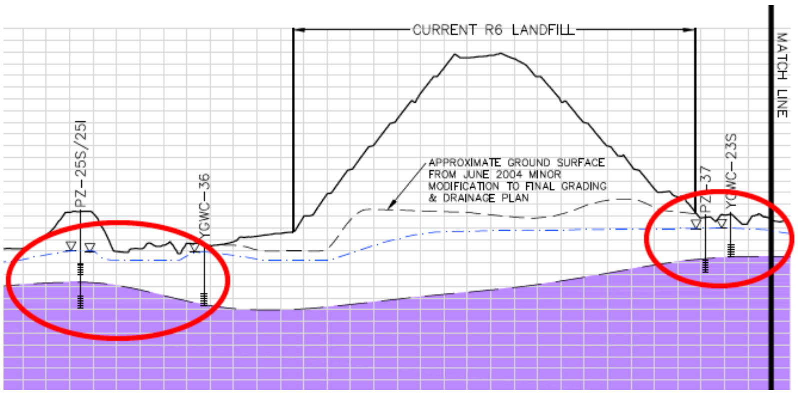


Figure 18 - Plant Yates

West-East Section (saturated below the dashed blue line, Part B, Figure 6B)



Plant Yates - West-East Section (Part B, Figure 6A)



4.5 Impoundment Leakage to Groundwater

There is clear evidence of leakage from Georgia Power's surface impoundments to groundwater, and some of that contamination has exceeded allowable EPA and / or Georgia state groundwater criteria. A brief summary of recent 2019 groundwater sampling results for each Plant, as reported by Georgia Power consultants, is included in **Table 3**.[53]

Table 3: Groundwater Sampling Results

Plant Name	SSI / SSL Constituent	Wells Affected	Other Constituents Indicative of Leakage
Bowen	cobalt, molybdenum	BGWC-20, 22, 23, and 30	boron, calcium, chloride, sulfate, total dissolved solids
Hammond	boron, calcium, chloride, fluoride, sulfate, TDS	HGWC-120, 121A, and 124	-
McDonough	boron, calcium, chloride, fluoride, pH, sulfate, TDS	AP-1: DGWC-37, 38, 39, 40, 67, 68A, 69 AP-2, 3, 4: 20 wells	AP-1: Arsenic numerous times greater than the GWPS (0.01 mg/L), ranging from 0.0113 to 0.164 mg/L. AP-2, 3, 4: Arsenic up to 0.04 mg/L.
Scherer	boron, calcium, cobalt, chloride, fluoride, pH, sulfate, TDS	21 wells	-
Wansley	lithium	WGWC-8, 9, 10, 19	boron, calcium, chloride, sulfate, total dissolved solids
Yates	beryllium, sulfate	YGWC-33S, 49	boron, calcium, chloride, sulfate, total dissolved solids

[53] 2019 Groundwater Monitoring Reports, Table 5, available at: https://www.georgiapower.com/company/environmental-compliance/ccr-rule-compliance-data/ccr-rule-compliance-plant-list.html

4.6 Groundwater Monitoring Systems are Non-Compliant

Although groundwater contamination has been documented at each Plant, Georgia Power's groundwater monitoring wells are not designed and installed to properly measure groundwater quality from the portion of the uppermost aquifer most likely to contain the highest concentrations of constituents or to provide the earliest indication of disposal unit leakage. Georgia Power drilled most of the wells to collect water samples from deeper portions of the uppermost aquifer—not the uppermost portion of the aquifer nearest the bottom of the wastes. Georgia Power cannot assume that the quality of the uppermost aquifer is the same bottom-to-top.

Given that the uppermost aquifers at each location were in the soil and generally unconfined, the measured groundwater elevations in the wells should generally correspond to the elevation of groundwater in the surrounding soil. Based upon my preliminary review of well construction details and boring logs for Plants Bowen, Hammond, Scherer, Wansley, and Yates, Georgia Power commonly screened wells much deeper than the top of the aquifer (see red OVAL examples as illustrated in **Figures 14** through **18**). My evaluation of the groundwater monitoring systems by aquifer thicknesses and well depths at each Plant is as follows:

- **Plants Bowen** and **Hammond** – **Figures 14** and **15** illustrate how the wells are screened in bedrock; they are much deeper than the top of the water table aquifer in soil; they miss groundwater that flows from the impoundment and through the dike, and there are no wells to measure the quality of groundwater that discharges into the adjacent creeks.
- **Plant Scherer – Figure 16** illustrates how wells are drilled into soil; however, the wells were screened much deeper than the top of the water table aquifer.
- **Plant Wansley** – **Figure 17** illustrates piezometers within the CCRs (grey area) and how well WGWC-19 is screened approximately 100 feet deeper than the top of the water table aquifer.
- **Plant Yates** – **Figure 18** illustrates how much deeper soil wells are screened compared to the surface of the water table.

Wells that are drilled deeper into the uppermost aquifer at each Plant are likely incapable of detecting the highest concentrations of contaminants which might be present in the aquifer. My review of actual Georgia Power groundwater results and shallow and deep well construction details indicates that shallowest soil wells are more likely to contain constituents at higher concentrations. The Plant-specific groundwater quality / well screen depth analyses are as follows:

- **Plant Bowen** – the highest concentrations of calcium, chloride, sulfate, and total dissolved solids were reported in wells with shallower screen intervals: BGWC-22, 23, and 24 (see **Figure 8**).[54] Those wells are isolated to the southwest corner of the impoundment.
- **Plant Hammond** – the highest concentrations boron, calcium, chloride, sulfate, and total dissolved solids were in the downgradient well with the shallower screen interval: HGWC-121/121A (see **Figure 9**).[55]
- **Plant Wansley** – the highest concentrations of boron, calcium, chloride, sulfate, and total dissolved solids were in the well with the second shallowest screen interval: WGWC-16 (see **Figure 12**).[56]
- **Plant Yates** – the highest concentrations of boron, calcium, chloride, sulfate, and total dissolved solids were in the well with the shallowest screen interval of the most downgradient wells: YGWC-33S (see **Figure 13**).[57]

In summary, Georgia Power's groundwater monitoring systems at Plants Bowen, Hammond, Scherer, Wansley, and Yates do not meet the Federal CCR Rule or Georgia CCR Rule for well design and construction. First, the wells do not provide a "high degree of certainty" that constituents due to leakage from disposal units will be "immediately detected" according to Georgia EPD guidance. Next, the wells do not always monitor the uppermost aquifer downgradient of the waste management boundary according to the CCR Rule. Georgia Power should have instead installed widespread wells at each Plant in the shallower soil portion of the aquifers nearest the bottom of the impoundments—in addition to deeper cluster wells at different depths. The groundwater monitoring system at Plant Bowen also likely does not meet the technical performance requirements of the Federal and Georgia CCR Rule because wells may not always accurately represent background or unaffected groundwater quality due to mounding.

Also, Georgia Power's reliance on recent CCR Rule-required "baseline" groundwater samples from upgradient wells is problematic and unreliable because the upgradient and downgradient groundwater quality might already be contaminated due to decades of unlined disposal and leakage to groundwater.

There is also no indication that Georgia Power completed a thorough investigation at Plants Bowen, Hammond, McDonough, Scherer, Wansley, or Yates to determine the nature and extent of contamination; the connectivity of groundwater to surface waters; the effects of groundwater discharges on sediments in streams; or the effects on human health and fish / aquatic life prior to selecting closure-in-place. Further, wells are not always installed and sampled in the hydraulically downgradient direction near property lines and rivers / streams. Where contamination has been detected and Georgia Power has attempted to delineate the extent of that contamination, its preference has been to drill wells deeper—rather than the shallower portion of the aquifer that is more likely to be contaminated.

[54] 2019 Groundwater Report, Table 1.
[55] 2019 Groundwater Report, Table 1.
[56] 2019 Groundwater Report, Table 1A.
[57] 2019 Groundwater Report, Table 1A.

5.0 GEORGIA POWER'S PLANS FOR SURFACE IMPOUNDMENT CLOSURE

Georgia Power plans to close surface impoundments by both closure-by-removal and closure-in-place. Closure-by-removal is a closure method where Georgia Power plans to excavate the CCRs from existing impoundments (plus approximately 6 inches of underlying soil) and transport those materials to other disposal areas. Georgia Power has already initiated or completed closures at Plants Hammond, McDonough, and Yates, as listed in **Table 2**. The Part A and Part B Applications that Georgia Power submitted to Georgia EPD in November 2018 for those Plants were to obtain permits for closure activities that are planned for the future—and even for some that have already been initiated or completed.

As described in **Table 2**, Georgia Power commonly chose to "consolidate" or re-dispose of excavated CCRs into the same or other unlined disposal units. For example, Georgia Power plans to excavate (i.e. closure-by-removal) CCRs from some impoundments at Plants McDonough, Scherer, Wansley, and Yates but then "consolidate" those CCRs into a smaller area ("footprint") in the same unlined impoundment or haul the CCRs to another unlined impoundment located nearby.

5.1 Closing Impoundments in Unstable Karst Conditions

There are numerous risks associated with the closure of surface impoundments at Plants Bowen and Hammond, which allow CCRs to remain in place in unstable karst geologic conditions. Georgia Power's past attempts to remedy unstable sinkhole collapse conditions by injecting more than 330,000 cubic yards of grout into the subsurface at Plant Bowen demonstrates that sinkhole collapses are unpredictable and can occur in the future—even with significant remedial efforts meant to prevent future collapses.

The Federal CCR Rule and Georgia CCR Rule do not prevent construction of disposal areas over karst terrain but do require that the disposal unit be designed to ensure the integrity of the landfill components (e.g. liner, leachate collection system) "will not be disrupted" in the event of collapse.[58] Such factors as local soil conditions and on-site geologic features (e.g. karst terrain) must be considered.

Both the CCR Rule and the Georgia CCR Rule require that closure-in-place of an existing impoundment be performed sufficient to "control, minimize, or eliminate, to the maximum extent feasible….releases of CCR, leachate, or contaminated runoff to the ground…" and to "minimize the need for further maintenance of the CCR unit…"[59] For Georgia Power to meet these criteria, it must complete sufficient analyses and subsurface remedies to "ensure" that the plan to leave CCRs in-place will overcome the unstable geologic conditions that have already resulted in releases of CCRs through the subsurface at both Plants Bowen and Hammond.

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[58] Federal CCR Rule, 40 CFR Part 257.64.
[59] Federal CCR Rule, 40 CFR Part 257.102.

Georgia Power is planning significant CCR excavation and soil / bedrock foundation repairs at Plant Bowen—in addition to constructing a new liner and leachate collection system; however, no such efforts are planned for the impoundment at Plant Hammond, which has already been officially closed. Georgia Power plans to excavate all of the CCRs at Plant Bowen, reinforce the unstable soil and bedrock beneath, construct a bridging layer to separate the wastes from the uppermost aquifer; and build a new lined landfill to attempt to overcome the same unstable karst geology and collapse potential.

The already-completed closure-in-place of AP-3 at Plant Hammond did not overcome the unstable karst geologic conditions beneath the impoundment because Georgia Power apparently did not perform any foundation improvements prior to completing closure. Without such modifications at Plant Hammond, Georgia Power has not minimized the risk for future collapses of the closed-in-place area "to the maximum extent feasible" that could lead to future releases of CCRs and leachate into groundwater, nor has it ensured prevention of sloughing and movement of the final cover system. As a result, closure-in-place of AP-3 at Plant Hammond does not meet the closure performance standards of 40 CFR Part 257.102(d)(i), (iii), and (iv).

Instead of constructing a new lined landfill at Plant Bowen as-planned on the same unstable karst geology at AP-1, Georgia Power has an existing CCR landfill that could conceptually be used to dispose of the AP-1 wastes. Disposal into that existing landfill would eliminate the costs (and time) associated with excavating and transporting wastes multiple times (i.e. dig, haul, temporarily store, dig, and haul again), eliminate foundation soil repairs needed to overcome unstable and unpredictable geology beneath the proposed new landfill footprint, and eliminate the costs to build a new lined landfill in that footprint.

5.2 Consolidated Closure-in-Place Continues with Unlined Disposal

Georgia Power's draft closure plans, which "consolidate" CCRs by closing existing impoundments in-place in existing unlined impoundment—and even transporting excavated wastes from other impoundments to them—will do nothing more but continue their past practice of dry stacking CCRs in unlined impoundments in shallow groundwater and in environmentally sensitive areas. This disposal practice is especially unreasonable given that the industry has recognized the groundwater contamination risks from unlined impoundments since the 1970s.

Although the total acreage will be reduced in a consolidated approach and an engineered cap will be constructed to minimize the amount of precipitation that can infiltrate into the CCRs, the wastes that remain deeper in the impoundment will remain "wet" unless groundwater and pore water is pumped from the CCRs to completely dry them. Further, the groundwater contamination beneath the original "footprint" (in acres) will remain, even though the wastes will be consolidated to a smaller area. Also, the consolidated approach at former stream valley sites (e.g. Scherer, Wansley) results in CCRs being excavated from the shallowest portions and relocating them to the deepest portions of the unlined impoundment where legacy CCRs are the thickest and more submerged in groundwater.

Saturated CCRs will continue to exist post-closure for the impoundments that will be closed-in-place. Since Georgia Power does not intend to pump any pore water from the complete depth of saturated wastes prior to constructing the cap at any point during post-closure, leaching and groundwater contamination will continue in perpetuity for any disposal area that contains submerged wastes. The engineered cap cover systems will not prevent groundwater from up-gradient, topographically higher areas from flowing underneath and into the wastes— thus allowing wastes to become re-saturated and leaching to continue.

Georgia Power completed numeric, predictive models for Plants Scherer and Wansley, and those models determined that CCRs will remain submerged in groundwater even after closure-in-place is completed. Further, Georgia Power did not propose any engineering measures to capture contaminated groundwater or prevent it from continuing to migrate from the disposal areas. As such, these closures do not satisfy the Federal or Georgia CCR Rule closure performance standards. Georgia Power concluded that these saturated conditions will exist after closure:

- **Plant Scherer –** groundwater elevations after closure of AP-1 will range from 440 to 490 feet above mean seal level.[60] When those elevations are compared to the pre-filling ground topography (**Figure 4**) that ranged from 410 to 450 feet in the same area, the data indicates that approximately 30 to 40 feet of CCRs will remain submerged in the former stream valley after closure is complete.
- **Plant Wansley** – a diagram included in the Closure Plan illustrates that at least 75 feet of CCRs will remain submerged in the former stream valley post-closure. In fact, the elevation of groundwater within the CCRs is the same as the water elevation that will remain standing in the adjacent pond.[61] The planned concrete pile wall will not prevent water from the adjacent pond from intermingling with and saturating CCRs in the closed-in-place area.

The closure-in-place methods at Plants Scherer and Wansley are not compliant with the CCR Rule or Georgia CCR Rule because according to Georgia Power's predictive modeling, saturated wastes will remain submerged and impounded below ground after closure—with no other groundwater remedy in place to prevent contamination from migrating from the units. The proposed closure-in-place methods at Plants Scherer and Wansley will therefore not meet the CCR Rule and Georgia CCR rule requirements to:

- "(i) control, minimize, or eliminate to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere;" and to
- "(ii) preclude the probability of future impoundment of water, sediment, or slurry."

In contrast to the numeric models completed for Plants Scherer and Wansley, Georgia Power did not numerically predict in either the Part A or Part B Permit Applications the amount of saturated CCRs that will remain post-closure at Plants Hammond, McDonough, or Yates—yet this determination is a critical factor in determining whether or not leaching will continue and

[60] Scherer 2018 Part B Application, Hydrogeologic Characterization Report at 18 and 32.
[61] Wansley 2018 Part A Application, Drawing 12 of 33 at 186.

whether or not the closure-in-place method is compliant with the Georgia CCR Rule and the Federal CCR Rule, If post-closure saturated conditions continue to exist at closed in-place impoundments at Plants Hammond, McDonough, and Yates, those closure methods would also be non-compliant for the same reasons.

5.3 Consolidated Closures Continue to Allow Unmitigated Groundwater Contamination

Georgia Power failed to complete predictive models for groundwater quality for any Plant site—which are especially valuable given the planned long-term closures-in-place in unlined areas. As a result, Georgia Power might be constructing engineered caps with the false hope of actually protecting or improving groundwater at some point in the future. Neither the draft closure plans nor the hydrogeologic assessments completed for the Part A and Part B applications included any groundwater modeling to predict:

1. How much groundwater quality will improve following closure-in-place,

2. When groundwater quality will return to non-affected 'background" levels after closure is complete, or

3. When groundwater quality will meet Georgia State water quality standards.

Predictive models are needed to support Georgia Power's decision to select closure-in-place and how it intends to meet the Federal and Georgia CCR Rule performance standard to "control, minimize or eliminate, to the maximum extent feasible, post closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated runoff to the ground" because closure-in-place might not even prevent continued leaching to groundwater or improve groundwater quality over time. Further, such predictive analyses are needed to determine whether or not the costs for such a closure are reasonable given the expected or predicted outcome. If leaching is not eliminated and no such groundwater quality improvements will occur over time following closure-in-place, the closure method would not meet the CCR Rule performance standard to prevent leaching to groundwater to the "maximum extent feasible."

As previously discussed, EPRI concluded that groundwater conditions at impoundments that are closed in-place can actually worsen when CCRs remain saturated after construction of a cap over wastes because the CCRs will continue to leach to groundwater. There is no indication that Georgia Power considered this fact in its closure evaluation process.

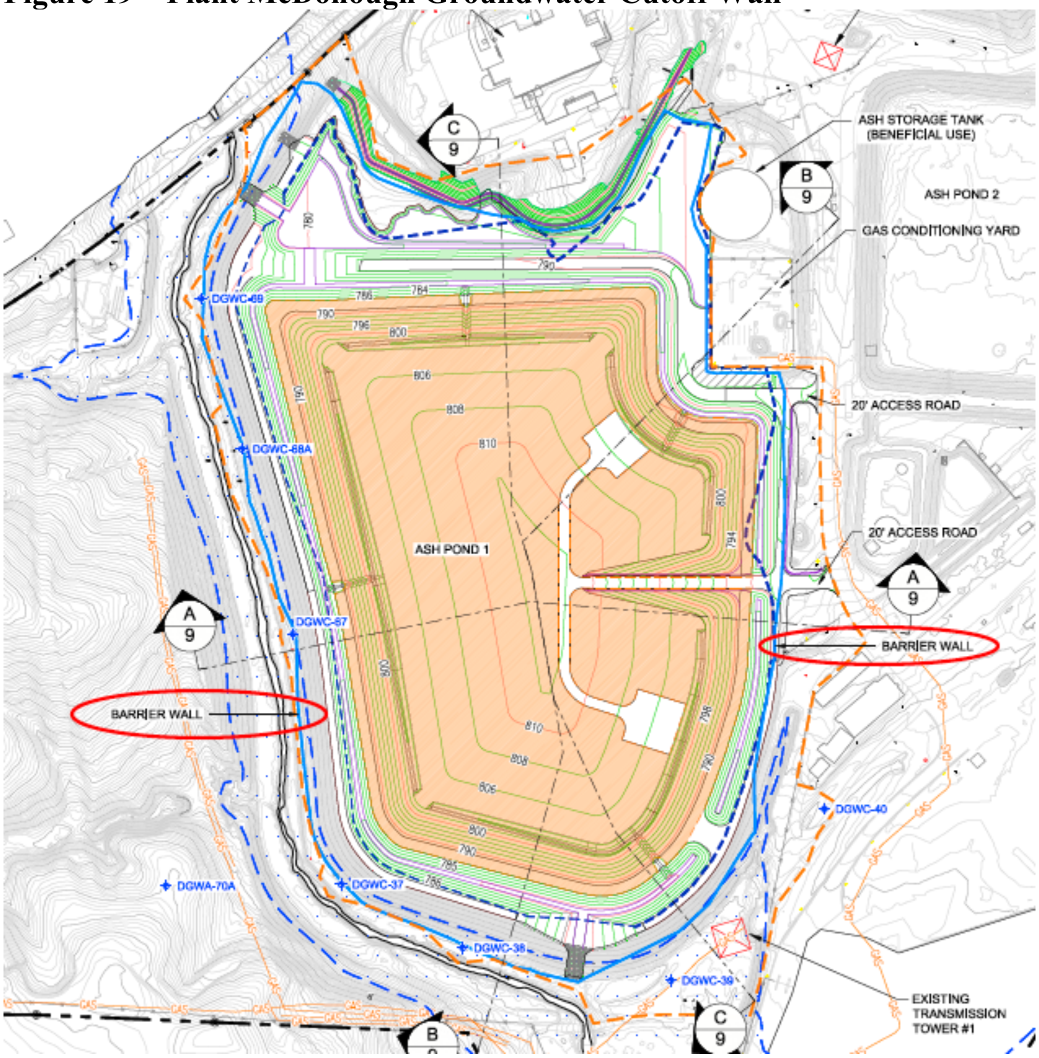
In my experience reviewing closure plans in other states for other utilities, groundwater quality predictive models determined that groundwater quality will not improve within 100 years or more (e.g. Duke Energy, Allen Plant, North Carolina). When groundwater quality does not improve over time, utilities must continue sampling groundwater and incurring the associated long-term costs of labor, laboratory analyses, and well maintenance, as examples, into the distant future. Those long-term costs should also be factored into whether or not closure-in-place is feasible or should even be selected.

5.4 Groundwater Capture or Remediation Options Exist

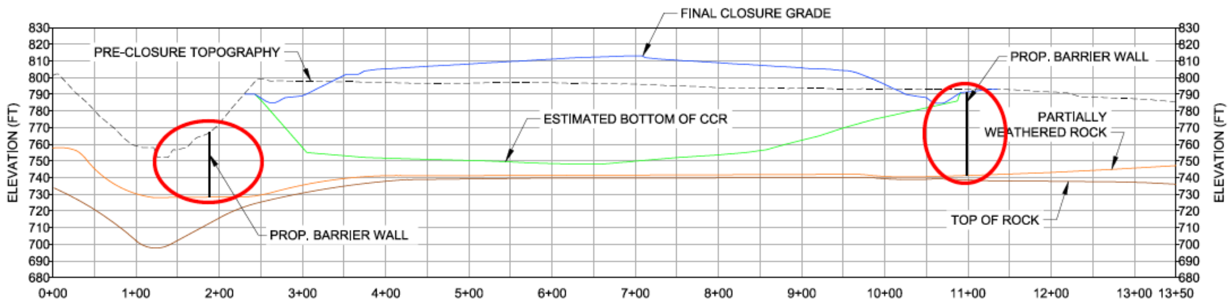
In an apparent attempt to capture contaminated groundwater from an unlined surface impoundment, Georgia Power included a conceptual layout of a groundwater cutoff wall (i.e. perimeter barrier wall) for impoundment AP-1 at Plant McDonough (**Figure 19** below). Georgia Power failed however, to include any such system at other impoundments at Plant McDonough or any other Plant evaluated in this analysis.[62]

The planned construction of a groundwater cutoff wall for impoundment AP-1 at Plant McDonough and not elsewhere creates unexplained disparity with Georgia Power's decision-making—with other Plants even being located within more environmentally sensitive areas (e.g. Most Significant Ground-Water Recharge Areas) than Plant McDonough.

Figure 19 – Plant McDonough Groundwater Cutoff Wall



[62] McDonough 2018 Part A Application, Closure Plan at 191.



Although a concrete pile wall is planned for the closure-in-place method at Plant Wansley, that wall will not prevent standing water in the adjacent pond from continuing to saturate CCRs. Instead, the purpose of the wall at Plant Wansley is structural to prevent piled, consolidated CCRs from sliding into the pond during the post-closure period.

Closure-in-place of surface impoundments with only an engineered cap should not be considered a groundwater remedial or corrective action because CCRs will continue to leach into groundwater, and contaminated groundwater will continue to flow away from the areas and discharge into streams. Further, Georgia Power has not determined what effects groundwater discharges have on receiving streams and fish / aquatic life.

5.5 Beneficial Reuse of Legacy CCRs

The legacy CCRs in Georgia Power's impoundments are capable of being excavated, processed and beneficially reused. Georgia Power's decision to incur the costs to excavate and transport CCRs into unlined impoundments for consolidated closure-in-place is a missed opportunity to beneficially reuse those wastes. Georgia Power already plans to excavate and transport those wastes. Technology already exists to suitably treat or process excavated wastes for raw material substitutes. In fact, reclamation and processing is already being completed in South Carolina[63] for other utility wastes. Excavated CCRs can be processed ex-situ sufficient to be used as raw material substitutions (e.g. in concrete). As a result, the excavated CCRs would instead have a monetary value and no long-term disposal site liability with continued costs. Of course, Georgia Power can excavate CCRs from closed-in-place impoundments for beneficial reuse at some point in the future after closure—but it would have already incurred the significant costs of building an engineered cap that would then be destroyed in order to reclaim the CCRs.

[63] *See* https://www.sefagroup.com/services/star-technology/star-process/

6.0 CONCLUSIONS

The following are the major conclusions from my preliminary analysis:

- Groundwater contamination is present due to the leakage of unlined surface impoundments that Georgia Power constructed from the early 1950s through the 1970s, and up until 1982—despite the electric power industry trend of constructing lined impoundments starting in the 1970s.
- Georgia Power's closure plans are based upon permit applications and not actual permits issued by the EPD. In fact, Georgia Power has already completed or initiated closures at Plants Hammond, McDonough, and Yates prior to receiving permits.
- Georgia Power's groundwater monitoring systems are not compliant with the Federal or Georgia CCR Rules.
- The proposed closure plans are inconsistent with State and Federal Laws because the plans do not meet the required technical standards for closure-in-place.
- According to Georgia Power's groundwater predictive modeling results for Plants Scherer and Wansley, Georgia Power's closure-in-place plans are non-compliant with the Federal or State CCR Rule performance standards since they will continue to leave CCRs saturated in groundwater even after closure is complete and without other measures (e.g. slurry walls, groundwater pumping wells) to prevent on-going leaching to groundwater or prevent contaminated groundwater from migrating away from the impoundments. Such predictive models for all Plants are necessary to demonstrate compliance.
- Georgia Power's closure plans will not resolve on-going groundwater contamination, and the nature and extent of contamination has not been determined for each Plant.
- Georgia Power's closure plans failed to model or predict how long groundwater will remain contaminated into the future, how much, if any, groundwater quality will improve over time, or when Georgia and EPA water quality standards will be met.

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10/15/19
Date

REFERENCES

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18. Plant McDonough Part A 2018, AP-2, 3, 4. Part A: Permit Documents, CCR Surface Impoundments (CCR Unit AP-2, Combined Unit AP-3/4), Plant McDonough-Atkinson, Golder, November 2018
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31. USGS 1965. USGS 1965 Whitesburg 7.5 Minute Topographic Quadrangle Map (Plant Yates).
32. USGS 1973. USGS 1973 East Juliette 7.5-Minute Topographic Quadrangle Map (Plant Scherer).

MARK A. QUARLES, P.G.

PROFESSIONAL SUMMARY

Environmental consultant with 30 plus years experience in a variety of local, state, EPA, and international regulatory programs. Expertise in industrial manufacturing process wastes, utility wastes, oil and gas exploration and production wastes, contaminant investigations and corrective actions, and environmental permitting and compliance. Consulting services to municipal governments, industrial manufacturers, private citizens, law firms, non-profit organizations, and environmental conservation organizations. Bachelor of Science, Environmental Engineering Technology. Master of Business Administration. Licensed Professional Geologist (P.G.) in Georgia, New York, and Tennessee.

CONTACT INFORMATION

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RANGE OF TECHNICAL EXPERIENCE

Coal Combustion Residuals

- *Sierra Club* – North Carolina
  Provided expert testimony at rate case hearings regarding coal combustion waste disposal practices, historical and current Electric Power Research Institute industry practices for disposal unit design and monitoring, and evaluation of proposed closure methods relative to Coal Combustion Residuals (CCR) Rule standards.
- *Multiple Clients* – Nationwide United States
  Conducted file reviews and groundwater data analyses for approximately 100 CCR disposal sites in 12 states, specific to identifying coal combustion waste constituents in the groundwater. Sites included wet surface impoundments and dry landfills.
- *Multiple Clients* – Nationwide United States
  Conducted file reviews regarding CCR Rule and state-specific requirements for disposal sites to evaluate compliance with liner, location restrictions (including separation from groundwater), monitoring system certifications, alternate source demonstrations, groundwater monitoring and reporting, closure-by-removal designs, and closure-in-place designs.
- *Sierra Club* – Georgia
  Reviewed surface impoundment dewatering results to determine chemical changes in water quality by depth from standing (i.e. free) water, pore water, and groundwater.
- *Southern Environmental Law Center* – Tennessee and Alabama
  Evaluated CCR disposal area closure plans for numerous fossil plants relative to CCR Rule performance standards for closure-in-place and beneficial reuse.
- *Southern Environmental Law Center* – Tennessee
  Developed technical comments for a proposed major permit modification associated with CCR landfill expansion. Technical considerations included groundwater connectivity to an adjacent river and unstable karst geology.
- *Southern Environmental Law Center* – Tennessee
  Prepared technical comments regarding the Draft Environmental Assessment for a proposed bottom ash dewatering system. Compared the proposed plan to other utility-owned plants and systems for water minimization, waste avoidance, and land disposal.
- *Chris Dennis Environmental Fund* – New York
  Developed technical comments regarding a SPDES permit renewal for leachate and stormwater discharges from a CCR landfill relative to NYDEC Part 360 landfill monitoring, operational, groundwater corrective action, and closure / post-closure standards.
- *Confidential Clients* – Tennessee
  Developed and implemented water and sediment sampling plans to locate discrete groundwater discharges above and below the water line of adjacent waterways.

- *Sierra Club* – Washington, DC
  Reviewed the hydrogeologic investigation, groundwater monitoring program, and engineering design for a proposed flue gas desulfurization (FGD) landfill relative to EPA and Tennessee standards.
- *Southern Environmental Law Center* – Virginia
  Reviewed historical groundwater monitoring reports, landfill designs, aerial and topographic maps, regulatory files, and a plan for monitored natural attenuation of constituents in the groundwater.
- *Southern Environmental Law Center* – Alabama
  Reviewed regulatory file data, current and historical aerial photography and topographic maps, and water seep sampling results for CCR constituents in groundwater and leachate.
- *Southern Environmental Law Center* – South Carolina
  Reviewed groundwater monitoring reports, plume maps, and a site assessment to compare closure-in-place and permeable reactive wall barriers as viable corrective actions, versus excavation and disposal in a lined Subtitle D landfill.
- *Prairie Rivers Network* - Illinois
  Evaluated Illinois standards for the disposal and beneficial re-use of CCRs compared to national standards. Included an in-depth analysis of chemical and physical characteristics, a summary of site characterization and siting standards, and a summary of national damage assessment cases.
- *Attorney* – Tennessee
  Developed a surface water monitoring program to determine the lateral extent of cenospheres from a release of 5.4 million cubic yards of CCRs to the surface water from a surface impoundment failure.

Unconventional Natural Gas and Hydraulic Fracturing

- *Tulane Environmental Law Clinic* – Louisiana
  Provided expert testimony at a public hearing for proposed oil and gas well in the Tuscaloosa Marine Shale in St. Tammany Parish. Compared the application to American Petroleum Institute (API) and EPA standards. Sensitive issues included a well pad in a wetland, drilling through multiple layers of a Sole Source Aquifer, and the cumulative effects of the proposed 60,000 acres of leases.
- *Northern Plains Resource Council* – Montana
  Provided testimony at a Board of Oil and Gas Conservation hearing for a proposed oil and gas well along the Beartooth Front. Reviewed the application and compared the proposed plan to API standards for hydraulic fracturing.
- *Shenandoah Valley Network, Shenandoah Riverkeeper* - Virginia
  Developed technical comments associated with the first proposed shale gas well in Virginia. Evaluated the proposed plan for hydraulic fracturing; storage of produced waters and flow back; protection of groundwater supplies; treatment and disposal of wastes; and the location relative to the floodplain.
- *Sierra Club* - Washington, D.C.
  Provided technical comments regarding proposed Tennessee oil and gas regulations. Compared the proposed regulations to API standards and other state's regulations.

Landfill Design and Operation

- *Confidential Clients* – Tennessee
  Created and implemented hydrogeologic investigations and groundwater monitoring programs for municipal solid waste, industrial, and construction / demolition debris landfills.
- *Tulane Environmental Law Clinic* – Louisiana
  Prepared technical comments for a proposed expansion of a construction / demolition debris landfill by comparing the site characteristics, operation plan, and monitoring program to LDEQ and EPA standards.
- *Sierra Club* – Tennessee
  Reviewed the hydrogeologic investigation and supporting documents for a permit expansion to evaluate site characteristics and the design relative to Tennessee and EPA Subtitle D standards.

- *Attorney* – Georgia
  Evaluated the technical merits of a municipal solid waste disposal permit that had been issued by the Georgia EPD.
- *Private Landowner* - Tennessee
  Reviewed waste characterization results, landfill designs, and hydrogeologic investigations for proposed secondary aluminum smelter waste landfills.
- *Municipal Landfill* – Tennessee
  Designed and installed methane gas collection wells through an engineered cap to mitigate methane migration along the property line.
- *Municipal and Industrial Landfills* – Tennessee
  Developed landfill closure plans for existing landfills that became subject to EPA Subtitle D technical standards.
- *Confidential Client* – Tennessee
  Managed a site hydrogeologic investigation, conceptual design, permit-level design, groundwater monitoring program, and construction-level design project for an industrial waste landfill.

Wastewater Permit Compliance

- *Friends of the Earth* – Florida
  Provided comments for a renewal application for disposal of nuclear power plant wastewater into earthen surface impoundments and the Biscayne Aquifer along the Biscayne Bay.
- *Kentucky Waterways Alliance* – Kentucky
  Provided technical review of a draft wastewater discharge permit for a proposed Integrated Gasification Combined Cycle (IGCC) plant and associated landfill. Included research into IGCC wastewater and solid waste constituents and a comparison to the proposed discharge criteria.
- *Sierra Club* – Kentucky
  Provided technical review of a draft wastewater discharge permit associated with a FGD expansion. Research included the characteristics of FGD process and gypsum by-product wastes; the leachability of solid wastes; the characteristics cooling water blowdown, metal cleaning wastewater, stormwater runoff, and coal and limestone pile runoff; the structural integrity of an existing ash surface impoundment proposed for vertical expansion; and the technical feasibility of a proposed gypsum disposal surface impoundment.
- *Tulane Environmental Law Clinic* – Louisiana
  Reviewed a draft LDEQ permit associated with a proposed oil and gas exploration, development, and production facility. Compared proposed effluent limitations to EPA Effluent Limitation Guidelines and compared sampling parameters to expected waste constituents.

Environmental Investigations and Remediation

- *Tera Tech / US EPA* – Tennessee
  Investigated the occurrence of a cluster of cleft palate / cleft lip birth defects relative to the occurrence of trichloroethylene in the groundwater and public water supply. Reviewed EPA, Tennessee, Center for Disease Control, and Department of Health reports; interviewed City, County, Tennessee, and EPA officials; and interpreted regional karst geologic and hydrogeologic data.
- *Multiple Industrial Clients* – Nationwide United States
  Performed hydrogeologic investigations in response to releases of industrial constituents to soil, groundwater, sediments, and / or surface water. Work was performed consistent with EPA and state-specific standards to define the nature and extent of contamination.
- *Confidential Industrial Client* – Kentucky
  Completed closure-by-removal of two earthen industrial wastewater surface impoundments, including waste characterization and disposal, soil sampling at the extent of the excavation, and closure certification.
- *Harpeth River Watershed Association* – Tennessee
  Provided technical comments for an environmental investigation and corrective action plan to a proposed monitor-only, natural attenuation remedial action. Contaminants of concern included free-phase toluene, dissolved-phase BTEX, dissolved-phase acetone, and dissolved-phase chlorinated solvents.

- *Natural Resources Defense Council* – Confidential Location
  Provided technical input for development of a Complaint for Declaratory and Injunctive Relief related to the disposal, investigation, and cleanup of volatile organic compounds in soil, groundwater, and surface water.
- *Multiple Clients* – Eastern United States
  Created Remedial Investigation / Feasibility Studies (RIFSs), Corrective Action Plans (CAPs). Quality Assurance Project Plans (QAPPs), Field Sampling and Analysis Plans (FSAPs), and Health and Safety Plans (HASPs) for Superfund, RCRA, and voluntary state programs to identify, quantify, and remediate releases of chlorinated solvents (notably trichloroethylene and is break-down components), volatile organic compounds, semi-volatile organic compounds, and heavy metals.
- *Industrial Client* – Tennessee
  Designed soil and groundwater corrective actions for a release of kerosene. Corrective actions included free product capture, air sparging, and soil vapor extraction.
- *Multiple Petroleum Clients* – Tennessee
  Completed petroleum underground storage tank closures, environmental assessment reports, and groundwater monitoring programs consistent with the Petroleum Underground Storage Tank fund reimbursement requirements.

Chemical, Petroleum, and Hazardous Waste Management

- *Confidential Clients – Tennessee and Kentucky*
  Performed audits of industrial manufacturing plants according to RCRA Subtitle C requirements for conditionally-exempt small quantity, small quantity, and large quantity generators.
- *Confidential Clients* – Tennessee
  Developed Spill Prevention Control and Countermeasure (SPCC) Plans for mobile and stationary petroleum storage tanks.

Local and FERC Utility Line Environmental Assessments

- *Private Landowner* - Tennessee
  Reviewed a proposed water line expansion - including the aquatic resources alteration permit, the cultural resources survey, the stream use classification, and the USACE Section 404 application.
- *Private Landowner* – Kentucky
  Provided technical comments of a Draft NEPA Environmental Assessment for the construction of a 220-mile electrical powerline.
- *Private Landowners* – Tennessee
  Provided technical comments and field inspections regarding wetland and aquatic resources alteration permits for a proposed 30-mile natural gas pipeline.

Reservoir Water Quality and Use Assessments

- *Attorney* - Tennessee
  Developed technical comments for Section 10 and Section 26A Regulation permit applications and a Recreational Boating Capacity Study for reservoir-wide community boat docks associated with residential development.
- *Attorney* - Alabama
  Developed technical comments for Section 10 and Section 26A Regulation permit applications for residential developments. Completed a detailed assessment of reservoir water quality relative to designated use standards.
- *Attorney* - Georgia
  Evaluated the technical merits of a water withdrawal permit, the effects of increased urbanization on stormwater runoff and groundwater recharge, and the effects on lake water levels.

Oil and Gas Exploration and Production Wastes

- *Indigenous Rights Organization* – Peru
  Developed a Best Management Practices guide for remediation of petroleum-contaminated soil and groundwater in remote areas of the Amazon basin of Peru.

- *Attorney* - Ecuador
  Evaluated oil exploration and production processes relative historical United States and international industry standards; groundwater and soil investigative standards in the United States; and groundwater and soil clean-up standards in the United States.
- *Indigenous Rights Organization* – Amazon Basin, Peru
  Provided independent third-party evaluation of crude oil remediation activities of 75 sites in Block 1AB. The work included sampling of soil, sediment, and surface water; evaluating the effectiveness of *in-situ* bioremediation; and comparing cleanup activities to Peruvian and United States standards.

Stormwater Permitting and Compliance

- *Tennessee Clean Water Network* – Tennessee
  Provided technical comments for the draft Knox County Phase II Municipal Separate Storm Sewer System (MS4) permit.
- *Tennessee Trucking Association* - Tennessee
  Completed a group EPA stormwater application for more than 100 trucking companies across the United States.
- *Multiple Clients* - Tennessee
  Completed multiple general and individual permit applications for stormwater associated with industrial activities and construction sites. Completed a Stormwater Pollution Prevention (SWPP) Plan for each facility.

Municipal Wastewater Management

- *Emory Law Clinic and Everglades Law Center* – Florida
  Provided technical comments and NRC hearing testimony regarding the proposed use and deep well injection of 90 million gallons per day of partially treated domestic wastewater and nuclear power plant cooling water into the Boulder Zone.
- *Various Municipalities* – Florida, Georgia, Kentucky
  Performed sewer modeling and point-source identifications for millions of linear feet of sanitary and combined sewers. Collected 24-hour, seasonal flow rates; identified sources of infiltration / inflow; performed television inspections; quantified defect flow rates; performed economic cost evaluations for source removal; and designed and implemented construction repairs for source elimination.
- *Boston Water and Sewer Commission* - Massachusetts
  Completed sewer modeling and point-source identification projects of combined and separate sewers up to 15 feet in diameter in order to design the Deer Island wastewater treatment plant. Identified sources of infiltration / inflow and performed cost evaluations for source removal.

EDUCATION

Master of Business Administration

Vanderbilt University, Owen Graduate School of Management, Nashville, Tennessee

Bachelor of Science, Environmental Engineering Technology

Western Kentucky University, Bowling Green, Kentucky

PROFESSIONAL REGISTRATIONS AND CERTIFICATIONS

Professional Geologist (P.G.), Georgia (#2266), New York (#779), and Tennessee (#3834)
Certified Hazardous Materials Manager, Masters Level (1993 – 2001)
Class II Water Pollution Control Operator, Massachusetts (1988)

TECHNICAL PUBLICATIONS AND LECTURES

- 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., Lisa Evans, and Peter Harrison, Panel Discussion on Coal Combustion Waste Management and the New CCR Rules, Appalachian Public Interest Environmental Law Conference, Knoxville, Tennessee, October 2015.
- Quarles, M., and William Wilson, "Unconventional Natural Gas and its Risk, A Tennessee Perspective," Appalachian Public Interest Environmental Law Conference, Knoxville, Tennessee, October 2011.
- Quarles, M., et. al., "*In Harms Way*: Lack of Federal Coal Ash Regulations Endangers Americans and their Environment," Environmental Integrity Project, Earthjustice, and Sierra Club, August 2010.
- Quarles, M., and Craig Segall, "*Slow Motion Spills*: Coal Combustion Waste and Water in Kentucky," Sierra Club, April 2010.
- Quarles, M., et al., "*Out of Control*: Mounting Damages from Coal Ash Waste Sites," Environmental Integrity Project and Earthjustice, February 2010.
- 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.
- Quarles, M., "New Tank Performance Standards," *Tennessee Environmental Law Letter*, July 1993.

EXPERT LEGAL TESTIMONY

- *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. Hearing including written and oral testimony. 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. Hearing including written and oral testimony. October 2017.
- *Joint Intervenors versus the Nuclear Regulatory Commission, Atomic Safety and Licensing Board Panel* on behalf of the Southern Alliance for Clean Energy, the National Parks and Conservation Association, the Emory University Law Clinic, and the Everglades Law Center. Evidentiary hearing including written and oral arguments. 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. Oral and written testimony. Qualified by the Court as an expert. 2017.
- *Tulane Environmental Law Clinic on behalf of the Town of Abita Springs (LA) and the Concerned Citizens of St. Tammany Parish,* New Orleans, Louisiana. Oral and written arguments for an Office of Conservation evidentiary hearing. Qualified by the Office as an expert. 2014.
- *Carbon County Resource Council, Northern Plains Resource Council versus Montana Board of Oil and Gas Conservation* - Oral and written testimony. 2014.
- *Chesney versus Tennessee Valley Authority* – US District Court. Written testimony. 2011.
- *Busch, et al versus Dr. Carol Couch,* Atlanta, Georgia. State Administrative Court. Written and verbal testimony. Qualified by the court as an expert in geology, hydrogeology, and stormwater runoff. 2008.
- *Darrel Segraves, et al versus Dr. Carol Couch,* Atlanta, Georgia. State Administrative Court. Written and verbal testimony. Qualified by the court as an expert in geology, hydrogeology, landfill design pertaining to landfill leakage, and stormwater runoff. 2008.
- *Republic of Ecuador and PetroEcuador vs. Chevron Texaco Corporation and Texaco Petroleum Company*, U.S. District Court, Southern District of New York. Written testimony regarding environmental investigation protocol. 2007.
- *Friends of Tims Ford vs. Tennessee Valley Authority and Tennessee Department of Environment and Conservation.* U.S District Court. Written testimony. 2007.
- *Freddie Howell vs. Creative Customs,* Atlanta, Georgia. Written testimony. 2007.

- *Aguida vs. ChevronTexaco*. Lago Agrio, Ecuador Court, Written testimony. 2006.

CONFERENCES AND TRAINING

Basic Spanish Language Proficiency
Applied Karst Hydrogeology, Field Studies, Western Kentucky University. 2017.
Clean Power Plan 111(d) / Sierra Club Beyond Coal Conference, San Francisco, CA. 2014.
Hydraulic Fracturing Conference, American Institute of Professional Geologists, Denver. 2009.
Water Efficiency, Cumberland River Compact, Lipscomb University. 2009.
Battelle Conferences - Investigation and Remediation, New Orleans, Monterey, multiple years
Summit for a Sustainable Tennessee. 2007.
Current Wetland Issues in Tennessee. 2007.
Professional Liability Education - Contract Review and Revision. 2000.
National Groundwater Association 51st Annual Convention. 1999.
Professional Liability Education – Mid-Town Developer Case Study Workshop. 1999.
Professional Liability Education – Liability IQ for Environmental Consultants. 1998.
Liquid Animal Waste Management System Design to NRCS Standards for CAFO. 1998.
8-Hour OSHA Health and Safety Refresher Training
Hazardous Materials / Waste Manager Course, University of Alabama. 1993.
40-Hour OSHA Health and Safety Training. 1990.