AlleghenyEnergy Supply
A FirstEnergy Company

800 Cabin Hill Drive
Greensburg, PA 15601

VIA EMAIL

November 30, 2020

Mr. Andrew R. Wheeler, EPA Administrator
Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Mail Code: 5304-P
Washington, DC 20460

Re: McElroy's Run CCR Disposal Impoundment - Alternative Closure Demonstration

Dear Administrator Wheeler:

Allegheny Energy Supply Company, LLC, a FirstEnergy Company ("Allegheny Energy") hereby submits this request to the U.S. Environmental Protection Agency (EPA) for approval of a site-specific alternative deadline to initiate closure pursuant to 40 C.F.R. § 257.103(f)(2) for the McElroy's Run CCR Disposal Impoundment located adjacent to the Pleasants Power Station near Willow Island, West Virginia.

Allegheny Energy is requesting this extension pursuant to 40 C.F.R. § 257.103(f)(2) so that the McElroy's Run CCR Disposal Impoundment may continue to receive CCR and non-CCR waste streams after April 11, 2021, and complete closure no later than October 17, 2028.

If you have any questions or comments regarding this submittal, please do not hesitate to contact me at (724) 454 - 9280 or dhoone@firstenergycorp.com.

Sincerely,

David L. Hoone
Supervisor, CCR and Waste Programs

Attachment

cc: Kirsten Hillyer
Frank Behan
Richard Huggins

DEMONSTRATION OF SITE-SPECIFIC ALTERNATE TO INITIATION OF CLOSURE DUE TO PERMANENT CESSATION OF COAL-FIRED BOILERS BY DATE CERTAIN

40 CFR 257.103(f)(2)

McELROY'S RUN COAL COMBUSTION RESIDUAL DISPOSAL IMPOUNDMENT

Pleasants Power Station
Pleasants County, West Virginia

Prepared by:

AlleghenyEnergy Supply™
A FirstEnergy Company

800 Cabin Hill Drive
Greensburg, PA 15601

November 2020

DEMONSTRATION OF SITE-SPECIFIC ALTERNATE TO INITIATION OF CLOSURE DUE TO PERMANENT CESSATION OF COAL-FIRED BOILERS BY DATE CERTAIN

40 CFR 257.103(f)(2)

McELROY'S RUN COAL COMBUSTION RESIDUAL DISPOSAL IMPOUNDMENT

PLEASANTS POWER STATION
PLEASANTS COUNTY, WEST VIRGINIA

Prepared by:

Allegheny Energy Supply Company, LLC

800 Cabin Hill Drive
Greensburg, PA 15601

November 2020

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1.0 INTRODUCTION

In accordance with 40 CFR 257.103(f)(2), Allegheny Energy Supply Company, LLC, a FirstEnergy Company ("Allegheny Energy") has prepared this demonstration for approval to extend the closure deadlines for the McElroy's Run Disposal Impoundment (the "Impoundment") based on permanent cessation of the coal-fired boilers at the Pleasants Power Station (the "Station") by October 1, 2024 and cessation of the acceptance of waste from the Station at the Impoundment on October 17, 2024 to achieve closure of the Impoundment by October 17, 2028.

1.1 GENERAL SITE DESCRIPTION AND HISTORY

The Station is a 1,300-megawatt (MW) coal-fired steam electric generating station located near the community of Willow Island in Pleasants County, West Virginia. It consists of two power generating units (Units 1 and 2) that commenced operation in 1979 with the start-up of Unit No. 1 and was expanded in 1980 by the addition of Unit No. 2. A scrubber system was installed when the Station was originally built and was upgraded in 2007. In 1999, a gypsum plant was installed to convert scrubber slurry into wallboard-quality synthetic gypsum, with as much as 600,000 tons of gypsum capable of being produced in a single year. When gypsum production is active a significant portion of the scrubber slurry can be diverted from the Impoundment and beneficially reused. The Station is also equipped with Selective Catalytic Reduction (SCR) systems to remove nitrogen oxides from the flue gases.

The Impoundment is situated in the former McElroy's Run watershed approximately one mile east-southeast of the Station. It is part of a captive disposal facility that has received CCRs from the Station since the coal-fired boilers first came on-line. The disposal facility consists of both the Impoundment and the McElroy's Run Landfill (the "Landfill") which is a dry CCR disposal unit (refer to attached Figure 1-1). The Impoundment is situated in the upper portion of the watershed and has been in continuous use since the late 1970s. The Landfill is situated in the lower portion of the watershed (adjacent to, and overlying, the Impoundment dam), is lined, and has been in continuous use since the early 1990s. Immediately west of the current Landfill toe area are Sedimentation Pond Nos. 1 and 2, which are lined ponds that manage flows from the Landfill's leachate collection and leak detection/groundwater underdrain systems, stormwater runoff from the Landfill's haul road, and flows from the Impoundment dam's blanket/chimney drain system. Together the Landfill and Impoundment are regulated under West Virginia Department of Environmental Protection (WVDEP) Solid Waste/National Pollutant Discharge Elimination System (NPDES) Water Pollution Control Permit No. WV0079171 (the "WVDEP Permit").

The Impoundment was developed by sequential downstream construction of a dam regulated under West Virginia Dam Permit ID# 07302. The crest of the dam is at elevation (El.) 900 feet, with El. 887 feet as the permitted final level of CCRs, which provides a total storage capacity of 28,000,000 cubic yards. At the current water level, the total surface area of the Impoundment is approximately 255 acres and the in-place CCR volume is approximately 26,500,000 cubic yards. The Impoundment dam is constructed with a clay-filled cut off trench at the upstream toe and a clay blanket on the upstream slope to provide a low permeability barrier to flow. The downstream portion of the dam was constructed using compacted fly ash and intermittent layers of bottom ash that function as blanket/chimney drains to convey any seepage to a series of discharge/monitoring pipes. The downstream face of the dam is covered by the Landfill which WVDEP considers to be a buttress to the dam.

The dam was constructed with a concrete discharge tower which is outfitted with an operational sluice gate at El. 885 feet (which is typically closed) and a 24-inch square (former sluice gate) opening at El. 890 feet. This structure is used for secondary (overflow) discharge with the flow directed under the dam via a 3,600-foot long 36-inch diameter concrete pipe. Flow from the concrete pipe is conveyed to a spillway, which discharges to a channel that leads to McElroy's Run Creek (as per WV0079171). Currently, the primary discharge from the Impoundment is via a 12-inch diameter siphon line which maintains the Impoundment water level between El. 886 and 888. The siphon flow can either be diverted to the Station for use as makeup water or discharged to a permitted NPDES Outfall (No. 001) at the Ohio River. The siphon line is the primary operating mechanism for withdrawing water from the Impoundment to maintain the pool elevation behind the dam. A concrete-lined emergency spillway is located near the left (western) dam abutment with a crest at elevation 893.5.

1.2 IMPOUNDMENT OPERATIONS

The Impoundment receives sluiced flue gas desulfurization (FGD) scrubber by-product generated at the Station and other low-volume materials authorized under the WVDEP Permit. The sluiced FGD influent is comprised of approximately 15% CCR solids and 85% water and is pumped to the Impoundment at a rate of 1,500 to 2,000 gallons per minute (gpm) through two eight-inch diameter slurry lines to a valve station located near the western dam abutment. The FGD slurry can be discharged into the Impoundment at the valve station location or directed into a floating pipeline boom for discharge at various locations across the Impoundment (this is done in an attempt to uniformly fill the Impoundment pool area). The solids settle out and the water is either retained in the Impoundment (up to a specific elevation), sent back to the Station scrubber process for reuse, discharged to the Ohio River via NPDES Outfall No. 001, or a combination thereof. The Impoundment's effluent siphon line has a maximum operational discharge rate of 3,000 gpm. The water flow interconnection between the Station (specifically the scrubber process) and the Impoundment amounts to nearly 6.8 million gallons of potential water flow per day, apportioned as approximately 2.5 million gallons of influent and a maximum of 4.3 million gallons of effluent. This flow interconnection provides large and flexible storage-retention and flow-control functionality to maintain Station operations.

The remaining sluice area in the Impoundment is approximately 122 acres in size and provides approximately 1,500,000 cubic yards of disposal capacity, which constitutes approximately 5% of total permitted capacity. With this demonstration submission, Allegheny Energy proposes, pursuant to 40 CFR 257.103(f)(2), to continue Impoundment operations in their current manner until closure activities are initiated as presented in Section 5 of this demonstration, and hereby formally requests such approval.

1.3 REGULATORY BASIS AND DEMONSTRATION SUMMARY

On September 28, 2020, the United States Environmental Protection Agency's (USEPA's) final rule entitled *A Holistic Approach to Closure Part A: Deadline to Initiate Closure* (Federal Register, Vol 85, No. 168, pp. 53516-53566, August 28, 2020) (the "Final Rule") became effective. As relevant to this demonstration, the Final Rule:

- Specified that all unlined surface impoundments are required to retrofit or close;
- Reclassified compacted-soil-lined or clay-lined surface impoundments from "lined" to "unlined";
- Established a new deadline of April 11, 2021 for surface impoundments that are unlined or do not meet the location restriction for placement above the uppermost aquifer to stop receiving waste and begin closure or retrofit; and
- Established procedures for facilities to obtain additional time to manage their waste streams before initiating closure or retrofitting their CCR surface impoundments.

Pursuant to the Final Rule, Allegheny Energy hereby submits this demonstration that an extension of the closure deadline for the McElroy's Run Disposal Impoundment is warranted under 40 CFR 257.103(f)(2) - *"Permanent Cessation of Coal-Fired Boiler(s) by a Date Certain"* – and that all related requirements thereunder have been satisfied. Since the Impoundment is larger than 40 acres in size, that provision allows for continued disposal operations beyond April 11, 2021, but requires cessation of waste placement and completion of closure activities for the Impoundment by October 17, 2028. In order to obtain this extension, a disposal facility owner or operator must submit a demonstration to USEPA containing:

- 40 CFR 257.103(f)(2)(v)(A) – A narrative explaining on- and off-site options considered to obtain alternative capacity;
- 40 CFR 257.103(f)(2)(v)(B) – A risk mitigation plan describing the measures that will be taken to expedite any required corrective action and that contains the elements listed under (v)(B)(1) through (v)(B)(3);
- 40 CFR 257.103(f)(2)(v)(C) – The certification, supporting technical documentation, and reports listed under (v)(C)(1) through (v)(C)(8); and
- 40 CFR 257.103(f)(2)(v)(D) – The closure plan required by 40 CFR 257.102(b) and a narrative regarding the date by which the owner or operator intends to cease receipt of waste to meet the closure deadlines.

Allegheny Energy has prepared this demonstration to fulfill these requirements as follows: Section 2.0 presents the on-site and off-site alternative capacity assessments; Section 3.0 presents the Impoundment's risk mitigation plan; Section 4.0 presents the compliance certification and technical documentation and reporting requirements; and Section 5.0 presents the Impoundment closure approach and timing.

2.0 ALTERNATIVE DISPOSAL CAPACITY UNAVAILABLE

In accordance with 40 CFR 257.103(f)(2)(i) and 103(f)(2)(v)(A), a demonstration submitted under the alternative closure standard in Section 103(f)(2) must show that alternative on- or off-site capacity is not available. To assess the availability of on-site alternative capacity that would be compliant with both the CCR Rule and the West Virginia Solid Waste Management Rule ("33CSR1"), Allegheny Energy: (1) developed a list of potential options; (2) screened those options by performing a high-level qualitative assessment of fatal flaws and other critical factors; and (3) performed a more in-depth evaluation of the remaining option focused on physical, regulatory and scheduling limitations. This assessment is presented in Section 2.1 below. To assess the availability of existing off-site alternative capacity and the feasibility of developing new off-site capacity that would be compliant with the CCR Rule, solid waste rules in West Virginia (33CSR1) and Ohio (OAC Chapter 3745-29), and the dam safety rules in West Virginia (47CSR34) and Ohio (OAC Chapter 1501:21), Allegheny Energy: (1) identified existing off-site disposal impoundments and landfills in the Station's vicinity; and (2) performed a high level assessment of their ability to accept the Station's wastes and an evaluation of the major limitations in doing so. This assessment is presented in Section 2.2 below. Neither cost nor inconvenience were considered as part of the assessments in Sections 2.1 and 2.2.

2.1 ON-SITE ALTERNATIVE CAPACITY

The options listed below were identified as possible approaches for developing alternative on-site capacity. They were then screened for fatal flaws or other critical factors that would render them unviable for developing alternative capacity. Summaries of the options, screening considerations, and determinations of viability are as follows:

A. Clean Close Impoundment and Retrofit with Liner. This option entails rerouting all influent from the Impoundment to temporary water and solids management systems, draining the existing impoundment, dewatering and stabilizing/solidifying all of the in-place CCRs, excavating and hauling all of the materials to either an existing or new lined dry disposal landfill, retrofitting the entire watershed with a regulatory-compliant liner system, and then resuming inflow to the retrofitted Impoundment. This option has several fatal flaws that make it implausible, which include insufficient acreage at the site and limited acreage at the Station to construct temporary water and solids management systems. The existing on-site landfill, even at full build-out, does not approach the required volume of approximately 30,000,000 cubic yards to support both clean closure and continued Station operations during retrofit, nor is there space to do so through on-site expansion. Further, the time required and logistics associated with dewatering, stabilizing, excavating, transporting, and placing the approximately 26,500,000 cubic yards of existing in-place CCRs in a landfill, which would require approximately 1.5 to 2 million standard truck trips and removing almost 5,000 cubic yards of material a day, 365 days a year in order to complete clean closure within a 15 year timeframe.

B. Drain Existing Impoundment and Install Liner. This option entails retrofitting the impoundment's remaining disposal area with a regulatory-compliant liner system. The Impoundment is a valley fill that was designed and developed as a singular disposal area and not subdivided into discrete disposal areas that can be operated independently. This configuration does not allow for filling in one area while constructing a liner over another area. Also, as shown on Figure 1-1, the existing upgradient disposal areas are currently filled to the permitted disposal elevation, making them unsuitable for development as temporary disposal areas. Consequently, to implement this option, influent would need to be temporarily rerouted. This would require the development of new infrastructure to temporarily manage water and solids from the Station's scrubber system. The infrastructure would need to be installed at the Station or the disposal facility and would consist of new large-volume water storage tanks or pond(s); slurry and reuse water transmission piping, pumps and controls; and equipment for dewatering/stabilizing/solidifying, handling, and transporting CCRs from the water storage system for temporary placement on either filled areas of the Impoundment or on the Landfill. This option also requires the removal of free water from the Impoundment and performing extensive dewatering of the in-place CCRs in order to establish subgrade conditions that allow for both the safe installation and proper long-term performance of a regulatory-compliant liner system.

In addition to the technical limitations discussed above, the time needed to plan, complete studies/testing, design, and permit temporary systems to reroute influent and retrofit the Impoundment with a liner system under West Virginia's 33CSR1 Class F industrial waste regulations; prepare the Impoundment for construction (i.e., dewater the pool and in-place CCRs); and construct the influent rerouting system and Impoundment liner system, is expected to require between 5 and 7 years. This timeframe is inconsistent with the continued operation of the Station given the current cessation of waste deadline for the Impoundment set forth in 40 CFR 257.101. In addition, as previously noted in Section 1.2, the Impoundment's remaining disposal volume is approximately 5 percent of the total permitted disposal capacity. Consequently, after retrofitting the Impoundment, the newly lined disposal area would only provide 3.5 to 9 years of CCR capacity, depending on the Station's utilization rate. Taking all the aforementioned factors into consideration, this option is not viable.

C. Vertically Expand Existing Impoundment and Install Liner. This option would entail raising the impoundment dam above its existing crest elevation to increase capacity, modifying all the Impoundment inlet and outlet works to accommodate the new operating levels, and lining both the existing disposal area and the upland slope areas with a regulatory-compliant liner system up to the new maximum disposal elevation. This option presents the same temporary influent rerouting issues and design, permitting and construction time constraints as the retrofitting options outlined above. In addition, this option would require an added permitting effort through West Virginia's Dam Safety Section. Taking all these factors into consideration, this option is not viable.

D. Construct New Impoundment in Undeveloped Area on Site. This option would entail siting and constructing a new lined disposal impoundment at the site and permanently rerouting the influent and effluent piping systems to service the new impoundment. As a newly permitted disposal area, the location criteria and design requirements of the CCR Rule and 33CSR1 would apply and major modifications to the facility's state-issued Solid Waste/NPDES permit would be required. As presented on Figure 1-1, the Impoundment is bounded by the facility's property line to the southwest, south, east, and northeast, which generally follows the surrounding ridgeline in those directions. The Impoundment is also bounded to the north and northwest by the Landfill and its associated leachate/stormwater ponds (Sedimentation Pond Nos. 1 and 2), which are the only other on-site ponds. With a combined surface area of 4.5 acres, these ponds are far too small to be repurposed for alternative disposal capacity themselves. As such, the only remaining undeveloped on-site areas are the upland slopes above the Impoundment pool and the storage/laydown area located down-valley (southwest) of the Landfill's leachate/stormwater ponds.

The upland slopes are situated between the Impoundment's pool and the ridgeline surrounding the pool. Due to a combination of their topographic and geologic settings, areal positioning, and associated size limitations, the upland slopes cannot be developed to provide sufficient capacity to support Station operations and they are unlikely to meet all required location restrictions, particularly with respect to the 33CSR1 requirements for bedrock separation distance. Similarly, the area down-valley of Landfill Sedimentation Pond Nos. 1 and 2 is not large enough to develop sufficient capacity to support Station operations and is unlikely to meet location restrictions, particularly with respect to the CCR Rule and 33CSR1 requirements for aquifer separation distance. Taken together, the inability to provide sufficient operating capacity and to meet required regulatory location criteria are considered fatal flaws and this option is not viable.

E. Vertically Expand Filled Areas Within the Impoundment Watershed. This option would entail constructing new containment dikes atop filled areas in the Impoundment's upstream watershed and lining both the existing disposal areas and the adjacent upland slope areas with a regulatory-compliant liner system up to the new maximum disposal elevation. A more in-depth evaluation of this option is presented in Section 2.1.1 below, which concludes that it too is not viable.

2.1.1 Application of On-Site Capacity Evaluation Criteria

As noted above, Option E (vertically expand filled areas within the Impoundment watershed) was selected for further consideration. Two filled areas within the existing Impoundment's watershed (referred to as Slurry Areas A and C) were identified for additional assessment for potential vertical expansion. These areas are shown on attached Figure 2-1 and summarized in Table 2-1 below:

Table 2-1. Key Metrics for Conceptual On-Site Vertical Expansion Disposal Areas[1]

Area Description	Size (Acres)	Estimated Total Capacity (MCY)[2]	Estimated Net Available Capacity (MCY)[3]	Estimated Disposal Life (Years)
Slurry Area A	78	2.6	2.2	4.7 to 12
Slurry Area C	157	6.4	5.6	12 to 30.6
Totals:	**235**	**8.9**	**7.7**	**16.7 to 42.6**

Notes:

[1] Values reported are concept-level estimates assuming a range of disposal rates varying between 460,000 and 180,000 cubic yards per year, with volumes in million cubic yards (MCY).

[2] Volume is total available between existing ground surface (natural ground and filled CCRs) and elevation 950, which represents the approximate lowest elevation points between surface drainage area divides around the conceptual development area perimeters.

[3] Volume is net available after accounting for required subgrade/liner system, final cover system, and operating freeboard.

Application of the evaluation criteria to determine the feasibility of developing these areas are based on physical, regulatory, and schedule limitations as presented in the subsections below.

2.1.1.1 Physical Limitations

These criteria include high-level engineering considerations associated with developing on-site capacity through vertical expansion which include existing utility locations, stability of in-place materials and structural integrity of the impoundment, leachate management, and soil availability.

Existing Utility Locations. The entire disposal facility property has an extensive history of oil and gas exploration, extraction, and transmission activities performed by several private companies that are not affiliated with Allegheny Energy. The upland areas situated between the existing Impoundment pool and surrounding ridgelines contain several active gas extraction wells and an extensive network of mapped and unmapped buried and above-ground oil and gas transmission pipelines. In order to develop Slurry Areas A and C, the wells and pipelines that fall within the conceptual expansion disposal limits would have to be relocated and/or abandoned. This presents significant engineering and timing issues since agreements with the various utility owners may be technically impractical or require extensive negotiations or litigation to resolve.

Stability of In-place CCR Subgrade and Impoundment Structural Integrity. The in-place strength of impounded CCRs that would function as subgrade material is critical to stability and constructability of any vertical expansion area within the Impoundment, particularly the CCRs that would serve as foundation materials for new containment dikes. Impounded CCR material properties can vary significantly across and at depth in an impoundment, resulting in localized areas of low shear strength and significant differential settling, which are not suitable for vertical expansion without significant ground improvements. The impounded CCRs at the site are FGD scrubber by-products and these types of materials oftentimes exhibit both hydrophilic and thixotropic behaviors. As such, they are unlikely to have acceptable strength characteristics for use as subgrade materials and would require extensive ground improvements such as dewatering, in-situ stabilization/solidification, surcharging, or some combination of these methods. Extensive geotechnical investigation would be necessary to determine the type(s) and extent of ground improvements necessary which may still present insurmountable issues due to performance limitations and/or related implementation and timing problems.

Leak Detection. 33CSR1 requires disposal impoundments to use a double liner with a leak detection system (LDS). In order to effectively collect and convey flow in a timely manner, the LDS would require subgrade construction with some minimum slope to promote gravity drainage during initial disposal operations (i.e., when there would be a low hydraulic gradient driving flow through a primary liner leak point and into the LDS). Similar to the low strength concerns discussed above, impounded CCRs tend to exhibit a high degree of compressibility due to their method of deposition. This high compressibility results in total and differential settlement concerns for the impounded materials used as LDS subgrade that would need to be mitigated with the same type(s) of ground improvement techniques (and underlying fundamental concerns) noted above.

Soil Availability. The proposed vertical expansion over Slurry Areas A and C would add to the site's already extensive soil demand which includes subgrade and soil liner for future permitted development areas at the on-site landfill; cover soil for closure of the on-site landfill; and cover soil for closure of the existing Impoundment's disposal area (approximately 255 acres). Development of Slurry Areas A and C would require additional soil to establish LDS subgrade (as noted above) and to close the additional disposal area (approximately 94 acres) that would be situated above the current permitted disposal elevation. Available on-site soil may be limited as existing borrow areas have been depleted over the last several years to construct and operate the on-site landfill. In addition, the development of remaining on-site borrow areas will be restricted by existing oil and gas utility conflicts, as discussed above. To support detailed closure design activities, additional field investigation work will be performed to determine the remaining on-site borrow soil resources and, if they are found to be insufficient to operate and close the site, off-site borrow areas would need to be acquired and developed to meet soil demands associated with any expansion effort.

2.1.1.2 Regulatory Limitations

For decades the disposal facility, permitted by the WVDEP, has undergone extensive studies and investigations to support the ongoing development of the Landfill and the Impoundment. Throughout the site's regulated history, it has been developed to comply with the location, design, operating, and groundwater monitoring requirements of 33CSR1. A vertical expansion of Slurry Areas A and C would similarly need to comply with 33CSR1 but also with the siting, design, and operating criteria in the CCR Rule. Taking both sets of regulations into consideration, the following requirements were identified that would inhibit development of this on-site disposal capacity:

Location Restrictions. In 2018, the existing facility design was evaluated for compliance with the CCR Rule's location restrictions, with the offsets to wetlands, fault areas, and seismic impact zones being found to meet the requirements of 40 CFR 257.61(a), 62(a), 63(a), and 64(a). Consequently, a vertical expansion of Slurry Areas A and C could be developed in compliance with these CCR Rule requirements as well as the corresponding requirements set forth in

33CSR1. However, the existing disposal area was determined to be non-compliant with the uppermost aquifer offset requirement of 40 CFR 257.60(a). Based on the geologic and hydrogeologic conditions of the slope areas situated above the existing Impoundment pool, it is unlikely that the vertical expansion of Slurry Areas A and C would comply with the aquifer offset requirement of the CCR Rule or the bedrock separation distance requirement of 33CSR1. Potentially, a significant volume of added geologic material could be placed in those expansion areas to achieve compliance. However, the added soil demand would increase the site's already large required soil needs and further strain the limited remaining on-site borrow areas.

In addition to the location restrictions noted above, an expansion of the facility would need to meet the offset requirements set forth in 33CSR1 for property lines, surface waters, perennial streams, floodways, highways, public parks, airports, dwellings, water supplies, underground mines, and surface mines. A general evaluation of these requirements indicates that the property line offsets could prove to be problematic for Slurry Areas A and C. These require a minimum separation of 100 feet between the limit of waste and the property line, and 50 feet between permanent berms or excavations (not related to surface water diversion) and the property line. These offsets were incorporated into the conceptual disposal area limits shown on attached Figure 2-1, but they could significantly impact the vertical expansion layout and associated capacity once detailed layout and design of ancillary features (e.g., access roads, stormwater collection channels, staging areas, etc.) were to be performed as these features could end up reducing the available disposal area footprint in order to maintain the required offsets.

Design Criteria. As discussed in Section 2.1.1.1, significant ground improvements to the in-place CCRs would be needed to provide a stable subgrade for the liner system. Without these improvements, localized areas of low strength waste and significant total/differential settlements are expected. As also noted in Section 2.1.1.1, such ground improvements may present insurmountable issues due to performance limitations and/or related implementation and timing problems.

Groundwater Monitoring. The potential vertical expansion of Slurry Areas A and C would need to comply with the CCR Rule and 33CSR1 with regard to groundwater monitoring systems. The expansion would necessitate the abandonment and relocation of multiple wells within the proposed expansion area limits. Two of the wells have been in use in the state monitoring program for over 25 years. All of the impacted wells would need to be relocated towards or onto the surrounding ridgeline, which could make it more difficult to develop replacement wells that have similar yields and geochemical conditions as the original wells. This would have a particularly significant impact on the 33CSR1 monitoring program which utilizes intrawell analyses.

2.1.1.3 Schedule Limitations

As outlined in the preceding sections, there are several significant limitations associated with the planning, design, permitting, and construction of the potential vertical expansions of Slurry Areas A and C. Although the physical and regulatory limitations provide sufficient indication that this option is not viable even if unlimited time for implementation was available, there are also significant scheduling limitations that would affect the development of alternative on-site capacity as outlined below:

Schedule Limitations. As noted in the preceding sections, the potential vertical expansions of Slurry Areas A and C would require permitting and approvals issued through WVDEP's Solid Waste and Dam Safety Sections. The timeline for preparing the submittals required to obtain these permits, construct the first new disposal area, and obtain an approval to operate would take substantially longer than the time afforded by the revised CCR Rule at 257.101(a)(1), which specifies an April 11, 2021 date for cessation of waste placement in the Impoundment. The key activities in this process and their estimated time to complete include:

- Field investigations/sampling/testing and studies (6 to 9 months);
- Engineering and environmental design and permit application preparation and submission (9 to 12 months);
- Regulatory agency review/comment/response cycles and permit issuance (12 to 18 months);
- Construction package preparation/bidding/award (3 to 6 months);
- Construction of one area and certification report preparation and submission (24 to 30 months);
- Regulatory review/comment/response cycles and approval to operate (3 to 6 months).

Based on these estimated activity durations, and assuming no interruptions, additional complications, or delays, the total time to initially develop either Slurry Area A or C for CCR acceptance would vary between 57 and 81 months (approximately 5 to 7 years).

Taking all the physical, regulatory, and scheduling factors presented above into consideration, alternative on-site capacity is unavailable to support Station operations.

2.2 OFF-SITE ALTERNATIVE CAPACITY

An evaluation of potential off-site locations for the disposal of the Station's FGD waste was performed. Sites within a 50-mile radius of the Station were identified from publicly available records based on the following assumptions:

- The volume of FGD solids and water (slurry) generated is approximately 1,500 to 2,000 gallons per minute (gpm) or approximately 2,200,000 to 2,900,000 gallons per day.
- Based on an assumed density of 8.3 pounds per gallon, the mass of FGD to be managed off-site is estimated to be approximately 9,000 to 12,000 tons per day.
- Disposal impoundments and landfills were considered the only types of existing facilities that could potentially manage the estimated quantity of FGD material. Consideration was also given to assessing commercial industrial wastewater treatment (IWT) facilities that may exist within the study radius. However, the extremely high daily volume and significant solids content of the slurry flow that would need to be managed would exceed the typical capabilities of commercial IWT facilities even without considering the existing treatment obligations they were created to meet. In addition, the logistics of establishing a reliable means to transport the slurry from the Station to the IWT (e.g., a pipeline or transport via tanker trucks) would also be prohibitive. Thus, conveying and adding these extremely high-volume flows with high solids content to existing treatment streams at an operating IWT facility was determined to be an unrealistic option and was omitted from further evaluation.
- 50 miles is a sufficiently large search radius to identify the range of potentially feasible off-site disposal options given the geographic location of the Pleasants Station and accounting for limiting logistical factors such as a rational hauling truck fleet size and the associated number of daily truck turns/trips that would be required while being performed safely and minimizing quality of life impacts for the communities through which hauling traffic would be routed.

Existing disposal impoundments and landfills were selected for evaluation because they were the only facilities deemed likely to provide the disposal services needed to support the Station in a timely manner. Consideration was also given to developing a new off-site disposal impoundment (referred to as a "greenfield development"), however, this option was unviable due to the following:

- Greenfield development would first require commissioning and completing a siting study to identify and evaluate potentially viable properties within a rational transport distance from the Station. These studies involve both desktop and field assessments of a broad range of environmental and socio-economic effects, permitting, engineering, and construction issues. This is a process that typically takes between one and one-and-a-half years to complete.
- Land acquisition would be needed for the selected site. This typically presents significant issues due to the need to secure a property or multiple properties large enough to develop a disposal site. This involves extensive negotiations that often take several months to several years to complete.
- Once the property for a site was acquired, detailed field investigations and studies, engineering design, permitting, and construction would all need to be completed before the site would be ready to receive CCRs. This is a process that typically takes three to five years and sometimes longer to complete.

Taking all the factors presented above into consideration, development of a new off-site disposal impoundment would not provide viable alternative disposal capacity within a timeframe that would allow the continued operation of the Station.

Within the following sections, existing disposal impoundment and landfill sites within the 50-mile radius study area were evaluated based on physical, regulatory, and schedule limitations.

2.2.1 Physical Limitations

2.2.1.1 Evaluation of Existing Impoundments

One of the primary functions of an FGD impoundment is to treat the slurry by allowing FGD solids to separate from transport water. Once separated, the transport water is typically discharged under an NPDES permit. Achieving the permitted water quality standards prior to discharge requires sufficient residence time within the impoundment, which is largely a function of its size and configuration. Only candidate impoundments with 50 or more acres of surface area were evaluated for this demonstration based on the assumption that smaller impoundments would be unlikely to consistently provide sufficient residence time for settling/treatment given the Station's daily slurry production rate.

Candidate impoundments were identified using the United States Army Corps of Engineers (USACE) National Inventory of Dams database. Dams within the search radius were then screened by purpose and surface area. An appropriate existing dam, at a minimum, would have a purpose type of “tailings” (fine-grained waste) and a surface area greater than or equal to 50 acres.

Based on the USACE database, there are seven existing dams in West Virginia that provide tailings disposal within 50 miles of the Station, as summarized in Table 2-2 below and shown on attached Figure 2-2.

Table 2-2. West Virginia Tailings Dams in Study Area

Dam Name	Surface Area (acres)	City	Distance from Station (miles)
Sporn Bottom Ash Dam	9.5	New Haven	43.8
Momentive Landfill #2	10	Long Reach	14.0
Mitchell Bottom Ash Ponds	11.9	Graysville	40.6
AEP Project 1301 Ash Pond	55	New Haven	44.0
Sporn Unit 5 Fly Ash Dam	70.3	New Haven	43.5
Conner Run Refuse Impoundment	155	Wheeling	40.7
Nolan Run Slurry Impoundment	NA, Closed	Lumberport	49.0

Based on this screening for West Virginia, there are three existing dams permitted for tailings greater than or equal to 50 acres within 50 miles of the Station that were identified as potentially suitable alternative disposal options. However, all three facilities were determined to be unavailable for use due to the following:

- The AEP Project 1301 Ash Pond (also known as the 1301 Ash Pond Dam or Bottom Ash Complex) is a component of American Electric Power's (AEP's) Mountaineer Power Plant located in New Haven, West Virginia. Based on documentation available on AEP's publicly available CCR compliance web site, the Mountaineer Plant Bottom Ash Complex was not constructed with a liner that meets the requirements of 40 CFR 257.71(a). In a progress report dated March 2020, AEP indicated they plan to close the bottom ash pond by removing the ash. Based on the lack of a regulatory-compliant liner and AEP's plan to clean close the CCR unit, this facility is unavailable for alternative capacity.

- The Sporn Unit 5 Fly Ash Dam is a component of AEP's Sporn Generating Station (also known as the Philip Sporn AEP Plant) which is also located in New Haven, West Virginia. This impoundment was officially retired in February 2012 under the provisions of its WVDEP Solid Waste/NPDES permit, and the plant was deactivated in May 2015. Due to the impoundment's closed status, this facility is unavailable for alternative capacity.
- The Conner Run Refuse Impoundment (also known as Conner Run Dam) is an impoundment formerly associated with AEP's Mitchell Power Station and is located in Moundsville, West Virginia. The impoundment was constructed in 1976 and was used for commingled fly ash and coal refuse disposal. Sometime during or before 2015, the Mitchell Power Station switched to dry fly ash handling and ownership of the impoundment was transferred from AEP to the Murray Energy Company. Since that time, Murray Energy has used the facility to manage coal slurry. Based on the age of this impoundment, it is highly unlikely to meet the liner requirements of 40 CFR 257.71(a). Based on the impoundment's unlikelihood of having a regulatory-compliant liner, this facility is unavailable for alternative capacity.

Based on the assessments noted above, there are no existing impoundments in West Virginia permitted for tailings that are greater than or equal to 50 acres in size and within 50 miles of the Station that are considered available alternative disposal options.

Based on a similar USACE database search for Ohio, there are 25 existing dams with the intended purpose of disposing tailings, as summarized in Table 2-3 below and shown on Figure 2-2.

Table 2-3. Ohio Tailings Dams in Study Area

Dam Name	Surface Area (acres)	City	Distance from Station (miles)
Ohio PCP MM-85	1.2	Unionville	33.9
Ohio PCP MB-165	2.4	Unionville	33.5
Ohio PCP MB-64 Dam	2.6	Renrock	33.5
Ohio PCP MB-166	4.6	Unionville	34.5
Eramet Slag Tailings Pond	5.2	Briscoe	12.4

Dam Name	Surface Area (acres)	City	Distance from Station (miles)
Ohio PCP NB-90 Dam	5.5	Renrock	33.9
Ohio PCP MB-144 Pond	5.7	Unionville	35.1
Ohio PCP MB-133 Dam	6	Meigs	36.2
Ohio PCP MMV-11 Dam	6.4	Unionville	31.7
Thomas Lake Dam	6.5	Tropic	46.6
Ohio PCP MB-115 Dam	7.2	Unionville	35.6
Ohio PCP MB-141 Dam	8.9	Unionville	35.5
Eramet Fluid Waste Pond 1A	9.9	Briscoe	12.3
Ohio PCP MM-62 Dam	10	Unionville	33.2
Horse Run No. 3 Dam MB-40	12	Unionville	34
Ohio PCP NB-43 Dam	13.1	Renrock	33.7
Muskingum River Middle Fly Ash Dam	17	Beverly	25.8
Muskingum River Lower Fly Ash Dam	18	Beverly	25.9
Ohio PCP MM-52 Dam	19	Unionville	32.1
Horse Run No. 1 Dam MB-42	27	Unionville	34.5
Ohio PCP MB-46 Dam	42	Unionville	34.2
Eramet Waste Retention Dam	76.2	Briscoe	12.2
Muskingum River Upper Fly Ash Dam	148	Beverly	25.4
The Ohio Valley Coal Slurry Disposal Dam	292.3	Alledonia	41.4
No. 2 Slurry Pond	NA	Alledonia	41.5

Based on this screening for Ohio, there are three existing dams permitted for tailings greater than or equal to 50 acres in size and within 50 miles of the Station that were identified as potentially suitable alternative disposal options. However, all three facilities were determined to be unavailable for use due to the following:

- The Eramet Waste Retention Dam is a structure used for storage of residual sludge (manganese ferroalloys and manganese dioxide by-products) from mining activities. Based on information from Eramet's website, the impoundment initially began operating in 1977. Given the age of the impoundment, it is unlikely to meet the liner requirements of 40 CFR 257.71(a). In addition, the Ohio Department of Natural Resources (ODNR) completed a risk assessment and found the Eramet facility to have high flooding risk, high mass movement risk, and medium severe weather risk. Due to the impoundment's elevated risks and unlikelihood of having regulatory-compliant liner, this facility is unavailable for alternative capacity.

- The Muskingum River Upper Fly Ash Dam was completed in 1975 and was a component of AEP's former Muskingum River Power Plant, located in Waterford, Ohio. The plant was decommissioned under the Ohio Environmental Protection Agency's Voluntary Action Program (OEPA VAP) and sold to Commercial Liability Partners (CLP) in 2015. CLP is currently in the process of closing the Upper Fly Ash Dam (pond) using an OEPA-approved aquatic habitat liner system and plans to redevelop the site as an industrial park and a wildlife preserve. Due to the closure of this impoundment, it is unavailable for alternative capacity.
- The Ohio Valley Coal Slurry Disposal Dam ("OVCSDD") is a coal wash slurry disposal facility owned by The Ohio Valley Coal Company, and is located in Alledonia, Ohio. While this site is large enough for the waste stream, the impoundment is permitted for the management of coal wash slurry, not CCRs. The facility was constructed in 1981 and, at that time, it was standard practice to line surface impoundments with natural in-place soil or reconstructed soil. Thus, it is unlikely the impoundment meets the liner requirements of 40 CFR 257.71(a) which specify a composite liner or equivalent. Due to the impoundment's permitted use and unlikelihood of complying with liner requirements, this facility is unavailable for alternative capacity.

Based on the assessments noted above, there are no existing impoundments in Ohio permitted for tailings that are greater than or equal to 50 acres in size and within 50 miles of the Station that are considered available alternative disposal options.

2.2.1.2 Evaluation of Existing Landfills

Landfills located within 50 miles of the Station were identified using databases from the West Virginia Department of Environmental Protection (WVDEP) and the Ohio Environmental Protection Agency Geographic Information System (OEPA GIS).

Based on the search criteria for West Virginia, five existing landfills were identified; they are summarized in Table 2-4 below and shown on Figure 2-2. Only three of the landfills are currently active commercial facilities and two of the facilities have been closed and are currently in post-closure monitoring.

Table 2-4. West Virginia Landfills in Study Area

Landfill Name	Type	Facility Capacity (tons/day)	City	Distance from Station (miles)
Northwestern Landfill	Municipal	~1,000	Parkersburg	13.3
Wetzel Co. Landfill	Municipal	~350	New Martinsville	28.6
S&S Landfill	Municipal	~350	Clarksburg	48.5
Jackson Co. Landfill	Municipal	NA, Post-Closure	Western	48.8
City of Moundsville	Municipal	NA, Post-Closure	Rosbys Rock	45.5

As the mass of FGD to be managed is approximately 9,000 to 12,000 tons per day, this screening indicates there are no active landfills in West Virginia with sufficient disposal capacity to receive the quantity of FGD material generated by the Station.

For the state of Ohio, there were two existing landfills identified within 50 miles of the Station, however, only one is actively receiving waste material, as summarized in Table 2-5 below and shown on Figure 2-2.

Table 2-5. Ohio Landfills in Study Area

Landfill Name	Type	Facility Capacity (tons/day)	City	Distance from Station (miles)
Athens-Hocking	Construction and Demolition Debris (C&DD) Landfill	2,500 tons/day	Nelsonville	49.8
Karrten	C&DD Landfill	NA, Post-Closure Status	Pomeroy	46.0

The Athens-Hocking Landfill Reclamation Center (Athens-Hocking) does not have sufficient capacity for the quantity of FGD material from the Station and is not permitted to accept FGD Waste. In addition, since both facilities are construction and demolition debris (C&DD) landfills, it is almost certain they were constructed with state-required soil-only C&DD landfill liners, which are not compliant with the liner system requirements of the CCR Rule. Based on these key factors and considering the transportation logistics issues and material amendment/solidification system that would need to be developed to landfill the Station's CCRs, there are no existing landfills in Ohio within 50 miles of the Station that are considered available alternative disposal options.

2.2.2 Regulatory Limitations

The McElroy's Run Disposal Impoundment is regulated under WVDEP Solid Waste/NPDES Permit No. WV0079171. This permit allows the facility to receive FGD scrubber by-product, effluent from the scrubber recirculation system, and waste materials collected as a result of general house-cleaning, maintenance and/or repair at the Station.

As previously noted in Section 2.2.1.1, based on the USACE dam database, there are six impoundments within 50 miles of the Station which are large enough to potentially provide alternative disposal capacity. Each has a regulatory limitation that impacts its potential use for alternative capacity, as summarized below:

- The Mountaineer Plant Bottom Ash complex was not constructed with a liner system that meets the requirements of 40 CFR 257.71(a);
- The Sporn Unit 5 Fly Ash Dam was closed in accordance with its state-issued Solid Waste/NPDES permit and is currently in post-closure monitoring;
- Given its construction date, the Conner Run Refuse Impoundment is highly unlikely to meet the impoundment liner requirements of 40 CFR 257.71(a);
- The Eramet Waste Retention Dam is permitted to manage residues (manganese ferroalloys and manganese dioxide by-products) from mining activities, not CCRs, and is separately unlikely to meet the liner requirements of 40 CFR 257.71(a);
- The Muskingum River Upper Fly Ash Dam is currently being closed under OEPA regulatory oversight; and
- The OVCSDD is permitted to manage coal wash slurry, not CCRs, and is separately unlikely to meet the liner requirements of 40 CFR 257.71(a).

Based on a review of the WVDEP and the OEPA GIS databases, there are also no existing landfills within 50 miles of the Station that are permitted to receive FGD slurry, even if they had sufficient capacity. Conversations with commercial landfill managers in both Ohio and West Virginia further confirmed that there are no landfills permitted to receive the daily quantity of FGD materials generated by the Station.

In addition to the issues presented above, there are other significant regulatory limitations associated with the potential use of any of the facilities identified herein, such as the difficulty in obtaining both regulatory agency and public approval of interstate waste transfer for facilities located in Ohio, and the likelihood that all of the mining sites identified above have legacy environmental impacts that could preclude modifying their permits to accept CCRs. Taking all these factors into consideration, there are no off-site disposal impoundments or landfills that could provide viable alternative disposal capacity from a regulatory perspective that are located within the 50-mile study area.

2.2.3 Schedule and Infrastructure Limitations

Given the nature and quantity of the materials generated by the Station, the nature and capacity of facilities located within a 50-mile radius of the Station, and the existing regulatory constraints discussed above, there are no existing impoundments or landfills that could serve as alternative capacity for the disposal of FGD material. Even if the search had identified a potentially viable off-site waste disposal facility, or if it were possible to develop a new facility, the logistics of establishing a reliable means to transport the FGD waste would still be prohibitive. For example, if a pipeline were selected as the means to transport FGD slurry, the ruggedness of the terrain to be traversed, the environmental impacts associated with developing a pipeline corridor of this size, the large amount of support infrastructure required (e.g., booster stations), the large volumes of material being transported, and the associated risk for large-scale inadvertent releases would result in a design, permitting, land acquisition, construction and approval process that would be very challenging under state and federal regulatory programs. Under the best of circumstances, these steps would require 5 years or more for permitting and construction.

Similarly, if over the road transport via tanker trucks were selected as the means to deliver FGD materials to a landfill in slurry form, an estimated 200 to 300 tanker trucks per day, operating around the clock, would be required. This volume of truck traffic would challenge or detrimentally impact existing infrastructure, could require infrastructure improvements involving efforts by local and state governments with their own funding and timing constraints, and would likely be met with considerable public opposition (e.g., nuisance allegations). Once the slurry was delivered to the landfill, dewatering and/or the addition of amendments would be needed prior to disposal. This would require installation of dewatering equipment, which takes an extended period to design, construct and install, and/or the use of significant quantities of amendment which have their own environmental and permitting ramifications.

Taking all the physical, regulatory, and scheduling factors presented above into consideration, alternative off-site capacity is unavailable to support Station operations. This finding is consistent with USEPA's guidance that "it would be illogical to require these facilities to construct new capacity" until plant closure occurs (85 Federal Register at 53, 548).

3.0 RISK MITIGATION PLAN FOR GROUNDWATER IMPACTS

In accordance with 40 CFR 257.103(f)(2)(v)(B) of the Final Rule, a demonstration submitted under the alternative closure standard in Section 103(f)(2) must include a plan to mitigate potential risks to human health and the environment due to groundwater impacts from continued use of the CCR surface impoundment. This plan must include a discussion of physical and chemical measures that could be taken to limit future releases to groundwater during continued operations; a discussion of the surface impoundment's groundwater monitoring data and any found exceedances; plume delineation (if necessary based on the groundwater monitoring data); identification of potential nearby receptors that might be exposed to current or future groundwater contamination; how such exposures could be promptly mitigated; and a plan to expedite and maintain containment of either an existing or future contaminant plume identified during continued operations. The following subsections present all the aforementioned risk mitigation plan components for the McElroy's Run Disposal Impoundment.

3.1 CCR RULE GROUNDWATER MONITORING

Under the WVDEP Permit, a groundwater monitoring program has been in effect at the site since 1994. Over the years, the total number of monitoring wells and piezometers used in that program varied to support development of the site as the Impoundment pool level was increased and the Landfill was laterally expanded. When the CCR Rule became effective in 2015, the WVDEP groundwater monitoring network consisted of 17 monitoring wells; 14 that were active and three that were inactive but used occasionally for water level readings. At that time, Allegheny Energy reviewed the existing monitoring network information and site hydrogeologic data to evaluate the suitability of the existing WVDEP wells for use in the CCR Rule monitoring program. Under the CCR Rule, the Landfill and Impoundment were considered two separate, existing CCR units that share a common boundary (the Impoundment dam). As such, a multiunit groundwater monitoring system encompassing both the Landfill and Impoundment was established for the site. It was determined that several of the WVDEP wells could not be integrated into the multiunit CCR Rule program and that additional monitoring wells were needed to establish a network that met the applicable requirements and performance standards for groundwater monitoring under the CCR Rule. The additional groundwater monitoring wells (nine total) were subsequently installed at the site in 2016.

The site's current CCR Rule groundwater monitoring network is shown on attached Figure 3-1. The network consists of 13 wells, four of which are also part of the WVDEP monitoring program.

It includes three upgradient (background) wells (GW-7, -21, and -22), six downgradient wells to monitor the northern/northeastern side of the site (GW-19, -20, -23, -24, -25, and -26), and four downgradient wells to monitor the western/northwestern side of the site (GW-9, -27, -28, and -29). This network monitors fractured bedrock flow in multiple vertically connected sandstone units at the site, including (listed in descending order) the Lower Connellsville, Morgantown, Grafton, Jane Lew, and Saltsburg sandstones, which have been collectively identified as the uppermost aquifer for CCR Rule groundwater monitoring at the site. Drilling logs and well construction diagrams for the CCR monitoring network are included as Attachment 3-1 of this demonstration. The CCR Rule groundwater monitoring program was initiated in 2016 and has been in effect continuously since that time as documented in the annual groundwater monitoring and corrective action reports included as Attachment 3-2 of this demonstration. The WVDEP groundwater monitoring program, required by 33CSR1, has also remained in effect but is managed separately from the CCR Rule program due to differing monitoring and reporting requirements in the facility's state-issued permit.

3.1.1 Detection Monitoring and Appendix III Alternate Source Demonstration

Allegheny Energy initiated CCR Detection Monitoring (DM) with the collection of the first DM samples in September and October of 2017 (referred to hereafter as sampling event DM-1). Statistical evaluation of the DM-1 data was subsequently completed in January 2018, and it was determined that Statistically Significant Increases (SSIs) existed for Appendix III parameters. Based on the parameters for which SSIs were identified, an Appendix III Alternative Source Demonstration (ASD) was undertaken. However, that ASD ultimately found that not all identified DM-1 Appendix III SSIs could be attributed to alternative sources. As such, a transition was made to the applicable requirements of CCR Rule Assessment Monitoring (AM) and the notification of such was posted to the facility's publicly accessible website in September 2018 as documented in Section 4, Table 4.1 of this demonstration.

3.1.2 Assessment Monitoring and Appendix IV Alternate Source Demonstration

The first AM event at the site was conducted in May 2018 (AM-1) and the second event in August 2018 (AM-2). AM sampling and analysis has continued since that time with a total of six AM events completed to date. All AM statistical evaluation work has been performed in accordance with certified methods and the results were used to determine whether there were any detected Appendix IV parameters at Statistically Significant Levels (SSLs) above the site's established

Groundwater Protection Standards (GWPS). Statistical evaluation of the AM-1 and AM-2 data initially identified arsenic, barium, fluoride, lithium, and radium along the site's northern boundary and arsenic along the western boundary as parameters detected at concentrations greater than their respective GWPS. In accordance with the CCR Rule, notification of these Appendix IV parameter SSLs was prepared and posted to the facility's publicly accessible website in April 2019 as documented in Section 4, Table 4-1 of this demonstration. However, subsequent to the AM-1 and -2 statistical evaluations, groundwater level data collected at the site necessitated a modified interpretation of current groundwater flow patterns along the northern boundary and an associated revision to the upgradient well comparisons in that area. The revised statistical evaluations determined that arsenic SSLs occurred in more wells than previously indicated but that fluoride was no longer an SSL for the single well in which it had originally been identified. As such, fluoride was no longer identified as an SSL at the site.

To date, results from statistical analysis of the AM-1, -2, -3, -4, and -5 data have been consistent with respect to having SSLs for arsenic, barium, lithium, and radium along the northern boundary and arsenic along the western boundary (AM-6 data development is currently underway). However, there have also been one-time SSLs identified for cobalt in well GW-26 and molybdenum in well GW-20. The validity of these individual SSLs is in question as, for GW-26, this was the first time a sample was able to be recovered during Assessment Monitoring and cobalt was not detected in any of the well's background sampling events. For GW-20, all previous background and AM sampling results for molybdenum were below the GWPS. These results are currently being assessed to determine if they are anomalies. If deemed to be actionable, they will be addressed by ASD, Nature and Extent (N&E) of Release Characterization, and Assessment of Corrective Measures (ACM), as applicable. To date, no other Appendix IV constituents have been detected at SSLs above their GWPS under the site's AM program.

During the SSL notification period and in accordance with the CCR Rule, an Appendix IV ASD was initiated to assess the AM-1 and -2 findings and later incorporated the AM-3 findings. For the Appendix IV ASD a multiple Line of Evidence (LOE) approach was followed that evaluated sampling, laboratory, and statistical evaluation causes; natural variation not accounted for in the basic AM statistics; potential natural or anthropogenic sources; regional groundwater chemistry studies/reports; and potential effects of on-site and nearby oil and gas wells. The following conclusions were reached for the SSLs that were identified for the AM-1, -2, and -3 events:

- The barium and combined radium 226/228 SSLs were attributable to historical and current oil and gas exploration and production activities that have occurred at the site and, as such, no corrective measures were required for those parameters and Assessment Monitoring for barium and radium should continue.

- The source of the lithium SSLs was indeterminate, but the available evidence indicates there is a high potential they are also attributable to oil and gas impacts at the site. To resolve this uncertainty, isotopic analysis and lithium sampling of well brine from on-site production equipment is currently being considered and Assessment Monitoring of lithium will continue.
- The arsenic SSLs could not be solely attributed to sources other than CCR disposal, to errors in sampling, analysis, or statistical evaluation, or from natural variation in groundwater quality.

Based on the Appendix IV ASD findings and recommendations, a transition to the applicable requirements of ACM for arsenic per the CCR Rule was determined to be warranted along with continued Assessment Monitoring of lithium to verify concentrations remain below its GWPS. In accordance with the CCR Rule, notification that an ACM was initiated was prepared and posted to the facility's publicly accessible website in May 2019 as documented in Section 4, Table 4-1 of this demonstration. The Assessment of Corrective Measures performed for the site is summarized below.

3.1.3 Nature & Extent of Release Characterization (Plume Delineation)

Following confirmation that the arsenic SSLs were not solely attributable to sources other than on-site CCR disposal, N&E of Release characterization activities commenced along with concurrent initiation of an ACM. A detailed discussion of the N&E of Release program is provided in Section 3.0 of Attachment 3-3 of this demonstration, with key activities and findings summarized below:

- Based on groundwater flow patterns at the site and proximity to the facility boundary, a combination of CCR and WVDEP groundwater monitoring program downgradient wells (GW-9, -19, -20, -23, -24, -25, and -26) were used to fulfill the CCR requirement of having at least one monitoring well positioned at the facility boundary in the direction of contaminant migration.
- To supplement these downgradient boundary wells and further delineate the extent of arsenic in groundwater, additional wells used only for the WVDEP monitoring program

(GW-12 and GW-17) were sampled for Appendix III parameters and for arsenic, barium, and lithium (barium and lithium were included to confirm the findings of the ASD).

- Elevated arsenic concentrations were identified in groundwater at the Impoundment and nearby adjacent areas. The highest concentrations occurred at GW-19 and GW-22, with both wells having some seasonal concentration fluctuations but exhibiting overall stability, with arsenic concentrations (including background sampling events) in GW-19 varying between 0.032 and 0.201 (averaging 0.143) milligrams per liter (mg/L), and GW-22 varying between 0.089 and 0.230 (averaging 0.146) mg/L. Based on the measured and interpreted concentrations in groundwater delineated on attached Figures 3-2 and 3-3, arsenic concentrations above the GWPS could potentially occur immediately downgradient of the facility boundary along the north and east/southeast sides of the site.

Any impacted groundwater that flows downgradient of the facility is expected to attenuate based on a combination of physical mechanisms such as advection, dispersion, and natural dilution, along with geochemical mechanisms specific to arsenic such as pH variation, redox potential, and adsorption. These various mechanisms would result in concentrations below the arsenic GWPS before reaching any potential off-site groundwater receptor. However, since arsenic concentrations greater than the GWPS were identified at the site and could not be entirely attributed to alternative sources, an ACM was performed as discussed in Section 3.1.4 below.

3.1.4 Assessment of Corrective Measures (ACM)

Consistent with the CCR Rule, the ACM included an evaluation of arsenic sources, key geochemical properties, and regulatory concentration limits for human health and environmental protection; the Nature and Extent of Release characterization activities that were performed and the extent of arsenic and trends in concentrations that were found; development of a Conceptual Site Model (CSM) that identified potential receptors; identification and screening of potential remediation technologies; an analysis of the effectiveness of potential corrective measures in meeting the remedy requirements and objectives as described under 40 CFR 257.97; and an outline of the process for evaluating and selecting a remedy to address arsenic impacts to groundwater at the site. The ACM Report, included as Attachment 3-3 of this demonstration, evaluated the following corrective measures against the referenced criteria: Source Control, Groundwater Extraction and Treatment, In-Situ Technologies, and Monitored Natural Attenuation (MNA).

Based on the evaluation of viable remediation technologies, MNA, combined with source control by the eventual installation of a final cover system, ranked highest among the evaluated options. In order to evaluate and select a final remedy that is both effective and implementable, the ACM Report also outlined additional data collection and analyses which included installation of step-out monitoring wells downgradient of the northern and east/southeastern groundwater flow paths to confirm attenuation of arsenic is occurring near the facility boundary, to gather geochemical information pertinent to evaluating arsenic natural attenuation, and to monitor the continued effectiveness of the attenuation mechanisms. Related implementation efforts are discussed in Section 3.2.1 below. The candidate corrective measures are currently being further evaluated as part of the ongoing Selection of Remedy work at the site as outlined in the initial semi-annual Selection of Remedy Progress Report included as attachment 3-4 of this demonstration.

3.2 POTENTIAL RECEPTORS

As part of Allegheny Energy's ongoing efforts to identify and mitigate risks associated with the Impoundment, an evaluation of human and environmental receptors has been undertaken. As discussed in the following sections, no receptors have been identified that require additional mitigation activities.

3.2.1 Human

The only identified groundwater pathway to human receptors would involve any release from the facility that would potentially intercept the intake zone of a supply well used for drinking water. West Virginia 33CSR1 includes location restriction criteria requiring publicly- or privately-owned water supply wells located within a 1,500-foot radius of a site (property) boundary to be identified as part of the initial disposal facility permitting effort, during regular (5-year) permit renewals, and for certain major permit modifications. As part of the disposal facility's most recent permit renewal, only two water supply wells (both privately-owned) were identified within a larger 1-mile search radius that included areas upgradient, side-gradient, and downgradient of the site. As shown on Figure 3-1, both supply wells are located northwest of the disposal facility boundary, near the towns of Eureka and Belmont, and are identified as Water Supply Well #1 and Water Supply Well #2.

Based on the current understanding of hydrogeologic conditions at the site, the two water supply wells are situated generally downgradient of the Impoundment. The shallowest monitored aquifer unit that exists in the vicinity of the two supply wells (i.e., that has not been eroded away) is the Grafton Sandstone. Based on elevations of the base of the Grafton Sandstone in the CCR and

WVDEP monitoring wells that were advanced to or through it , the horizontal extent (or "crop line") for the Grafton Sandstone is estimated to occur approximately 1,000 feet in the northwest, downgradient direction from the property boundary. As shown on Figure 3-1, the current understanding is that Water Supply Well #1, which is located approximately 700 feet from the property boundary, is near the crop line for the Grafton Sandstone, suggesting that the Grafton Sandstone, if present, is likely at shallow depths. Water Supply Well #2 is located approximately 1,500 feet north-northwest of the property line, indicating that the Grafton Sandstone is not present at that location.

As shown on Figure 3-1, CCR groundwater monitoring wells GW-9 and GW-19 are situated along the site property boundary, in an interpreted upgradient direction from Water Supply Wells #1 and #2. GW-9 and GW-19 have exhibited a range of total arsenic concentrations of between 0.0003 and 0.0007 mg/L and 0.032 and 0.201 mg/L, respectively. The arsenic GWPS for the site is the federal drinking water maximum contaminant level (MCL) of 0.01 mg/L. Significant attenuation of arsenic concentrations is expected over the relatively long flow path between the facility boundary and the water supply wells due to the physical and geochemical mechanisms noted in Section 3.1.3 and discussed in the ACM Report included as Attachment 3-3 of this demonstration. Given the current and historical data from GW-9 and GW-19 and expected attenuation, the plume delineation does not encompass any human receptors, including Water Supply Wells #1 and #2. In addition, given the horizontal proximity of Water Supply Wells #1 and #2 to the Ohio River, it is likely that one or both draw their water from the Ohio River alluvial aquifer or an underlying bedrock aquifer with some vertical connection. These are very high-yield aquifers that would significantly dilute any upland groundwater flows that discharge into them, indicating the wells are not a realistic exposure pathway. This provides further support that no human receptors are impacted by the Impoundment, even if the arsenic plume delineation depicted on attached Figures 3-2 and 3-3, which currently available data indicate is exhibiting overall stability, is expanded based on future data.

As part of ongoing Selection of Remedy activities, current tasks include the installation of additional CCR groundwater monitoring wells at five locations to further delineate the extent of arsenic in groundwater downgradient of the site and to support data acquisition for the proposed arsenic natural attenuation evaluation. These additional wells are also shown on Figure 3-1. As indicated, proposed monitoring well GW-30 is strategically situated between GW-19 (the monitoring well exhibiting the highest total arsenic concentration) and the closest water supply well (#1). This new monitoring well will be used to refine the groundwater flow direction in this area and provide additional information for arsenic concentrations in groundwater in the Grafton Sandstone at that location. Currently, all five new well locations have been field-located and staked, right-of-access and lease agreements to install the new wells are in final negotiations, and bids have been solicited with drilling firms to install and develop the new wells, with work scheduled to start no later than January 2021. If these Selection of Remedy activities reveal the presence of arsenic beyond the currently suspected plume delineation, Allegheny Energy will immediately implement the mitigation measures presented in Section 3.3.1 of this demonstration.

In summary, the potential impact to human receptors via the groundwater pathway is limited to two possible water supply wells located approximately 700 and 1,500 feet downgradient of the site property boundary. For the reasons stated above, these are low risk potential receptors due to their proximity to the Ohio River and the expected significant attenuation of arsenic in groundwater between the facility boundary and the supply well locations. Despite those considerations, to be conservative Allegheny Energy is developing additional information as part of ongoing Selection of Remedy activities to confirm the absence of a realistic potential exposure pathway. In the unexpected event that a potential exposure pathway is found now or in the future, which is considered unlikely given that the existing distribution of arsenic concentrations at the site, which currently available data indicate is exhibiting overall stability, has been established after approximately 40 years of continuous operation of the Impoundment, the mitigation measures presented in Section 3.3.1 will be implemented.

3.2.2 Environmental

To identify potential environmental receptors, Allegheny Energy evaluated possible pathways for the monitored CCR aquifer units to discharge to downgradient surface waters around the site. Streams were identified in the vicinity of the site from a review of United States Geologic Survey (USGS) topographic maps, Goggle Earth imagery, and site knowledge. The streams identified are presented on Figure 3-1. Surface elevations within each stream's watersheds were compared to the interpreted groundwater contours for the monitored CCR aquifers to identify potential groundwater discharges to surface water. The only area in the site vicinity where this geologic condition appears is where the remaining portion of McElroy's Run is located.

As presented on Figure 3-1, McElroy's Run originates on-site near the western property boundary (immediately down-valley of the Landfill's leachate/stormwater ponds), flows westward a short distance, and then turns to the northeast toward the Ohio River. The total length of this remaining portion of McElroy's Run is approximately 0.8 miles. The groundwater elevations at WVDEP monitoring wells MP-3 and MP-4, which are adjacent to the current headwaters of McElroy's Run, are near the surface elevations of the McElroy's Run headwater area. MP-3 and MP-4 are screened in alluvium and the underlying Saltsburg Formation, respectively, and have exhibited total arsenic concentrations ranging between non-detect and 0.019 mg/L (MP-3) and non-detect and 0.005 mg/L (MP-4). Information is currently not available on arsenic concentrations in McElroy's Run. Allegheny Energy has evaluated related environmental risks using the very conservative assumption that arsenic concentrations in McElroy's Run match the highest arsenic concentration measured in the two nearby monitoring wells. Specifically, this approach assumes a direct connection exists between impacted groundwater and surface water with no dilution, even though, as shown on Figure 3-1, the crop line of the Grafton Sandstone is interpreted to occur along the eastern boundary of a portion of McElroy's Run, indicating there is likely discharge of groundwater from the Grafton Sandstone to McElroy's Run.

In summary, the potential for impact to environmental receptors via the groundwater pathway appears limited to direct discharge to McElroy's Run. Further investigatory and potential mitigation and containment measures are discussed in the following section.

3.3 EXPOSURE RISKS AND MITIGATION/CONTAINMENT MEASURES

Arsenic in groundwater can be derived from various natural and anthropogenic sources, including sedimentary rocks, pesticides, herbicides, and CCRs. It can occur in various forms and its concentration and migration characteristics in groundwater are controlled by the properties of the aquifer materials and their geochemical conditions (e.g., pH, oxidation-reduction potential, presence of competing anions which may inhibit sorption, etc.). A change in downgradient aquifer properties and geochemical conditions can result in changes to the mobility and concentration of arsenic. As previously noted, Allegheny Energy is conducting an arsenic natural attenuation evaluation at the site as part of on-going Selection of Remedy activities. This evaluation will consider the above-referenced factors. Taking these on-going activities into consideration, for this demonstration potential exposure risks were assessed by direct comparison of measured arsenic concentrations in site groundwater to established state and federal drinking water and ecological standards.

Research into state and federal drinking water, NPDES, and environmental standards identified the following concentration limits:

- The federal MCL for arsenic in drinking water is 0.01 mg/L, which is the CCR Rule GWPS in effect at the site.

- For non-potable water sources, federal ambient water quality criteria (AWQC) have been developed that are protective of aquatic life. For arsenic, current statutes list both chronic and acute criteria for arsenic in fresh waters as 0.15 mg/l and 0.34 mg/L, respectively (USEPA, May 2020[a]).
- West Virginia water quality criteria are determined by the state's water use category assigned to the receiving water which, for arsenic, varies between 0.01 mg/L (for public water supply or recreational water contact use) and 0.1 mg/L (for all other uses). In those instances where a receiving water does not have a use category assigned in the state regulations (47CSR2), it is designated for the propagation and maintenance of fish and other aquatic life and for water contact recreation, with the protective concentration limits for recreational water contact use (0.01 mg/L) applied. There are also separate criteria for arsenite [As(III)] that apply to aquatic life only and vary between 0.15 mg/L (chronic limit) and 0.34 mg/L (acute limit), which align with the federal AWQC noted above.
- Effluent discharges from the Impoundment that are routed to Solid Waste/NPDES Outfall 001 at the Ohio River have current arsenic limits of 0.124 mg/L (average monthly) and 0.303 mg/L (maximum daily).

3.3.1 Human Exposure Risks and Mitigation/Containment Measures

For purposes of this demonstration, human exposure is focused on ingestion of arsenic in groundwater as the potential exposure pathway. The USEPA maintains the Integrated Risk Information System (IRIS), an electronic database that contains information on human health effects from exposure to various substances in the environment. IRIS classifies inorganic arsenic as a "human carcinogen," based on human studies of links to lung cancer through inhalation and to multiple organ cancers (e.g., bladder, kidney, skin, lung and liver) through ingestion. In populations that regularly consumed drinking water "high in inorganic arsenic" (ranging from 0.01 to 1.752 mg/L in the critical study), chronic ingestion exposure to arsenic may also be associated with a number of non-cancer health effects, the most sensitive of which are skin effects (USEPA, May 2020[b]).

As discussed in Section 3.2.1, the highest potentially relevant arsenic concentrations in groundwater (measured in GW-9 and GW-19) have ranged from approximately 0.0007 to 0.2 mg/L, versus the GWPS of 0.01 mg/L. However, as also discussed in that section, impacts to human receptors via the groundwater pathway have not been identified to date and Allegheny Energy does not anticipate the development of any human exposure risks in the future. This determination is further substantiated by the AM data collected to date from CCR monitoring wells GW-9 and GW-19. Omitting arsenic, which is the focus of this risk evaluation, along with barium and radium, which have been demonstrated to be attributable to oil and gas exploration and extraction activities at and around the site, of the twelve remaining Appendix IV parameters, ten (antimony, beryllium, cadmium, chromium, cobalt, lead, mercury, molybdenum, selenium, and thallium) have not been found at detectible concentrations during any of the AM sampling events, while two (fluoride and lithium) have been found at concentrations that are well below their associated GWPS.. Despite the absence of current or expected human exposure risks, Allegheny Energy will continue its CCR groundwater monitoring program, ongoing Selection of Remedy work, and ultimately implement the selected remedy in order to continuously assess and expeditiously mitigate any risk by performing the following activities:

- Continued AM sampling, testing, and reporting for the existing CCR monitoring well network;
- Installation and subsequent AM/Selection of Remedy sampling, testing and reporting of the new step-out CCR monitoring wells;
- If groundwater sampling and testing results in a future determination that there is potential risk of human exposure via the two downgradient water supply wells, Allegheny Energy will promptly undertake efforts to either demonstrate the absence of or eliminate that risk. Such efforts would involve a range of options which include sampling the supply wells, supply well abandonment/connection to public water supply (City of Belmont), well head treatment, localized pump and treat of hotspots in the supply well vicinity, or some combination thereof to expeditiously mitigate any risk; and
- Deactivate the Station's coal-fired boilers, cease accepting CCRs at the facility, and complete closure of the Impoundment as discussed in Section 5 of this demonstration.

As required by 40 CFR 257.103(f)(2)(v)(B)(3), a variety of contaminant containment measures have been considered in the ACM provided as Attachment 3-3. However, the ACM found that the hydrogeologic characteristics of the site's uppermost aquifer (primarily vertically-connected fractured bedrock flow with a combination of structural and topographic control), combined with the size of the Impoundment, make effective implementation of currently available containment techniques such as cutoff walls and perimeter extraction or injection systems infeasible. As such, activities to address any potential future contaminant release plume during the limited continued operation time of the Impoundment will focus on any necessary immediate human exposure risk mitigation measures noted above followed by short-term source reduction by deactivation of the coal-fired boilers and cessation of waste placement in the Impoundment, supplemented with long-term source reduction by installation of a final cover (cap) system as discussed in Section 5 of this demonstration.

3.3.2 Environmental Exposure Risks and Mitigation/Containment Measures

As noted in Section 3.2.2, groundwater at the site presents an ecological concern only to the extent that it is a source for surface water bodies; more specifically, the remaining portion of McElroy's Run. Key effects to ecological receptors due to arsenic in surface water can include both acute (e.g., survival) and chronic endpoints (e.g., growth and reproduction). Levels of arsenic in groundwater located near the headwaters of McElroy's Run (measured in MP-3 and MP-4) have been found to range from non-detect to approximately 0.02 mg/L. The highest measured concentration is approximately 7.5 times lower than the chronic AWQC (0.15 mg/L) and 17 times lower than the acute AWQC (0.34 mg/L). Similarly, the highest measured concentration is approximately six times lower than the Impoundment's permitted average monthly arsenic limit and 15 times lower than the permitted maximum daily arsenic limit at Solid

Waste/NPDES Outfall 001 at the Ohio River. Thus, even conservatively disregarding dilution effects and comparing the highest measured groundwater concentration for arsenic to the criteria, there is no current indication of appreciable risk of environmental harm from the Impoundment. This determination is further substantiated by the AM data collected to date from CCR monitoring wells GW-27, GW-28, and GW-29, which are positioned along the facility's western waste boundary and upgradient of MP-3 and MP-4. Omitting arsenic, which is the focus of this risk evaluation, along with barium and radium, which have been demonstrated to be attributable to oil and gas exploration and extraction activities at and around the site, of the twelve remaining Appendix IV parameters, nine (antimony, beryllium, cadmium, chromium, cobalt, lead, mercury, selenium, and thallium) have not been found at detectible concentrations during any of the AM sampling events, while three (fluoride, lithium, and molybdenum) have been found at concentrations that are well below their associated GWPS.

In the event that a risk of environmental harm to McElroy's Run is later identified, which is considered unlikely given that the existing distribution of arsenic concentrations at the site has been established after approximately 40 years of continuous operation of the Impoundment, Allegheny Energy will mitigate that risk by either:

- Performing a field study to establish the actual arsenic concentration in McElroy's Run and, should it exceed the ecological criteria discussed above, performing toxicity testing to develop site-specific water quality criteria for the stream; or
- Performing a feasibility evaluation of mitigation measures that would include modeling the impact of the eventual capping the Impoundment on in-stream concentrations of arsenic and/or using an active water treatment system (e.g., package plant) or a passive water treatment system (e.g., constructed wetlands) to reduce or remove arsenic from McElroy's Run before it leaves the site, and then select and implement the best alternative.

As noted in Section 3.3.1, the hydrogeologic characteristics of the site's uppermost aquifer, combined with the size of the Impoundment, make effective implementation of currently available containment techniques such as cutoff walls and perimeter extraction or injection systems infeasible. As such, activities to address any potential future contaminant release plume during the limited continued operation time of the Impoundment will focus on the immediate environmental exposure risk mitigation measures noted above followed by short-term source reduction by deactivation of the coal-fired boilers and cessation of waste placement in the Impoundment, supplemented with long-term source reduction by installation of a final cover (cap) system as discussed in Section 5 of this demonstration.

3.4 MEASURES TO LIMIT FUTURE RELEASES DURING CONTINUED OPERATION

In accordance with 40 CFR 257.103(f)(2)(v)(B)(1), this section includes a discussion of any physical or chemical measures that could limit future releases to groundwater during continued operation of the Impoundment. There are no viable physical and chemical measures that could potentially be taken to limit future releases to groundwater during that period. Liquid or solid amending agents to fixate or otherwise immobilize potential constituents in the inflow sluice water were assessed, but are not realistic options due to the following key factors at the site:

- Physical and chemical measures to control arsenic that could be implemented for the remaining waste would focus on the addition of oxidizing agents to transform arsenic into more absorbable forms and/or the addition of metal oxides in conjunction with pH control that would enable sorption as a method to stabilize arsenic in the new disposal material. However, the long-term arsenic stability for this approach is highly uncertain due to placement in the remaining Impoundment disposal area where both physical and chemical transformations that could occur upon mixing with existing materials may limit the effectiveness and, as such, the overall feasibility of controlling arsenic mobility.

- As discussed in Section 1.2, the Impoundment is currently at approximately 95% of its total permitted disposal capacity. As such, any control measures applied to the limited remaining waste volume placed under this proposed boiler cessation demonstration would be masked by release from existing materials and would be unlikely to have any discernible effect on future releases from the Impoundment.
- As discussed in Section 3.3, the current levels of risk for human and environmental exposure to impacted groundwater at the site are considered low and negligible, respectively, despite approximately 40 years of continuous operation of the Impoundment and with currently available data indicating that arsenic is exhibiting overall concentration stability and that there are no other Appendix IV parameters related to the CCR unit that have either been found at detectible concentrations or that are approaching their respective GWPS. Given the comparatively limited amount of continued operation time allowed under this demonstration, any control measures that were implemented during this period would be unlikely to have any discernible effect on future releases from the Impoundment.
- Many of the liquid and solid amending agents that could be used carry their own human and environmental exposure risks. These risks would offset (and could well exceed) the limited risks currently associated with impacted groundwater at the site.

4.0 CCR RULE COMPLIANCE CERTIFICATION

Since the publication of the final CCR Rule in April of 2015, Allegheny Energy has managed a comprehensive CCR Rule compliance program for the McElroy's Run Landfill and Disposal Impoundment. The CCR Rule compliance program has been, is currently, and will continue to address all applicable engineering, groundwater monitoring, recordkeeping, notification, and public information accessibility requirements of the Rule. As required by 40 CFR 257.103(f)(2)(v)(C)(1), a signed certification from Allegheny Energy documenting that the facility is in compliance with all applicable requirements of the CCR Rule is provided as Attachment 4-1 to this demonstration. Table 4-1 summarizes the various inspections, records, plans, reports, notifications, and other supporting information prepared for the Landfill and Impoundment through late November 2020, all of which are available on the FirstEnergy publicly accessible CCR Compliance website (http://ccrdocs.firstenergycorp.com) unless specifically noted.

Table 4-1. CCR Rule Compliance Summary (through late November 2020)

CCR Rule Citation	Description	CCR Unit[1]	Date Posted on Publicly Accessible Website
Engineering Requirements			
40 CFR §257.60(a), 61(a), 62(a), 63(a), and 64(a)	Location Restrictions Demonstration	I & LF	November 6, 2018
40 CFR §257.71(a)	Liner Design Criteria Demonstration	I	October 14, 2016
40 CFR §257.73(a)(2)	Initial Hazard Potential Classification Assessment Report	I	October 14, 2016
40 CFR §257.73(a)(3)(i)(A)-(E)	Emergency Action Plan (EAP)	I	April 15, 2017
40 CFR §257.73(a)(3)(i)(A)-(E)	Emergency Action Plan (EAP)	I	January 18, 2019
40 CFR §257.73(a)(3)(i)(E)	Annual EAP Local Emergency Responders Meeting	I	January 18, 2019
40 CFR §257.73(c)(1)	History of Construction	I	October 14, 2016

CCR Rule Citation	Description	CCR Unit[1]	Date Posted on Publicly Accessible Website
40 CFR §257.73(d)(1)	Structural Stability Assessment Report	I	October 14, 2016
40 CFR §257.73(e)(1)(i)-(iv)	Safety Factor Assessment Report	I	October 14, 2016
40 CFR §257.80(b)	Fugitive Dust Control Plan	I & LF	October 19, 2015
40 CFR §257.80(c)	2016 Fugitive Dust Control Annual Report	I & LF	December 6, 2016
40 CFR §257.80(c)	2017 Fugitive Dust Control Annual Report	I & LF	December 5, 2017
40 CFR §257.80(c)	2018 Fugitive Dust Control Annual Report	I & LF	January 16, 2019
40 CFR §257.80(c)	2019 Fugitive Dust Control Annual Report	I & LF	January 16, 2020
40 CFR §257.81(c)	Run-on and Run-off Control System Plan	LF	October 14, 2016
40 CFR §257.82(c)	Inflow Design Flood Control System Plan	I	October 14, 2016
40 CFR §257.83(a)(1)(iv)	Weekly Inspections (Commenced October 2015)	I	Only required to be posted in Operating Record
40 CFR §257.84(a)(1)(ii)	Weekly Inspections (Commenced October 2015)	LF	Only required to be posted in Operating Record
40 CFR §257.83(b)(2), 84(b)(2)	2015 Annual Inspection Report	I & LF	January 18, 2016
40 CFR §257.84(b)(2)	2016 Annual Inspection Report	LF	December 22, 2016
40 CFR §257.83(b)(4)(ii)	2016 Annual Inspection Waiver	I	December 22, 2016
40 CFR §257.83(b)(2), 84(b)(2)	2017 Annual Inspection Report	I & LF	October 17, 2017

CCR Rule Citation	Description	CCR Unit[1]	Date Posted on Publicly Accessible Website
40 CFR §257.83(b)(2), 84(b)(2)	2018 Annual Inspection Report	I & LF	January 16, 2019
40 CFR §257.83(b)(2), 84(b)(2)	2019 Annual Inspection Report	I & LF	January 16, 2020
40 CFR §257.102(b)	Closure and Post-Closure Plans	I & LF	October 14, 2016 (Updated Plans to be posted concurrent with this Demonstration)
Groundwater Requirements			
40 CFR §257.91(f)	Groundwater Monitoring System Certification	I & LF	October 17, 2017
40 CFR §257.93(f)(6)	Groundwater Statistical Method Selection Certification	I & LF	October 17, 2017
40 CFR §257.90(e)	2017 Annual Groundwater Monitoring and Corrective Action Report	I & LF	February 28, 2018
40 CFR §257.90(e)	2018 Annual Groundwater Monitoring and Corrective Action Report	I & LF	February 26, 2019
40 CFR §257.90(e)	2019 Annual Groundwater Monitoring and Corrective Action Report	I & LF	January 30, 2020
40 CFR §257.94(e)(3)	Transition to Assessment Monitoring Notification	I & LF	September 7, 2018
40 CFR §257.95(g)	Notice of Groundwater Protection Standard Exceedance	I & LF	April 5, 2019
40 CFR §257.95(g)(5)	Notice of Corrective Measures Assessment	I & LF	May 22, 2019
40 CFR §257.96(c)	Assessment of Corrective Measures (ACM) Report	I & LF	October 16, 2019
40 CFR §257.97(a)	Semi-Annual Selection of Remedy Report (1Q and 2Q 2020)	I & LF	September 23, 2020

[1] On-site CCR units include the Impoundment (I) and Landfill (LF).

As required by 40 CFR 257.103(f)(2)(C)(2) through (8), some of the supporting information listed above is required to be submitted as part of this demonstration. Each of these requirements are listed below along with where they may be found in this demonstration. As previously noted in Section 3.1, a multiunit groundwater monitoring system encompassing both the Landfill and Impoundment has been established for the site. As such, any of the supporting information listed below related to groundwater monitoring addresses both the Landfill and Impoundment (i.e., there are not separate maps, reports, etc. for each CCR unit):

- *40 CFR 257.103(f)(2)(C)(2)(i) – Map(s) of groundwater monitoring well locations in relation to the CCR units:* Shown on Figure 3-1.
- *40 CFR 257.103(f)(2)(C)(2)(ii) – Well construction diagrams and drilling logs for all groundwater monitoring wells:* Included in Attachment 3-1.
- *40 CFR 257.103(f)(2)(C)(2)(iii) – Maps that characterize the direction of groundwater flow accounting for seasonal variations:* Included in Attachment 3-2.
- *40 CFR 257.103(f)(2)(C)(3) – Constituent concentrations, summarized in table form, at each groundwater monitoring well monitored during each sampling event:* Included in Attachment 3-2.
- *40 CFR 257.103(f)(2)(C)(4) – Description of site hydrogeology including stratigraphic cross-sections:* Included in Attachment 3-3.
- *40 CFR 257.103(f)(2)(C)(5) – Any corrective measures assessment required at 40 CFR 257.96:* Included in Attachment 3-3.
- *40 CFR 257.103(f)(2)(C)(6) – Any progress reports on remedy selection and design and the report of final remedy selection required at 40 CFR 257.97(a):* Selection of Remedy progress reports developed to date included in Attachment 3-4.
- *40 CFR 257.103(f)(2)(C)(7) – The most recent structural stability assessment required at 40 CFR 257.73(d):* Included in Attachment 4-2.
- *40 CFR 257.103(f)(2)(C)(8) – The most recent safety factor assessment required at 40 CFR 257.73(e):* Included in Attachment 4-3.

Ongoing and future CCR Rule compliance activities will continue through the requested extension period and completion of closure for both the Landfill and the Impoundment. Table 4-2 summarizes the various activities that will be performed and information that will be prepared through October 2028 for the facility.

Table 4-2. CCR Rule Compliance Requirements Through Completion of Closure

CCR Rule Citation	Description	CCR Unit[1]	Deadline/Frequency
Engineering Requirements			
40 CFR §257.83(a), 84(a)	Weekly Inspections	I & LF	Weekly Until Cessation of Waste Acceptance (Operating Record Only)
40 CFR §257.83(b), 84(b)	Annual Inspections and Reports	I & LF	Annually Through October 2028
40 CFR §257.80(c)	Fugitive Dust Control Annual Reports	I & LF	Annually Through October 2028
40 CFR §257.73(a)(3)(i)(A)-(E)	Emergency Action Plan (EAP) Updates (As Changes Occur or Every 5-Years)	I	January 2022 and January 2027
40 CFR §257.73(a)(2)	Periodic Hazard Potential Classification Assessment Report (Every 5-Years)	I	October 2021 and October 2026
40 CFR §257.73(d)(1)	Structural Stability Assessment Report (Every 5-Years)	I	October 2021 and October 2026
40 CFR §257.73(e)(1)(i)-(iv)	Safety Factor Assessment Report (Every 5-Years)	I	October 2021 and October 2026
40 CFR §257.80	Fugitive Dust Control Plan Updates (As Changes Occur or Every 5-Years)	I & LF	October 2020 and October 2025
40 CFR §257.81(c)	Run-on and Run-off Control System Updates (As Changes Occur or Every 5-Years)	LF	October 2021 and October 2026
40 CFR §257.82(c)	Inflow Design Flood Control System Updates (As Changes Occur or Every 5-Years)	I	October 2021 and October 2026
40 CFR §257.102(b)(3)	Closure and Post-Closure Plan Updates (As Changes Occur)	I & LF	As Required

CCR Rule Citation	Description	CCR Unit[1]	Deadline/Frequency
Groundwater Requirements			
40 CFR §257.93-95	Groundwater Sampling and Analysis	I & LF	Bi-Annual or More Frequent, Depending on Monitoring Program in Effect (Detection, Assessment, or Corrective Action)
40 CFR §257.90(e)	Annual Groundwater Monitoring and Corrective Action Report	I & LF	Annually
40 CFR §257.96-98	Assessment of Corrective Measures Selection of Remedy Corrective Action	I & LF	As Required by CCR Rule, Depending on Current Compliance Phase in Effect

[1] On-site CCR units include the Impoundment (I) and Landfill (LF).

As they become required, Allegheny Energy will complete the various inspections, records, plans, reports, notifications, and other supporting information required by the CCR Rule for the remaining active life and post-closure care period for the facility in accordance with applicable sections of the Rule.

5.0 BOILER CESSATION AND IMPOUNDMENT CLOSURE

In accordance with 40 CFR 257.103(f)(2)(v)(D), a narrative must be included regarding the date by which the Impoundment will cease receipt of waste in order to meet the October 17, 2028 closure deadline. The closure plan required under 40 CFR 257.102(b) must also be included. Attachment 5-1 to this demonstration includes the current Closure Plan required by 257.102(b). As explained in the remainder of this Section 5, cessation of the Station's coal-fired boiler operations is expected to occur on October 1, 2024, and the Impoundment will cease accepting waste from the Station on October 17, 2024 to meet the October 2028 Impoundment closure deadline. The difference in the cessation dates for boiler operations and waste acceptance is to allow time to clean the boilers and related Station equipment during the deactivation period, with the associated waste materials normally disposed of in the Impoundment still needing to be placed there.

5.1 DISPOSAL IMPOUNDMENT CLOSURE

In accordance with the Impoundment's current CCR Rule Closure Plan, included as Attachment 5-1 of this demonstration, a final cover system and associated stormwater collection controls compliant with both 40 CFR 257.102 and West Virginia 33CSR1 will be installed atop the in-place CCRs in the Impoundment. The stormwater collection controls will be installed, excess liquids removed from the Impoundment (to the extent necessary), and the remaining waste surface will be stabilized and contoured to support the final cover system and provide positive drainage to prevent ponding of stormwater. An outline of the high-level construction activities necessary to close the Impoundment is presented below.

5.1.1 Site Preparation

Before ceasing of receipt of CCR materials, work will occur to prepare the Impoundment for closure, including the design and construction of various erosion and sedimentation (E&S) and stormwater run-on/run-off controls and initial development of construction staging and soil borrow areas on the disposal facility's property. As discussed in Section 2.1.1.1, additional field investigation work will be performed to determine the remaining on-site borrow soil resources and, if they are found to be insufficient to close the Impoundment, off-site borrow areas will be acquired and developed to meet soil demands associated with closure of the Impoundment.

5.1.2 Dewatering

Removal of water from the Impoundment is a critical activity with regard to establishing and maintaining closure construction safety and schedule. Dewatering involves removing both "free" water, which is liquid sitting atop the impounded CCRs, and "pore" water which is liquid within the pore spaces of the impounded CCRs.

- Free Water Removal. Based on the existing configuration of the Impoundment's outlet works and impounded CCR elevations, discharge via gravity will be the primary means of removing free water once cessation of waste (influent sluicing) occurs. The use of pumps for free water removal is expected to be limited or possibly unnecessary.

- Pore Water Removal. Removal of pore water will occur primarily due to seepage out of the CCR surfaces that become exposed as the Impoundment's pool level (free water) drops. Supplemental dewatering will be assessed and conducted if necessary, to stabilize the upper CCR surface (e.g., upper 10 to 25 feet) so that heavy equipment can safely operate on it to perform any necessary surface contouring and to support the installation of the final cover system.

The discharges associated with both types of dewatering will be routed to the Impoundment's existing NPDES Outfall 001 at the Ohio River. The CCR dewatering discharges as well as other impounded water will continue to be subject to the site's NPDES permit requirements. Compliance will be maintained with the permitted analytical parameters and associated discharge limits established by the WVDEP.

Dewatering is scheduled to begin in October 2024, after the Impoundment ceases accepting waste. By the 2025 construction season, sufficient dewatering is expected to have occurred to permit contouring of the surface in preparation for installation of the final cover system.

5.1.3 Surface Contouring

As dewatering is completed, the surface of the impounded CCR material may require adjustments to provide positive drainage from the head of the watershed towards the dam to prevent post-closure ponding of stormwater. The contour plan will also include a designed low point to allow stormwater runoff from completed areas in the upstream watershed to flow past the dam and continue down valley. Surface contouring will occur incrementally such that the final cover system installation can be completed by the required deadline.

5.1.4 Final Cover System Installation

In accordance with 40 CFR 257.102(d)(3)(i), the Impoundment will be closed by leaving the CCRs in place and installing a final cover (cap) system. The final cover system presented in the Impoundment's current CCR Rule Closure Plan (refer to Attachment 5-1), is a soil-only cap consisting of the following (listed from the bottom layer to the top layer):

- Infiltration Layer: 18 inches of Compacted Soil (Permeability of $1x10^{-5}$ cm/sec or less);
- Erosion Layer: 6 inches of Cover Soil; and
- Vegetation: Mulch, Fertilizer, and Seed.

The final cover system's compacted soil infiltration layer will be installed directly atop the contoured CCR surface to act as a precipitation infiltration barrier. This will be overlain with an erosion layer capable of supporting vegetative growth and preventing erosion of the infiltration barrier soil. The soil-only cap specified in the current closure plan meets the requirements of both the CCR Rule and 33CSR1. The work is anticipated to proceed incrementally as completion of dewatering and surface contouring provides areas suitable for installation work to commence. Alternative cap systems that would utilize geosynthetic materials will also be evaluated during closure design.

5.1.5 Site Restoration

Site restoration will be performed incrementally as the final cover system installation progresses. Areas to be restored beyond the disposal footprint include access roads developed for construction and final cover installation, soil borrow areas, and construction staging areas. Primary restoration activities include grading disturbed areas, removing temporary E&S and stormwater controls; applying fertilizer, seed and mulch to regraded areas; repairing gravel and asphalt roads adversely affected during construction activities; and upgrading and/or installing necessary site access control measures (e.g., fencing and gates).

5.1.6 Estimated Closure Schedule

The construction activities presented above involve varying levels of planning, design, and permitting that will occur prior to construction. Pre-construction activities include the following: a variety of field investigations and studies (e.g., geotechnical characterization of impounded CCRs, soil borrow area delineations, etc.); completing engineering layout, analysis and design; preparing permit application submittals and responding to agency and public review comments; and developing construction drawings, technical specifications and bid documents. Once a construction contract is awarded, construction can commence with mobilization and site preparation, followed by supplemental dewatering activities (which will be an on-going process over the duration of work), annual sequences of concurrent contouring, final cover installation, site restoration activities, construction demobilization/remobilization, and preparation/submission of construction certification record documentation required by WVDEP.

The general sequencing and estimated durations of the activities described above are graphically illustrated in a timeline presented on attached Figure 5-1 and are based on reasonable judgement and prior experience with similar projects completed by Allegheny Energy and its contractors. As shown on Figure 5-1, closure of the Impoundment will include a mix of concurrent and sequential activities in order to safely and efficiently complete all work by the October 2028 deadline.

5.2 ANNUAL PROGRESS REPORTS AND NOTIFICATIONS

In accordance with 40 CFR 257.103(f)(2) of the revised CCR Rule, Allegheny Energy will complete the notices and progress reports required for closure of the Impoundment. These include:

- 40 CFR 257.103(f)(2)(viii) – Notification of the submission of this demonstration to USEPA;
- 40 CFR 257.103(f)(2)(ix) – Notification from USEPA of either the approval or denial of this demonstration; and
- 40 CFR 257.103(f)(2)(x) – Annual reports documenting the continued lack of alternative capacity and the progress towards closure of the Impoundment, including describing any problems encountered and a description of the actions taken to resolve the problems.

The recordkeeping, notifications, and public reporting associated with the items above will be performed in accordance with the applicable requirements of 40 CFR 257.105, 106, and 107.

6.0 REFERENCES

Agency for Toxic Substances & Disease Registry (ATSDR), "Public Health Statement for Arsenic (CAS#: 7440-38-2)", August 2007, https://www.atsdr.cdc.gov/phs/phs.asp?id=18&tid=3.

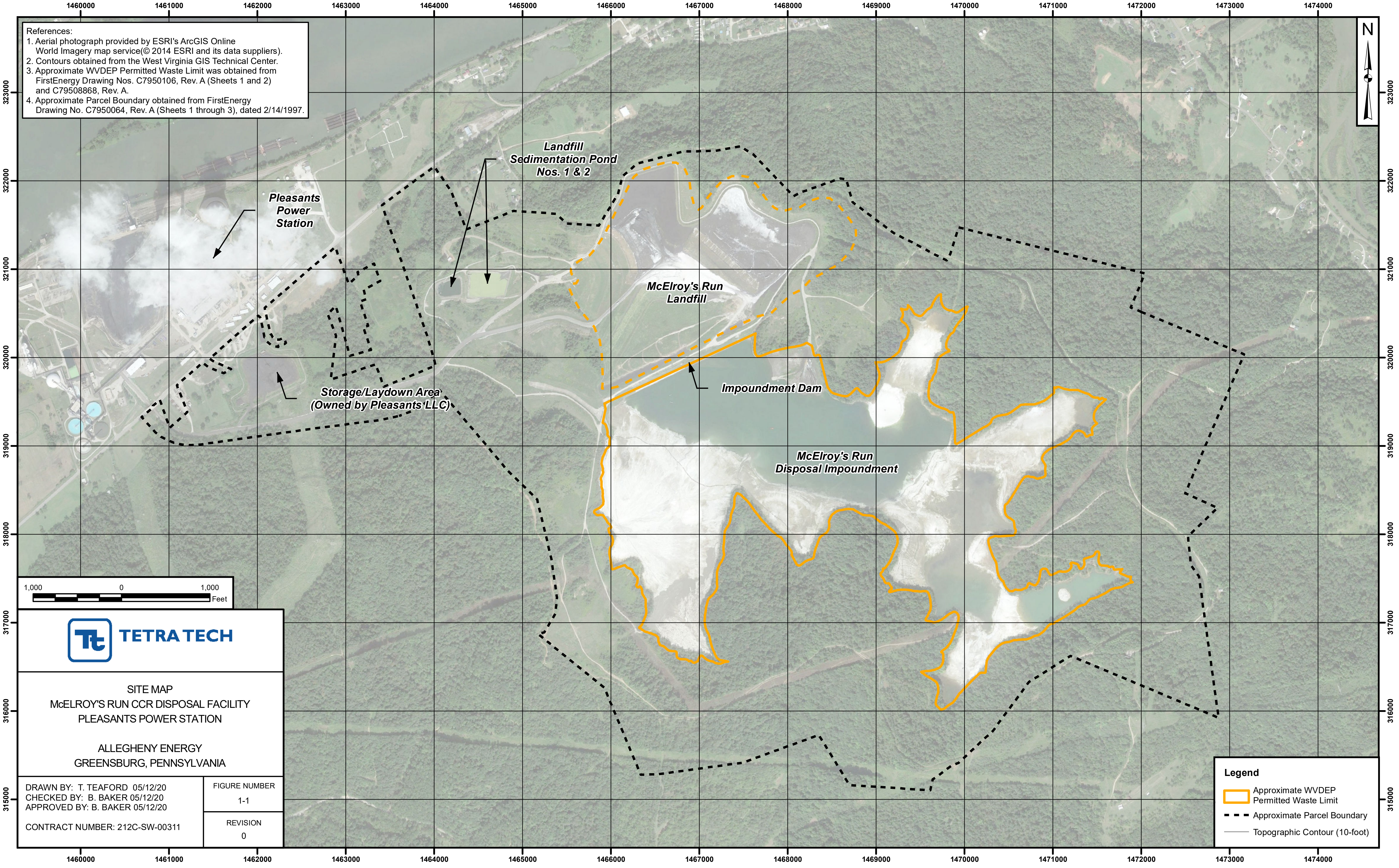
Electric Power Research Institute (EPRI), "Arsenic Health and Ecological Effects: Soil and Water", Palo Alto, CA: 2007. 1014015.

United States Environmental Protection Agency (USEPA), National Recommended Water Quality Criteria – Aquatic Life Criteria Table, https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table#table, Accessed May 2020[a].

United States Environmental Protection Agency (USEPA), Integrated Risk Information System (IRIS) Chemical Assessment Summary – Arsenic, inorganic; CASRN 7440-38-2, https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0278_summary.pdf, Accessed May 2020[b].

FIGURES

PGH Document Path: P:\GIS\FIRST_ENERGY\MAPDOCS\PLEASANTSCO_MCELROY_AERIAL_B.MXD 5/12/2020 TIM.TEAFORD



References:
1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service(© 2014 ESRI and its data suppliers).
2. Contours obtained from the West Virginia GIS Technical Center.
3. Approximate WVDEP Permitted Waste Limit was obtained from FirstEnergy Drawing Nos. C7950106, Rev. A (Sheets 1 and 2) and C79508868, Rev. A.
4. Approximate Parcel Boundary obtained from FirstEnergy Drawing No. C7950064, Rev. A (Sheets 1 through 3), dated 2/14/1997.

Legend

- Approximate WVDEP Permitted Waste Limit
- Approximate Parcel Boundary
- Topographic Contour (10-foot)

TETRA TECH

SITE MAP
McELROY'S RUN CCR DISPOSAL FACILITY
PLEASANTS POWER STATION

ALLEGHENY ENERGY
GREENSBURG, PENNSYLVANIA

DRAWN BY: T. TEAFORD 05/12/20
CHECKED BY: B. BAKER 05/12/20
APPROVED BY: B. BAKER 05/12/20

CONTRACT NUMBER: 212C-SW-00311

FIGURE NUMBER
1-1

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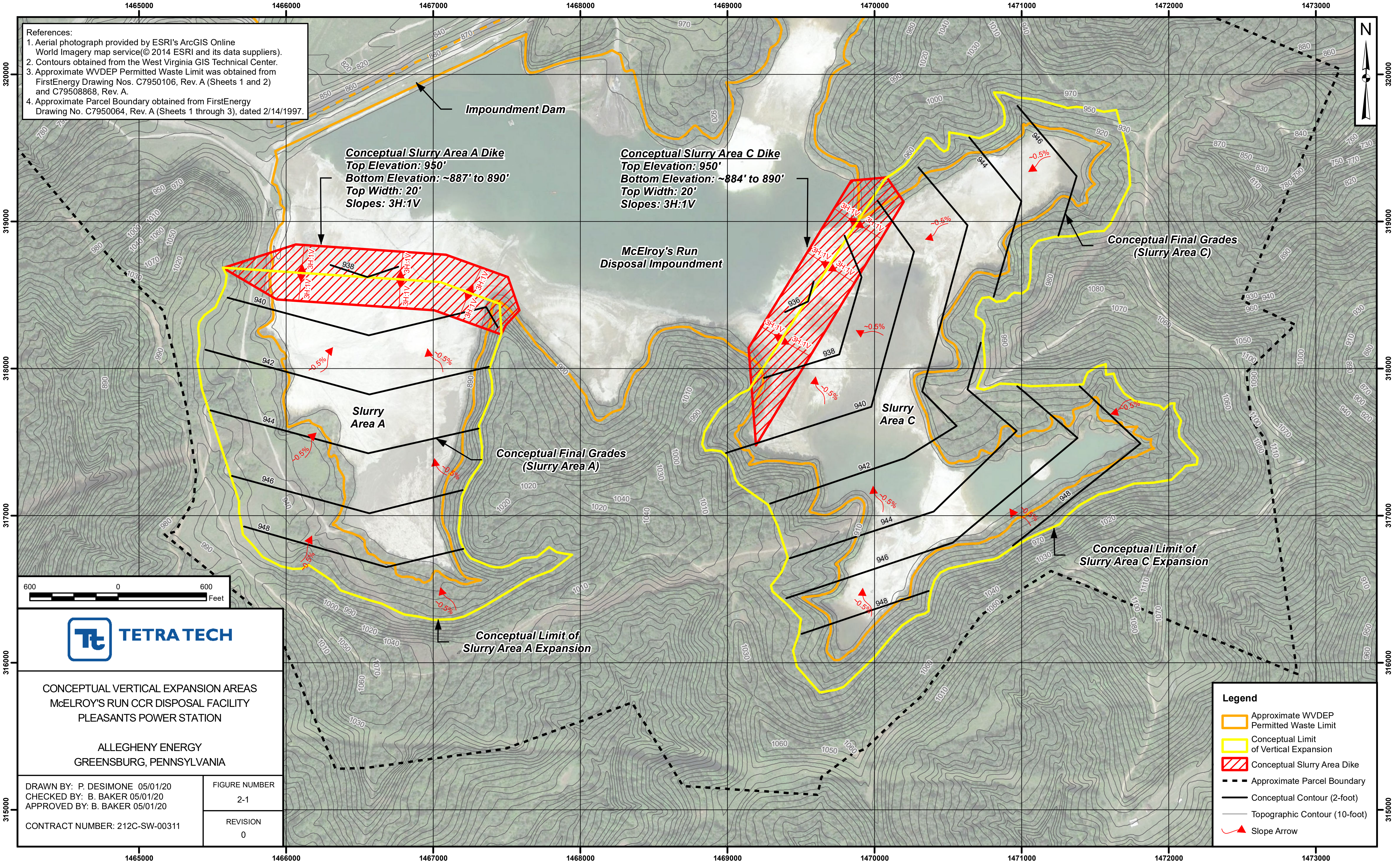


References:
1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service(© 2014 ESRI and its data suppliers).
2. Contours obtained from the West Virginia GIS Technical Center.
3. Approximate WVDEP Permitted Waste Limit was obtained from FirstEnergy Drawing Nos. C7950106, Rev. A (Sheets 1 and 2) and C79508868, Rev. A.
4. Approximate Parcel Boundary obtained from FirstEnergy Drawing No. C7950064, Rev. A (Sheets 1 through 3), dated 2/14/1997.

TETRA TECH

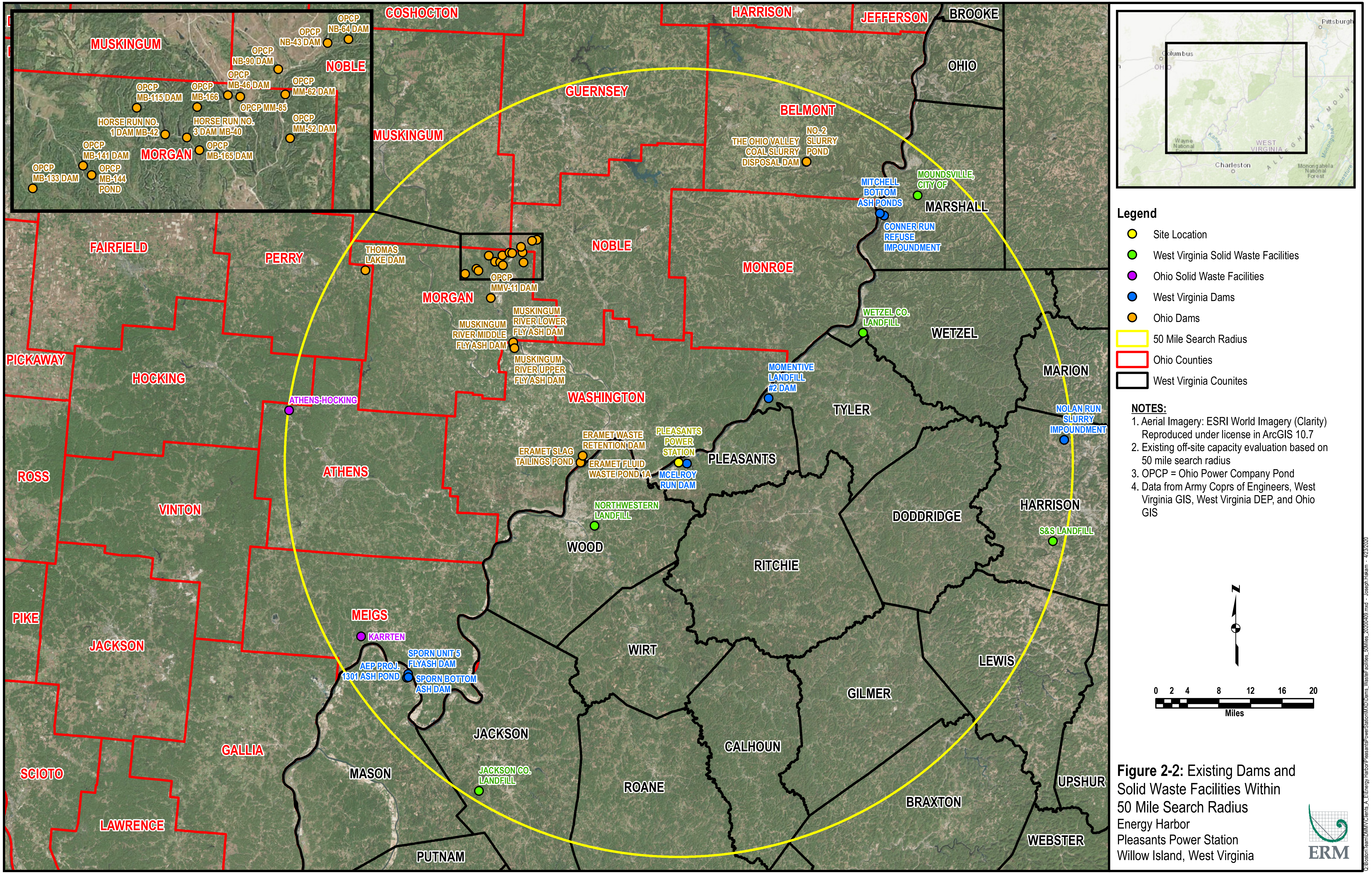
CONCEPTUAL VERTICAL EXPANSION AREAS
McELROY'S RUN CCR DISPOSAL FACILITY
PLEASANTS POWER STATION

ALLEGHENY ENERGY
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 05/01/20 CHECKED BY: B. BAKER 05/01/20 APPROVED BY: B. BAKER 05/01/20	FIGURE NUMBER 2-1
CONTRACT NUMBER: 212C-SW-00311	REVISION 0

Legend

🟧	Approximate WVDEP Permitted Waste Limit
🟨	Conceptual Limit of Vertical Expansion
▨	Conceptual Slurry Area Dike
- - -	Approximate Parcel Boundary
—	Conceptual Contour (2-foot)
—	Topographic Contour (10-foot)
▲	Slope Arrow



Legend

- ● Site Location
- ● West Virginia Solid Waste Facilities
- ● Ohio Solid Waste Facilities
- ● West Virginia Dams
- ● Ohio Dams
- ☐ 50 Mile Search Radius
- ☐ Ohio Counties
- ☐ West Virginia Counites

NOTES:

1. Aerial Imagery: ESRI World Imagery (Clarity) Reproduced under license in ArcGIS 10.7
2. Existing off-site capacity evaluation based on 50 mile search radius
3. OPCP = Ohio Power Company Pond
4. Data from Army Coprs of Engineers, West Virginia GIS, West Virginia DEP, and Ohio GIS

Figure 2-2: Existing Dams and Solid Waste Facilities Within 50 Mile Search Radius
Energy Harbor
Pleasants Power Station
Willow Island, West Virginia

ERM

Q:\Boston\Team\DMM\Clients_A_E\Energy Harbor\PleasantsPowerStation\MXD\Dams_WasteFacilities_50Miles_20200409.mxd - Joseph.Hakam - 4/23/2020

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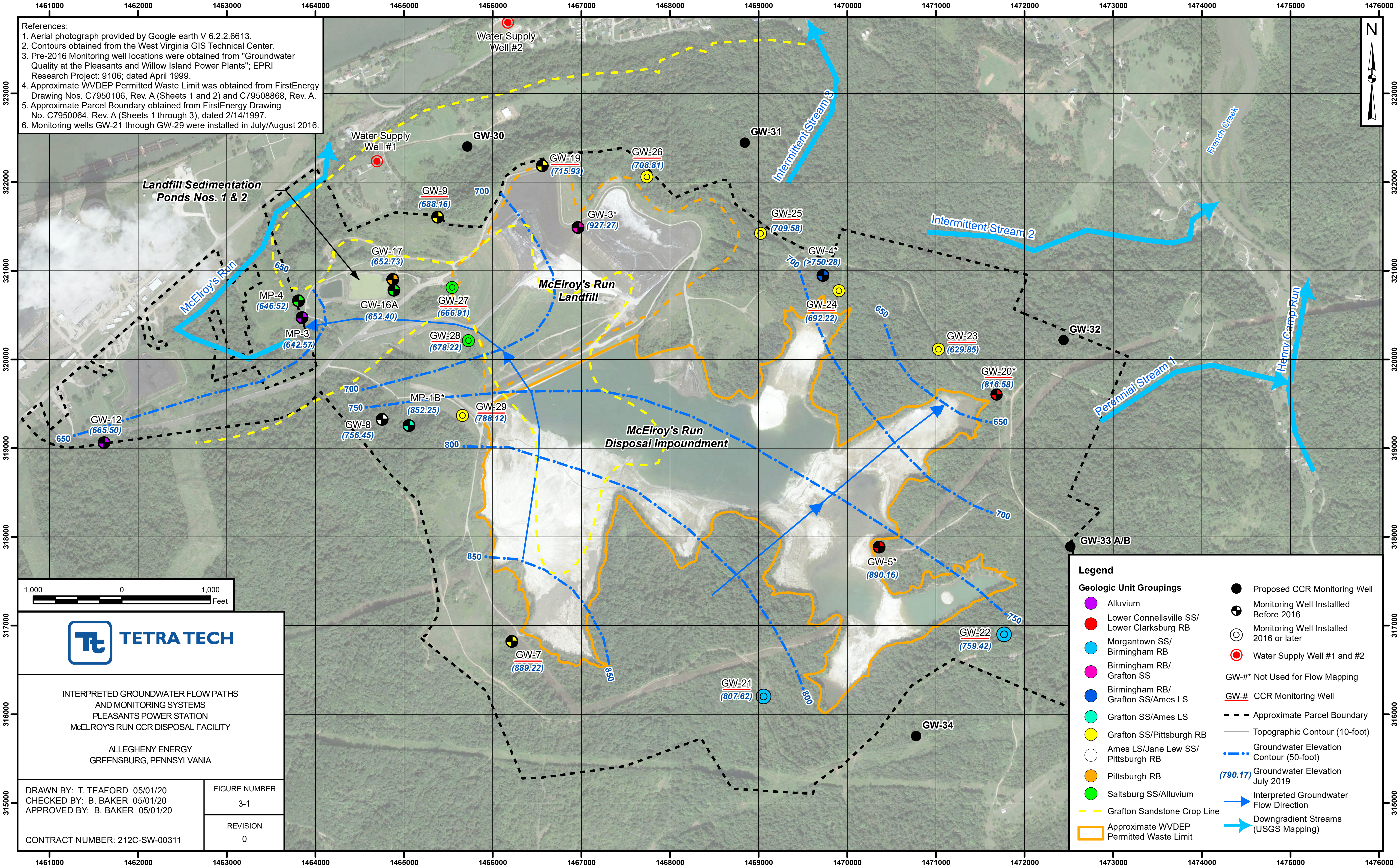

References:
1. Aerial photograph provided by Google earth V 6.2.2.6613.
2. Contours obtained from the West Virginia GIS Technical Center.
3. Pre-2016 Monitoring well locations were obtained from "Groundwater Quality at the Pleasants and Willow Island Power Plants"; EPRI Research Project: 9106; dated April 1999.
4. Approximate WVDEP Permitted Waste Limit was obtained from FirstEnergy Drawing Nos. C7950106, Rev. A (Sheets 1 and 2) and C79508868, Rev. A.
5. Approximate Parcel Boundary obtained from FirstEnergy Drawing No. C7950064, Rev. A (Sheets 1 through 3), dated 2/14/1997.
6. Monitoring wells GW-21 through GW-29 were installed in July/August 2016.

TETRA TECH

INTERPRETED GROUNDWATER FLOW PATHS
AND MONITORING SYSTEMS
PLEASANTS POWER STATION
McELROY'S RUN CCR DISPOSAL FACILITY

ALLEGHENY ENERGY
GREENSBURG, PENNSYLVANIA

DRAWN BY: T. TEAFORD 05/01/20
CHECKED BY: B. BAKER 05/01/20
APPROVED BY: B. BAKER 05/01/20

CONTRACT NUMBER: 212C-SW-00311

FIGURE NUMBER
3-1

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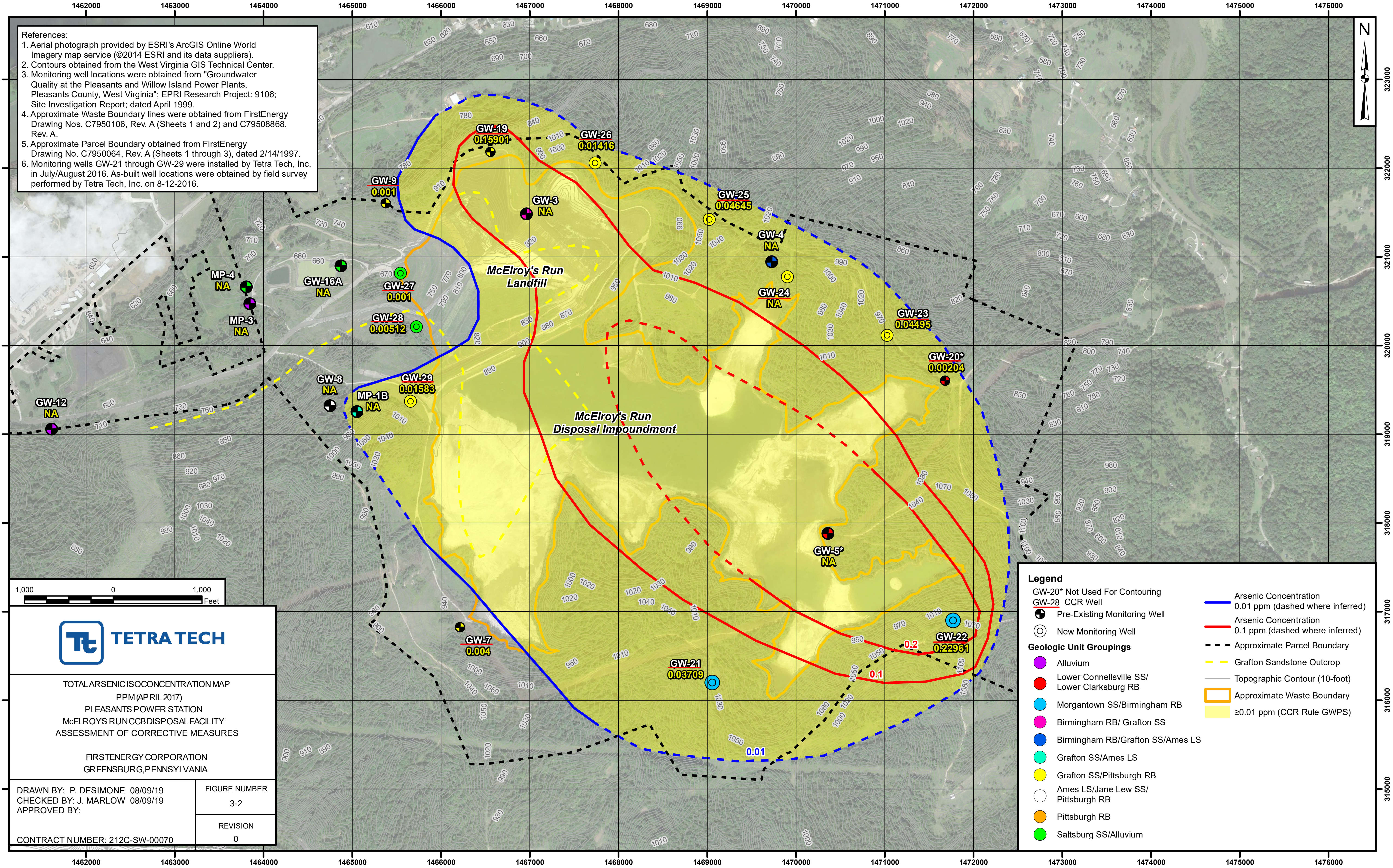

References:

1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (©2014 ESRI and its data suppliers).
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3. Monitoring well locations were obtained from "Groundwater Quality at the Pleasants and Willow Island Power Plants, Pleasants County, West Virginia"; EPRI Research Project: 9106; Site Investigation Report; dated April 1999.
4. Approximate Waste Boundary lines were obtained from FirstEnergy Drawing Nos. C7950106, Rev. A (Sheets 1 and 2) and C79508868, Rev. A.
5. Approximate Parcel Boundary obtained from FirstEnergy Drawing No. C7950064, Rev. A (Sheets 1 through 3), dated 2/14/1997.
6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

Legend

GW-20* Not Used For Contouring
GW-28 CCR Well
⊕ Pre-Existing Monitoring Well
◎ New Monitoring Well

Geologic Unit Groupings

● Alluvium
● Lower Connellsville SS/ Lower Clarksburg RB
● Morgantown SS/Birmingham RB
● Birmingham RB/ Grafton SS
● Birmingham RB/Grafton SS/Ames LS
● Grafton SS/Ames LS
● Grafton SS/Pittsburgh RB
○ Ames LS/Jane Lew SS/ Pittsburgh RB
● Pittsburgh RB
● Saltsburg SS/Alluvium

Arsenic Concentration 0.01 ppm (dashed where inferred)
Arsenic Concentration 0.1 ppm (dashed where inferred)
Approximate Parcel Boundary
Grafton Sandstone Outcrop
Topographic Contour (10-foot)
Approximate Waste Boundary
≥0.01 ppm (CCR Rule GWPS)

TETRA TECH

TOTAL ARSENIC ISOCONCENTRATION MAP
PPM (APRIL 2017)
PLEASANTS POWER STATION
McELROYS RUN CCB DISPOSAL FACILITY
ASSESSMENT OF CORRECTIVE MEASURES

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 08/09/19
CHECKED BY: J. MARLOW 08/09/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
3-2

REVISION
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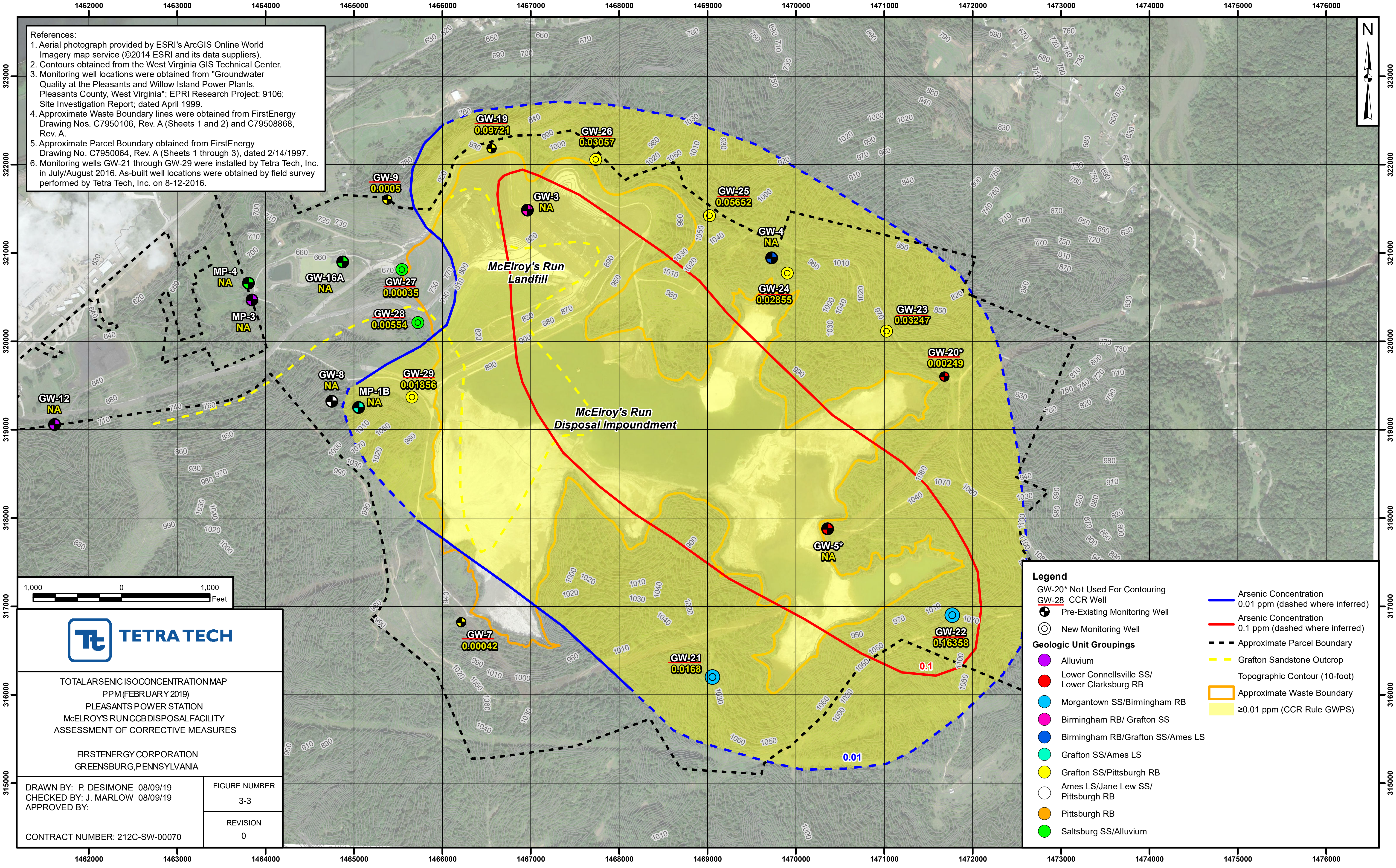


References:
1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (©2014 ESRI and its data suppliers).
2. Contours obtained from the West Virginia GIS Technical Center.
3. Monitoring well locations were obtained from "Groundwater Quality at the Pleasants and Willow Island Power Plants, Pleasants County, West Virginia"; EPRI Research Project: 9106; Site Investigation Report; dated April 1999.
4. Approximate Waste Boundary lines were obtained from FirstEnergy Drawing Nos. C7950106, Rev. A (Sheets 1 and 2) and C79508868, Rev. A.
5. Approximate Parcel Boundary obtained from FirstEnergy Drawing No. C7950064, Rev. A (Sheets 1 through 3), dated 2/14/1997.
6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

Legend

GW-20* Not Used For Contouring
GW-28 CCR Well
⊕ Pre-Existing Monitoring Well
◎ New Monitoring Well

Geologic Unit Groupings

- ● Alluvium
- ● Lower Connellsville SS/ Lower Clarksburg RB
- ● Morgantown SS/Birmingham RB
- ● Birmingham RB/ Grafton SS
- ● Birmingham RB/Grafton SS/Ames LS
- ● Grafton SS/Ames LS
- ● Grafton SS/Pittsburgh RB
- ○ Ames LS/Jane Lew SS/ Pittsburgh RB
- ● Pittsburgh RB
- ● Saltsburg SS/Alluvium

Arsenic Concentration 0.01 ppm (dashed where inferred)
Arsenic Concentration 0.1 ppm (dashed where inferred)
Approximate Parcel Boundary
Grafton Sandstone Outcrop
Topographic Contour (10-foot)
Approximate Waste Boundary
≥0.01 ppm (CCR Rule GWPS)

TETRA TECH

TOTAL ARSENIC ISOCONCENTRATION MAP
PPM (FEBRUARY 2019)
PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY
ASSESSMENT OF CORRECTIVE MEASURES

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

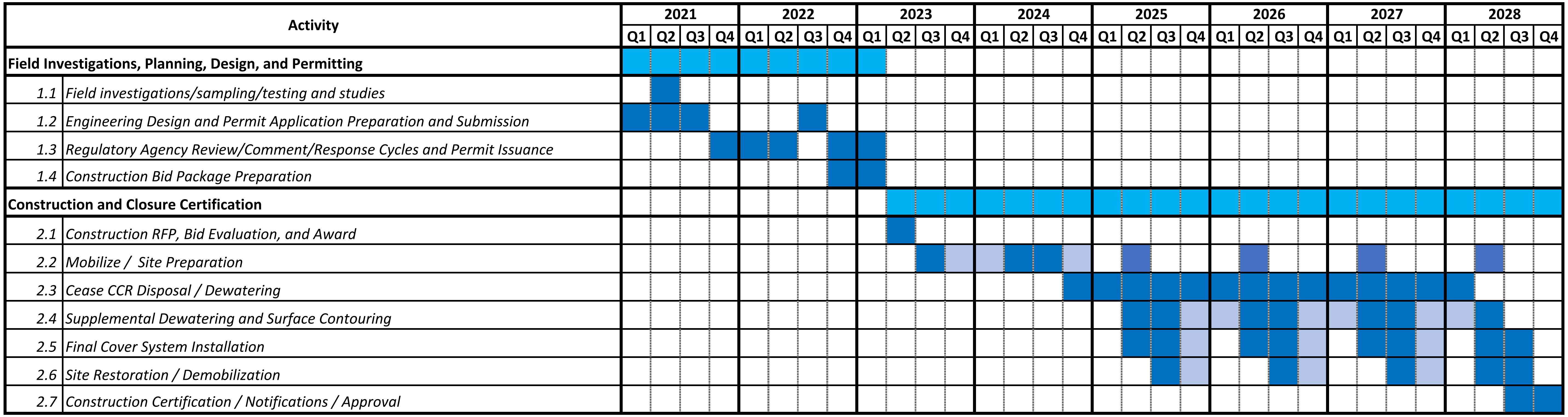
DRAWN BY: P. DESIMONE 08/09/19
CHECKED BY: J. MARLOW 08/09/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
3-3

REVISION
0

FIGURE 5-1. ESTIMATED CLOSURE SCHEDULE



Activity		2021				2022				2023				2024				2025				2026				2027				2028			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Field Investigations, Planning, Design, and Permitting		■	■	■	■	■	■	■	■	■																							
1.1	*Field investigations/sampling/testing and studies*		🟦																														
1.2	*Engineering Design and Permit Application Preparation and Submission*	🟦	🟦	🟦				🟦																									
1.3	*Regulatory Agency Review/Comment/Response Cycles and Permit Issuance*				🟦	🟦	🟦		🟦	🟦																							
1.4	*Construction Bid Package Preparation*								🟦	🟦																							
Construction and Closure Certification											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
2.1	*Construction RFP, Bid Evaluation, and Award*										🟦																						
2.2	*Mobilize / Site Preparation*											🟦	░	░	🟦	🟦	░		🟦				🟦				🟦				🟦		
2.3	*Cease CCR Disposal / Dewatering*																🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦			
2.4	*Supplemental Dewatering and Surface Contouring*																		🟦	🟦	░	░	🟦	🟦	░	░	🟦	🟦	░	░	🟦		
2.5	*Final Cover System Installation*																		🟦	🟦	░		🟦	🟦	░		🟦	🟦	░		🟦	🟦	
2.6	*Site Restoration / Demobilization*																			🟦	░			🟦	░			🟦	░		🟦	🟦	
2.7	*Construction Certification / Notifications / Approval*																															🟦	🟦

░ = Construction timeframe with seasonally-limited activities and/or possible winter shutdown period

ATTACHMENTS

ATTACHMENT 3-1

CCR Groundwater Monitoring Well Drilling Logs and Construction Diagrams

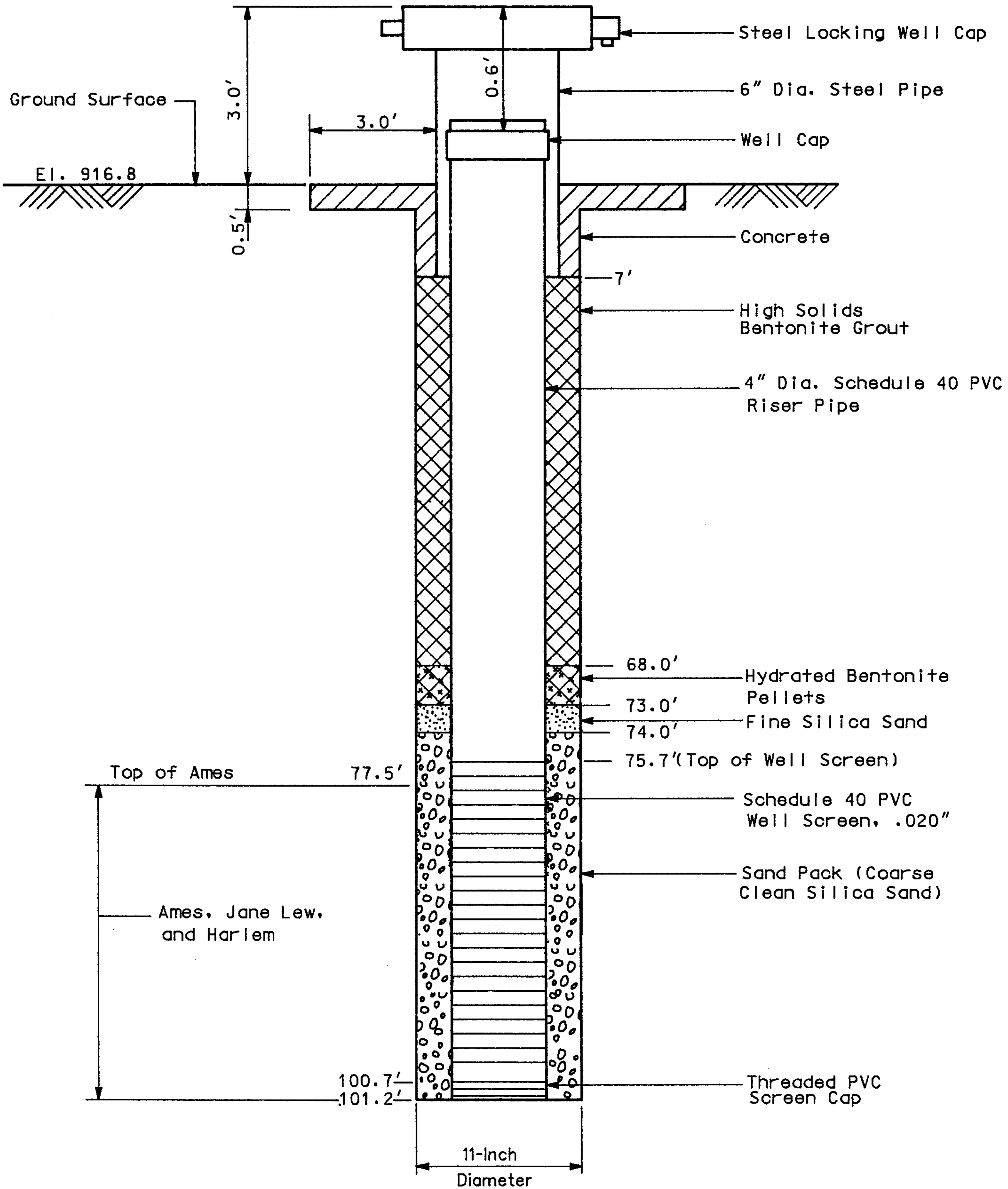


FIGURE 5

MONONGAHELA POWER COMPANY
PLEASANTS POWER STATION
McELROYS RUN DISPOSAL SITE
AS-BUILT MONITORING WELL GW-7

ALLEGHENY POWER SERVICE CORPORATION
GREENSBURG, PENNSYLVANIA

CONSULTANTS, INC.
Engineers Geologists Planners
Environmental Specialists
570 Beatty Rd. Pittsburgh
Monroeville, Pa. 15146
412-856-6400

DWN. NERowley
CHKD. AC
APPD. SRM
DATE 4/4/94
SCALE Not to Scale
DRAWING NUMBER 81-237-A97
REV

CAD FILE: 81237A01.DGN DATE: 04/05/94

PROJECT APS-McElroys Run
GAI PROJECT NO. 81-237-44
CONTRACT NO.
DATES DRILLED: 10/25/93
DATES INSTRUMENTED:

GAI CONSULTANTS, INC.

NON - SAMPLED BOREHOLE LOG

BOREHOLE NO. GW-7
NORTH COORDINATE: 496,263.30
EAST COORDINATE: 2,345,907.90
SURFACE ELEVATION: 916.83
INSPECTOR: F. J. Lotito

DEPTH		MATERIAL DESCRIPTION					REMARKS
FROM	TO						
0.0	6.0	Brn./Yellow Clay					
6.0	6.5	Brn. Clay w/ Grey Limestone nodules					
6.5	18.0	Red/Brn. And Brn./Yellow Clay					
18.0	22.0	Grey Sandy Shale					
22.0	30.0	Grey Fine-grained Sandstone					
30.0	39.0	Grey Silty Claystone					
39.0	40.0	Red/Brn Claystone					
40.0	45.0	Grey Claystone w/ Tan Cherty Limestone					
45.0	49.5	Grey Fine-grained Sandstone					
49.5	51.0	Grey Claystone					
51.0	53.0	Grey Fine-grained Sandstone w/ Cherty Matrix					
53.0	60.0	Grey Fine-grained Sandstone					
60.0	77.5	Grey Silty Claystone					~77.0' Blk. Natural Crude w/ odor
77.5	80.0	Dk. Grey Fossilliferous Limestone					Ames LS
80.0	84.0	Dk. Grey Limestone					
84.0	87.0	Blk. Coal					
87.0	99.0	Dk. Grey Claystone					
99.0	102.0	Grey Limestone					
		Bottom of Boring 102.0'					

SUMMARY:

DRILLING (LF): ~~13 7/8"~~ 13¼" 20.0', ~~12 1/4"~~ 10 5/8" 82.0', 9 7/8" ____, 7 7/8" ____, 5 7/8" ____
CASING (LF): ~~12"~~ 12¼" 19.5', 10" ____, 8" ____, 6" ____
THERMOCOUPLE (LF): ____ GAS SAMPLING TUBE (LF): ____ INSTRUMENTATION: ____ CAP: ____
STANDBY TIME: ____ EXPLANATION: ____
BOREHOLE SEAL: ____ EXPLANATION: ____
REMARKS:

BOREHOLE NO. GW-7

PAGE 1 of 1

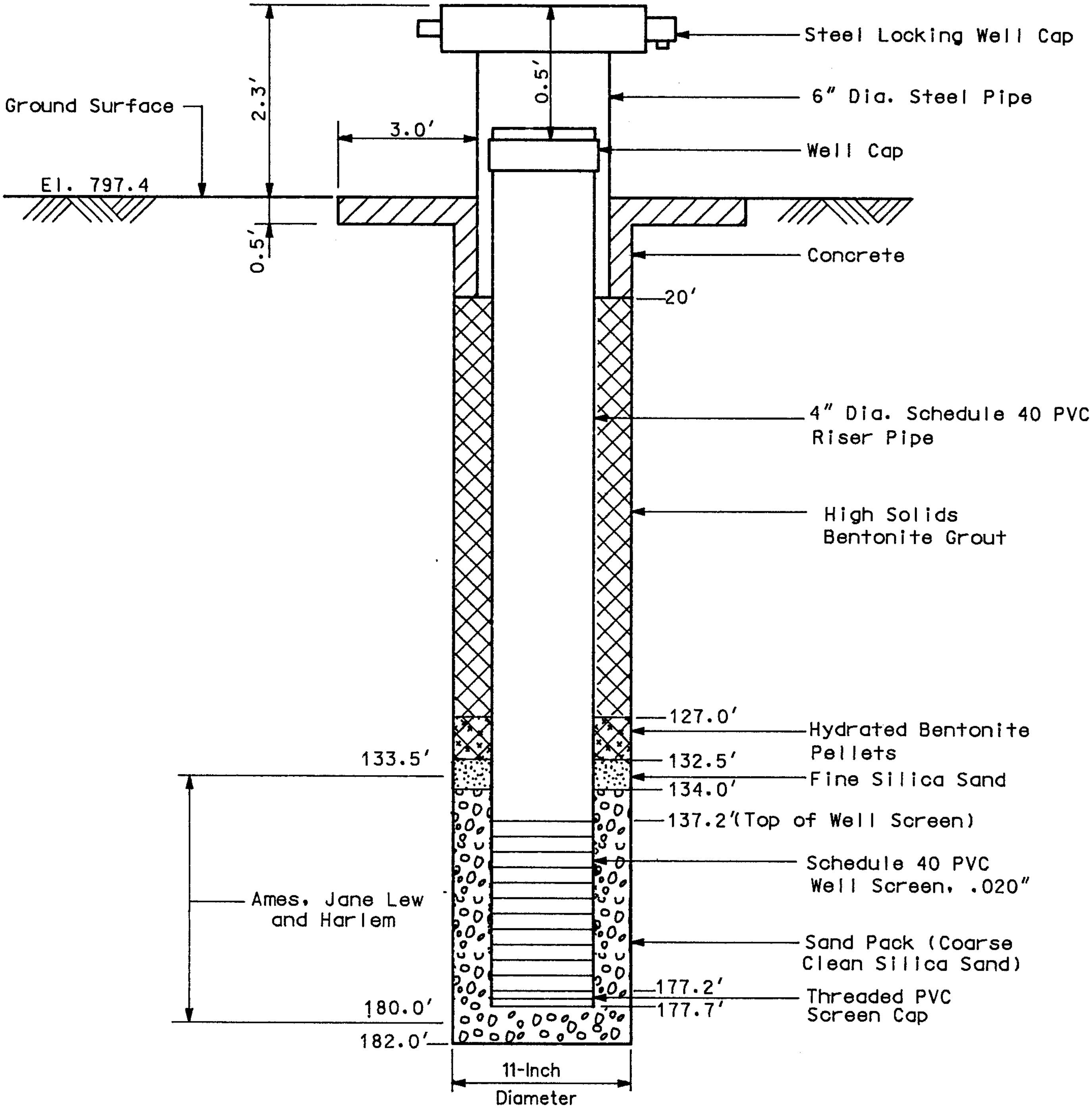


FIGURE 7

CONSULTANTS, INC.
Engineers Geologists Planners
Environmental Specialists

570 Beatty Rd. Pittsburgh
Monroeville, Pa. 15146
412-856-6400

MONONGAHELA POWER COMPANY
PLEASANTS POWER STATION
McELROYS RUN DISPOSAL SITE
AS-BUILT MONITORING WELL GW-9

ALLEGHENY POWER SERVICE CORPORATION
GREENSBURG, PENNSYLVANIA

DWN. NERowley
CHKD. AC
APPD. SRM
DATE 4/4/94
SCALE Not to Scale
DRAWING NUMBER 81-237-A99
REV

CAD FILE: 81237A01.DGN DATE: 04/05/94

Figur 1.

PROJECT McElroys Run
GAI PROJECT NO. 81-237-44
CONTRACT NO.
DATES DRILLED: 10-5-93
DATES INSTRUMENTED:

gai CONSULTANTS, INC.

NON - SAMPLED BOREHOLE LOG

BOREHOLE NO. GW-9
NORTH COORDINATE: 500,010.12
EAST COORDINATE: 2,344,916.82
SURFACE ELEVATION: 797.42
INSPECTOR: A. Caffas

DEPTH		MATERIAL DESCRIPTION					REMARKS
FROM	TO						
0.0	13.0	Tan Silty Clay trace Rock Frags					
13.0	31.0	Red Claystone					w/ Limestone Nodules
31.0	34.0	Gry Claystone					
34.0	53.0	Red Claystone					Gry zones 45.0'-53.0'
53.0	57.0	Gry Claystone					
57.0	62.0	Red & Gry Claystone					
62.0	71.0	Gry Claystone					67.0-67.5 Limestone or Limestone Nodules
71.0	73.0	Red & Gry Silty Claystone					
73.0	78.0	Gry Silty Shale					
78.0	79.0	Gry Sandy Shale					
79.0	80.0	Gry Siltstone w/ Shale Partings					Some water @ ~78.0'-79.0'
80.0	86.0	Gry Sandstone (Medium-Fine Grained)					
86.0	88.0	Gry Silty Shale and Siltstone					
88.0	98.0	Gry Silty Shale					
98.0	100.0	Gry Silty Claystone					More water @ ~94.0'
100.0	102.0	Red Claystone					Began adding water to drill with @ ~100.0'
102.0	108.0	Gry Siltstone (Hard)					Thin clay seam @ ~105.0'
108.0	111.0	Gry Sandstone (Med.-Fine Grained)					
111.0	126.0	Gry Silty Shale and Siltstone					
126.0	132.0	Gry Silty Shale					

SUMMARY:

DRILLING (LF): ~~13 7/8"~~ 20.0 , ~~12 1/4"~~ 10 5/8" 162.0 , 9 7/8" ____ , 7 7/8" ____ , 5 7/8" ____

CASING (LF): 12" 21.0 , 10" ____ , 8" ____ , 6" ____

THERMOCOUPLE (LF): ____ GAS SAMPLING TUBE (LF): ____ INSTRUMENTATION: ____ CAP: ____

STANDBY TIME: ____ EXPLANATION: ____

BOREHOLE NO. GW-9

BOREHOLE SEAL: ____ EXPLANATION: ____

PAGE 1 of 2

REMARKS: Drilled w/ a Davey-Kent DR-30 Trackmounted Air Rotary Drill.
Nick Cursi-Driller

Field Classification Sheet for Non-Sampled Borehole

Figur 1.

PROJECT McElroys Run
GAI PROJECT NO. 81-237-44
CONTRACT NO.
DATES DRILLED: 10-5-93
DATES INSTRUMENTED:

gai CONSULTANTS, INC.

NON - SAMPLED BOREHOLE LOG

BOREHOLE NO. GW-9
NORTH COORDINATE:
EAST COORDINATE:
SURFACE ELEVATION:
INSPECTOR: A. Caffas

DEPTH		MATERIAL DESCRIPTION					REMARKS
FROM	TO						
132.0	138.5	DK. Gry Shale (Soft)					
138.5	142.0	DK Brn Limy Siltstone to Limestone					Ames @ ~138.5'
142.0	156.0	Gry Silty Shale & Siltstone					
156.0	157.0	Gry Sandstone					
157.0	162.5	Gry Siltstone					
162.5	171.0	Gry Siltstone w/ Limestone & Chert Nodules					
171.0	172.0	Gry Sandstone					
172.0	180.0	Gry Siltstone					
180.0	182.0	Red Claystone					Pittsburgh Red Beds
							Finished Drilling @ 1730 10-5-93
		Bottom of Borehole @ 182.0'					

SUMMARY:

DRILLING (LF): 13 7/8" ______, 12 1/4" ______, 9 7/8" ______, 7 7/8" ______, 5 7/8" ______
CASING (LF): 12" ______, 10" ______, 8" ______, 6" ______
THERMOCOUPLE (LF): ______ GAS SAMPLING TUBE (LF): ______ INSTRUMENTATION: ______ CAP: ______
STANDBY TIME: ______ EXPLANATION: ______
BOREHOLE SEAL: ______ EXPLANATION: ______
REMARKS: ______

BOREHOLE NO. GW-9
PAGE 2 of 2

Field Classification Sheet for Non-Sampled Borehole

EPRI West Virginia
Groundwater Study

Allegheny Power System

Log of Boring GW-19

McElroy's Run Disposal Facility
Pleasant's/Willow Island Power Station

Sheet 1 of 7

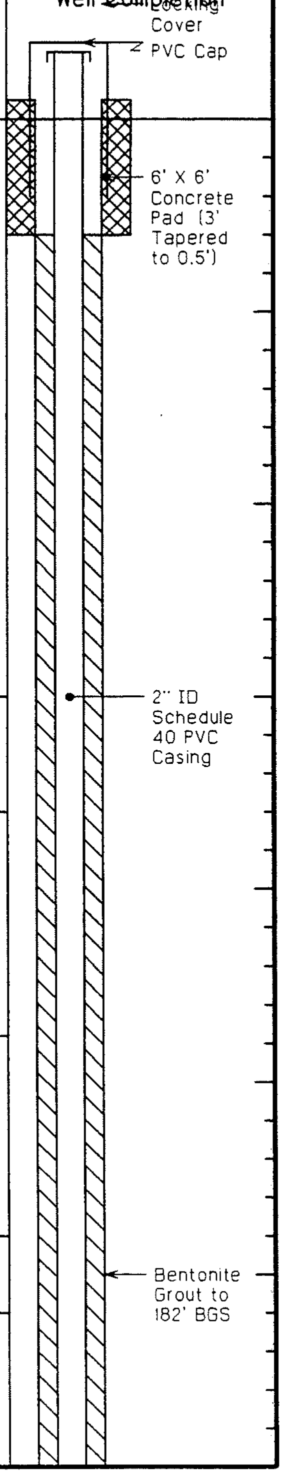
JOB NUMBER: 2008-202

LOGGED BY: G. Goldstein

DRILLER: Jim Crockett	**RIG:** Deidrich D-120	**N:** 0H501708	**E:** 0H2346163
DRILL METHOD: NQ Wireline Coring	**GS Elevation:** 920.64	**TOC ELEV.:** 923.23	**TOC (6"):** 923.50
SAMPLE METHOD: NQ Core	**CHECKED BY:** M. Shupe	**DEPTH BORING:** 243.8 f	**DEPTH WELL:** 238.9 ft
BOREHOLE DIAMETER: 3"	**WATER LEVEL:** 160.86	**DATE STARTED:** 7/13/95	**DATE FINISHED:** 7/14/95

Sample No./ Type	Sample Depth From/To	SPT (Blows/6")/ ROP (ft/min)	Recovery/ RQD (%)	Depth (feet)	Materials Description
				5 10	Top Soil and Decomposed Bedrock
1/NQ	15-23.8'	0.6 1.0	100/66	15 20	CLAYSTONE, 5 R 2/2, blackish red, massive, soft, weathered, not reactive to dilute HCL. CLAYEY SILTSTONE, 10 YR 4/2, moderate yellowish brown, very soft, fresh to slightly weathered. Clean horizontal fracture at ~23' BGS; slight water loss.
2/NQ	23.8-33.8'	1.0 0.8	100/66	25 30	Same, with mild staining. One fracture 2" thick with mild Fe-staining and clay infilling at 29' BGS. SILTSTONE, N6, medium light gray, fresh, soft, 4" limey section at ~30' BGS. CLAYSTONE, 5 Y 7/2, yellowish gray, very soft, fresh to highly weathered, not reactive to dilute HCL.
3/NQ	33.8-43.8'		100/72		

Well Completion



EPRI West Virginia
Groundwater Study

Allegheny Power System

Log of Well GW-19

McElroy's Run Disposal Facility
Pleasant's/Willow Island Power Station

Sheet 2 of 7

JOB NUMBER: 2008-202

LOGGED BY: G. Goldstein

Sample No./ Type	Sample Depth From/To	SPT (Blows/6")/ ROP (ft/min)	Recovery/ RQD (%)
3/NQ	33.8-43.8	0.8 0.6	100/72
4/NQ	43.8-53.8	0.6 0.8	100/80
5/NQ	53.8-63.8	0.6	100/91
6/NQ	63.8-73.8	0.6 0.8	100/100
7/NQ	73.8-83.8	0.6	100/83

Depth (feet): 40, 45, 50, 55, 60, 65, 70

Graphic Log

Materials Description

CLAYSTONE, N5, medium gray, soft, fresh, not reactive to dilute HCL.

Bottom 1/2' fractured with clay infilling.

SANDSTONE, N3, dark gray, fine sand grain size, hard, fresh, micaceous, crossbedded, not reactive to dilute HCL.

CLAYSTONE, N4, medium dark gray, very soft, few fractures and clay infilling, not reactive to dilute HCL.

SILTSTONE, N4, medium dark gray, hard, fresh, not reactive to dilute HCL.

2" wide fractured interval at 45.3' BGS.

CLAYSTONE, N4, medium dark gray, very soft, fresh to highly weathered, not reactive to dilute HCL.

Clay filled fractures at 50.3, 52.3, and 52.8' BGS.

Same

CLAYSTONE, 10 R 2/2, very dusky red, very soft, highly weathered, not reactive to dilute HCL.

SILTSTONE, N4, medium dark gray, medium hardness, fresh, not reactive to dilute HCL.

CLAYSTONE, N4, medium dark gray, fresh, very soft, not reactive to dilute HCl.

CLAYEY SILTSTONE, N5, medium gray, soft to medium hardness, fresh, not reactive to dilute HCL.

SILTSTONE, N5, medium gray, hard, fresh, minor calcite cement, slight iron-staining, not reactive to dilute HCL.

Large 8" vertical fracture at 72.8' BGS.

Same

Well Completion

EPRI West Virginia Groundwater Study Allegheny Power System	**Log of Well GW-19** McElroy's Run Disposal Facility Pleasant's/Willow Island Power Station	**Sheet 3 of 7** **JOB NUMBER:** 2008-202 **LOGGED BY:** G. Goldstein

Sample No./Type	Sample Depth From/To	SPT (Blows/6")/ROP (ft/min)	Recovery/RQD (%)	Depth (feet)	Graphic Log	Materials Description	Well Completion
						CLAYSTONE, N4, medium dark gray, highly weathered, soft, minor calcite not reactive to dilute HCL.	
7/NQ	73.8-83.8'	0.6	100/83	80			
						SANDSTONE, N5, medium gray, fresh, hard, fine sand grain size, quartz, micaceous, crossbedded, not reactive to dilute HCL.	
				85		SANDSTONE, N4, medium dark gray, fine sand grain size, hard, fresh, quartz, micaceous, crossbedded. Areas of iron-staining at ~89 and ~92' BGS, not reactive to dilute HCL.	
8/NQ	83.8-93.8'	0.6	100/100				
				90			
				95		Same, without iron-staining. Large 45 degree 5" fracture at 96.3' BGS.	
		0.4					
9/NQ	93.8-103.8'		100/90				
		0.6		100		LIMESTONE, N6, medium light gray, microcrystalline, massive, hard, fresh, some pyrite, reaction to dilute HCL. 2" vertical fracture at 100' BGS.	
				105		LIMEY CLAYSTONE, 5 G 2/1, greenish black, soft, highly weathered, slickensided, minor reaction to dilute HCL.	
						LIMESTONE, N6, medium light gray, microcrystalline, massive, hard, fresh, reaction to dilute HCL.	
10/NQ	103.8-113.8'	0.8	100/75				
				110		CLAYSTONE, 5 YR 4/1 brownish gray to 5 G 4/1 greenish gray, soft, some weathering, not reactive to dilute HCL.	
11/NQ	113.8-123.8'	0.8	100/87				

EPRI West Virginia
Groundwater Study

Allegheny Power System

Log of Well GW-19

McElroy's Run Disposal Facility
Pleasant's/Willow Island Power Station

Sheet 4 of 7

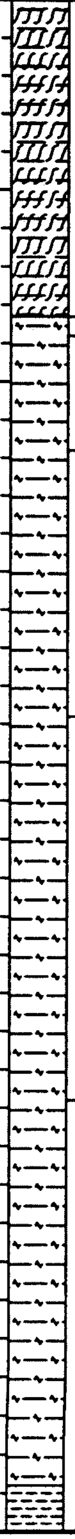
JOB NUMBER: 2008-202

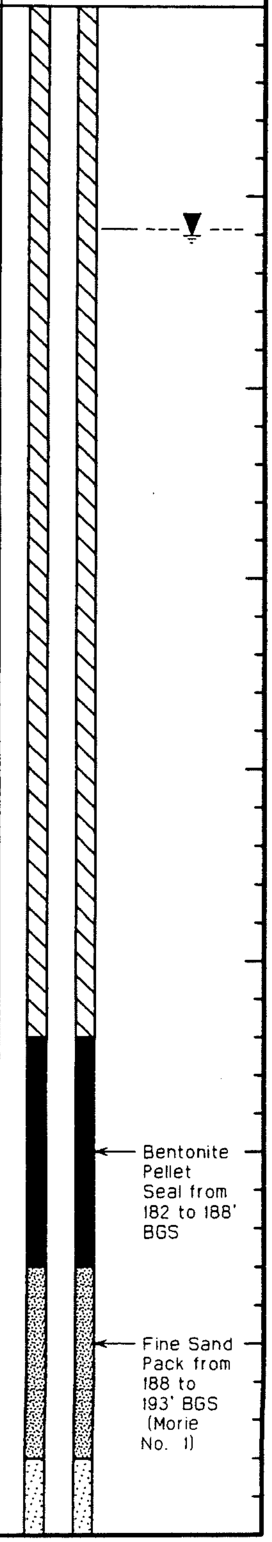
LOGGED BY: G. Goldstein

Sample No./ Type	Sample Depth From/To	SPT (Blows/6")/ ROP (ft/min)	Recovery/ RQD (%)	Depth (feet)	Graphic Log	Materials Description	Well Completion
11/NQ	113.8-123.8'	0.8	100/87	120		CLAYSTONE, 5 B 5/1 medium bluish gray and 5 R 3/4 dusky red, fresh, soft, limey deposits in top 5' of core, slickensides at bottom of core	
12/NQ	123.8-133.8'	1.2	100/65	125 130		CLAYEY SHALE, 5 YR 4/1, brownish gray, clay interbedded, soft, not reactive to dilute HCL. LIMESTONE, N4, medium dark gray, microcrystalline, massive, hard, fresh, with pyrite, reaction to dilute HCL. LIMEY CLAYSTONE, 5 G 6/1, greenish gray, soft, fresh, with limestone clasts.	
13/NQ	133.8-143.8'	1.4 2.0	100/73	135 140		LIMEY CLAYSTONE, 5 YR 4/1, brownish gray, soft, fresh, multiple slickensides and fractures throughout core.	
14/NQ	143.8-153.8'	2.0	100/79	145 150		Same, with 5 R 4/2 grayish red limey claystone interbedded.	
15/NQ	153.8-163.8'	2.0	100/78			Same as 133.8' BGS, with calcite nodules.	

EPRI West Virginia Groundwater Study Allegheny Power System	**Log of Well GW-19** McElroy's Run Disposal Facility Pleasant's/Willow Island Power Station	**Sheet 5 of 7** **JOB NUMBER:** 2008-202 **LOGGED BY:** G. Goldstein

Sample No./ Type	Sample Depth From/To	SPT (Blows/6")/ ROP (ft/min)	Recovery/ RQD (%)	Depth (feet)	Materials Description
15/NQ	153.8-163.8'	2.0	100/78	160	
16/NQ	163.8-173.8'	2.0	100/86	165 170	LIMEY SHALE, 10 GY 5/2, grayish green, hard, fresh, minor reaction to dilute HCL. LIMEY SHALE, 5 B 5/1, medium bluish gray, soft to medium hardness, fresh, calcite nodules, few small fractures, 45 degree slickensides. Same, color change to 5 YR 4/1, brownish gray.
17/NQ	173.8-183.8'	2.0	100/81	175 180	LIMEY SHALE, 5 B 5/1, medium bluish gray, soft-medium hardness, fresh, calcite, few small fractures, 45 degree slickensides.
18/NQ	183.8-193.8'	2.0	100/80	185 190	LIMEY SHALE, 5 B 5/1 medium bluish gray and 5 YR 4/1 brownish gray, hard, fresh, 45 degree slickensides, small horizontal fractures.
19/NQ	193.8-203.8'	1.4	100/87		

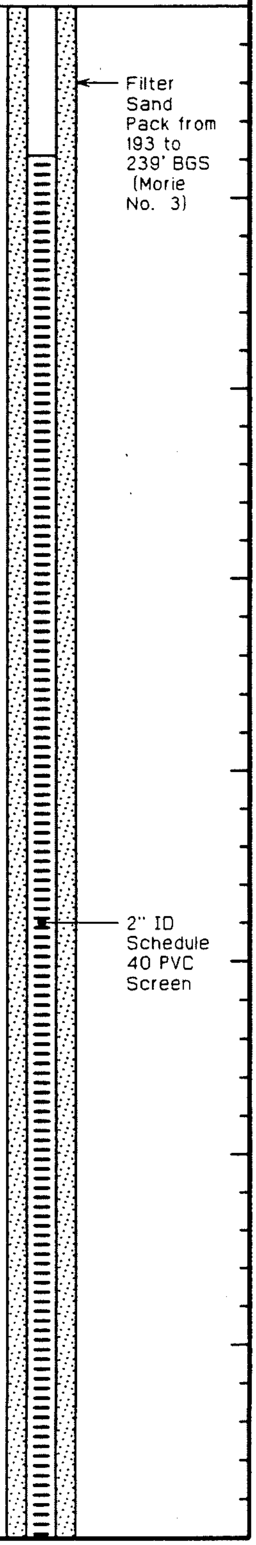




EPRI West Virginia Groundwater Study Allegheny Power System	**Log of Well GW-19** McElroy's Run Disposal Facility Pleasant's/Willow Island Power Station	**Sheet 6 of 7** **JOB NUMBER:** 2008-202 **LOGGED BY:** G. Goldstein

Sample No./ Type	Sample Depth From/To	SPT (Blows/6")/ ROP (ft/min)	Recovery/ RQD (%)	Depth (feet)	Graphic Log	Materials Description
19/NQ	193.8-203.8'	1.4 1.2	100/87	200		CLAYSHALE, 5 G 6/1, greenish gray, hard, fresh, minor calcite viens, not reactive to dilute HCL. Horizontal fracture at 198.8' BGS.
20/NQ	203.8-213.8'	0.8	100/95	205		CLAYEY SILTSTONE, N7, light gray, medium hardness, fresh, minor calcite, not reactive to dilute HCL.
				210		SILTSTONE, N7, light gray, hard, fresh, not reactive to dilute HCL. Large fracture at 211.8' BGS ~1' long.
21/NQ	213.8-223.8'	0.8 0.6	100/25	215 220		SANDSTONE, N6, medium light gray, fine to medium sand grain size, hard fresh, not reactive to dilute HCL. Crude oil odor. Series of fractures in bottom 5' of core.
22/NQ	223.8-233.8'	0.8	100/95	225 230		SANDSTONE, N7, light gray, hard, fresh, small 3" clay seam at ~229' BGS, minor quartz, not reactive to dilute HCL. Crude oil odor.
23/NQ	233.8-243.8'	1.2	100/95			CLAYSTONE, N7, light gray, soft, fresh, few fossils, not reactive to dilute HCL.

Well Completion



EPRI West Virginia
Groundwater Study

Allegheny Power System

Log of Well GW-19

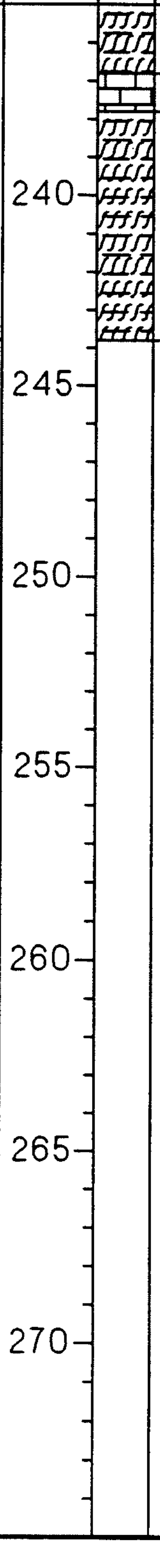
McElroy's Run Disposal Facility
Pleasant's/Willow Island Power Station

Sheet 7 of 7

JOB NUMBER: 2008-202

LOGGED BY: G. Goldstein

Sample No./ Type	Sample Depth From/To	SPT (Blows/6")/ ROP (ft/min)	Recovery/ RQD (%)
23/NQ2	3.8-243.8'	1.2	100/95



Materials Description

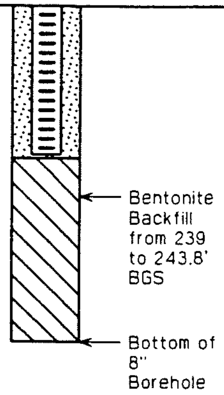
LIMEY CLAYSTONE, N4, medium dark gray, soft, fresh, minor reaction to dilute HCL.

LIMESTONE, N4, medium dark gray, microcrystalline, fresh, hard, reaction to dilute HCL.

LIMEY CLAYSTONE, N4, medium to dark gray, soft, fresh, minor reaction to dilute HCL.

End of Borehole at 243.8' BGS.

Well Completion



EPRI West Virginia
Groundwater Study

Allegheny Power System

Log of Boring GW-20

McElroy's Run Disposal Facility
Pleasant's/Willow Island Power Station

Sheet 1 of 4

JOB NUMBER: 2008-202

LOGGED BY: T. White

DRILLER: Nick Cursi, Lambert Drilling Co., Inc.

RIG: Schramm Rotodrill

N: 0H499215

E: 0H2351292

DRILL METHOD: Air Rotary

GS Elevation: 923.00

TOC ELEV.: 925.68

TOC (8"): 925.97

SAMPLE METHOD: Drill Cuttings Grab Sample

CHECKED BY: M. Shupe

DEPTH BORING: 151 ft.

DEPTH WELL: 150.5 ft.

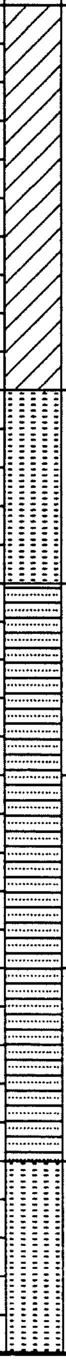
BOREHOLE DIAMETER: 8"

WATER LEVEL: 70.53 ft.

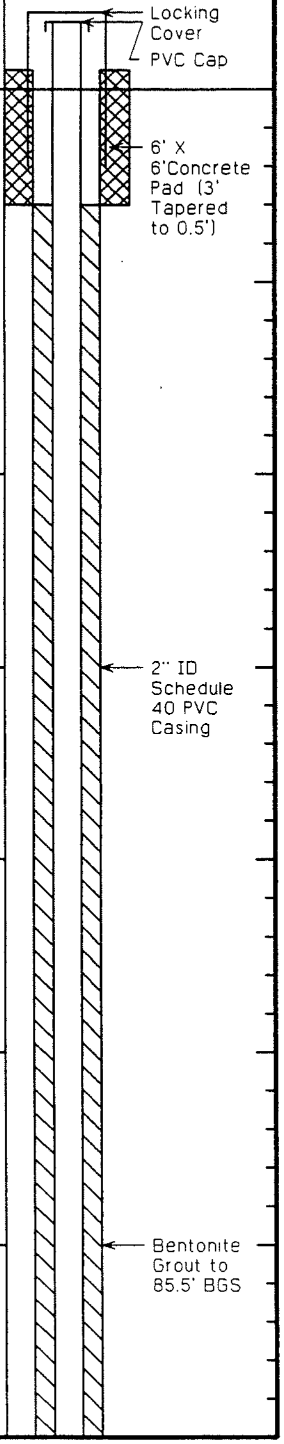
DATE STARTED: 8/7/95

DATE FINISHED: 8/7/95

Sample No./ Type	Sample Depth From/To	SPT (Blows/6")/ ROP (ft/min)	Recovery/ RQD (%)	Depth (feet)	Graphic Log	Materials Description
				5		Top Soil and Decomposed Bedrock
1/GS	10-15'			10		SILTSTONE, 10 YR 6/2, pale yellowish brown, with some clay mixed in, not reactive to dilute HCL.
2/GS	15-20'			15		SANDSTONE, 5 B 5/1, medium bluish gray, micaceous, medium sand grain size, fresh, hard, not reactive to dilute HCL.
3/GS	20-25'			20		Same, more micaceous.
4/GS	25-30'			25		SANDSTONE, 5 B 5/1, medium bluish gray, micaceous, medium grained, fresh, hard, not reactive to dilute HCL.
5/GS	30-35'			30		SILTSTONE, 5 GY 2/1, greenish black, fresh, hard, not reactive to dilute HCL.



Well Completion



EPRI West Virginia
Groundwater Study

Allegheny Power System

Log of Well GW-20

McElroy's Run Disposal Facility
Pleasant's/Willow Island Power Station

Sheet 2 of 4

JOB NUMBER: 2008-202

LOGGED BY: T. White

Sample No./ Type	Sample Depth From/To	SPT (Blows/6")/ ROP (ft/min)	Recovery/ RQD (%)	Depth (feet)	Graphic Log	Materials Description	Well Completion
6/GS	35-40'					Same	
7/GS	40-45'			40		CLAYSTONE, 5 G 4/1, dark greenish gray, very soft, fresh, not reactive to dilute HCL	
8/GS	45-50'			45		Same	
9/GS	50-55'			50		SILTSTONE, 5 R 2/2, blackish red, medium hardness, fresh, not reactive to dilute HCL.	
10/GS	55-60'			55		LIMEY SHALE, 5 GY 4/1, dark greenish gray, micaceous, minor reaction to dilute HCL.	
11/GS	60-65'			60		SANDSTONE, 5 G 4/1, dark greenish gray, fine sand grain size, hard, micaceous, some interbedded siltstone, 5 R 2/2 blackish red, not reactive to dilute HCL.	
12/GS	65-70'			65		SANDSTONE, 5 G 2/1, greenish black, fine sand grain size, micaceous, with interbedded blackish red siltstone, not reactive to dilute HCL.	
13/GS	70-75'			70		CLAYSTONE, 5 R 2/2, blackish red, fresh, very soft, not reactive to dilute HCL.	

EPRI West Virginia
Groundwater Study

Allegheny Power System

Log of Well GW-20

McElroy's Run Disposal Facility
Pleasant's/Willow Island Power Station

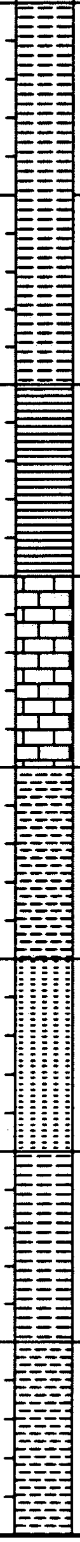
Sheet 3 of 4

JOB NUMBER: 2008-202

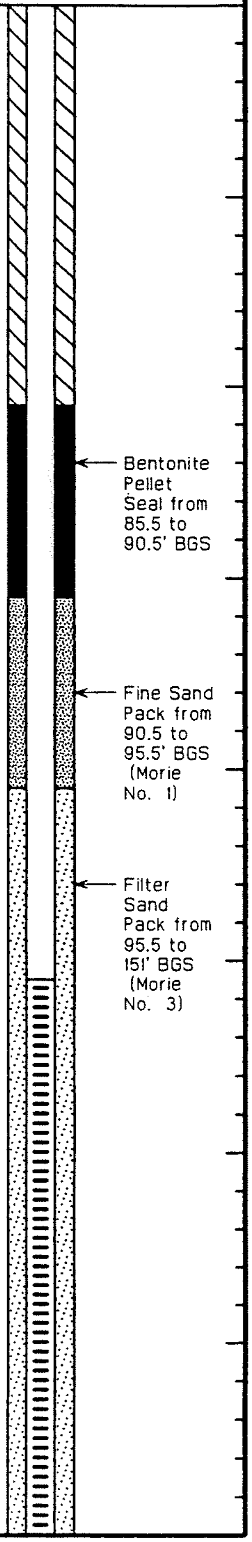
LOGGED BY: T. White

Sample No./ Type	Sample Depth From/To	SPT (Blows/6")/ ROP (ft/min)	Recovery/ RQD (%)	Depth (feet)	Materials Description
14/GS	75-80'				Same
15/GS	80-85'			80	Same, with shale, 5 YR 2/1 brownish black mixed in.
16/GS	85-90'			85	SHALE, 5 YR 2/1, brownish black, fresh, hard, platy cleavage, not reactive to dilute HCL.
17/GS	90-95'			90	LIMESTONE, 5 Y 2/1, olive black, carbonacoeus, microcrystalline, massive, hard, fresh, very reactive to dilute HCL.
18/GS	95-100'			95	Same, with mixture of gray, purple, and gold subrounded pebbles mixed in, very weathered, fracture zone.
19/GS	100-105'			100	SILTSTONE, 5 GY 2/1, greenish black, hard, fresh, not reactive to dilute HCL.
20/GS	105-110'			105	CLAYSTONE, 5 GY 2/1, greenish black, soft, fresh, not reactive to dilute HCL.
21/GS	110-115'			110	CLAYSHALE, 5 G 4/1, dark greenish gray, soft, platy cleavage visible in larger cuttings, not reactive to dilute HCL.

Graphic Log



Well Completion

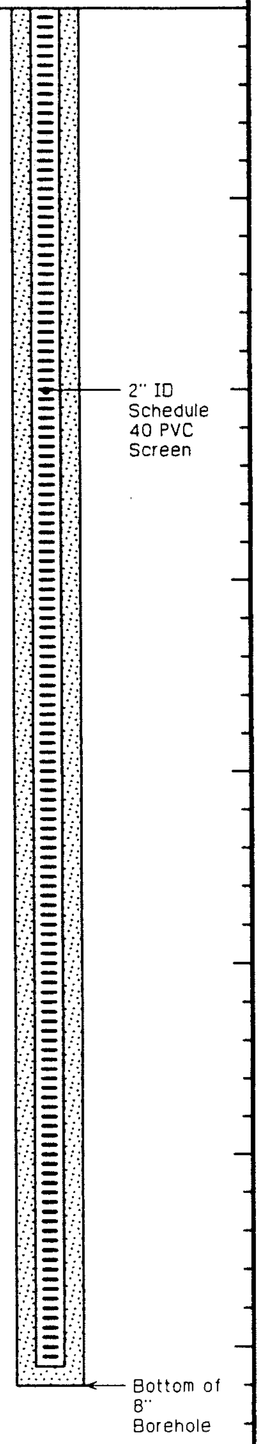


EPRI West Virginia Groundwater Study Allegheny Power System	**Log of Well GW-20** McElroy's Run Disposal Facility Pleasant's/Willow Island Power Station	**Sheet 4 of 4** **JOB NUMBER:** 2008-202 **LOGGED BY:** T. White

Sample No./ Type	Sample Depth From/To	SPT (Blows/6")/ ROP (ft/min)	Recovery/ RQD (%)	Depth (feet)	Materials Description
22/GS	115-120'				SANDSTONE, 5 G 2/1, dark greenish gray, fine sand grain size, hard, fresh, micaceous, not reactive to dilute HCL.
23/GS	120-125'			120	CLAYSTONE, 5 G 4/1, dark greenish gray, soft, not reactive to dilute HCL.
24/GS	125-130'			125	CLAYSTONE, 5 R 2/2 blackish red and 5 GY 2/1 greenish black, interbedded, very soft, not reactive to dilute HCL.
25/GS	130-135'			130	LIMESTONE, N3, dark gray, microcrystalline, massive, hard, reaction to dilute HCL.
26/GS	135-140'			135	SILTSTONE, 5 R 2/2, blackish red, medium hardness, not reactive to dilute HCL.
27/GS	140-145'			140	CLAYSHALE, 5 R 2/2, blackish red, soft, platy cleavage in larger cuttings, not reactive to dilute HCL.
28/GS	145-150'			145	Same
				150	CLAYSTONE, 5 R 2/2, blackish red, very soft, fresh, not reactive to dilute HCL. End of Borehole at 151' BGS.

Graphic Log

Well Completion

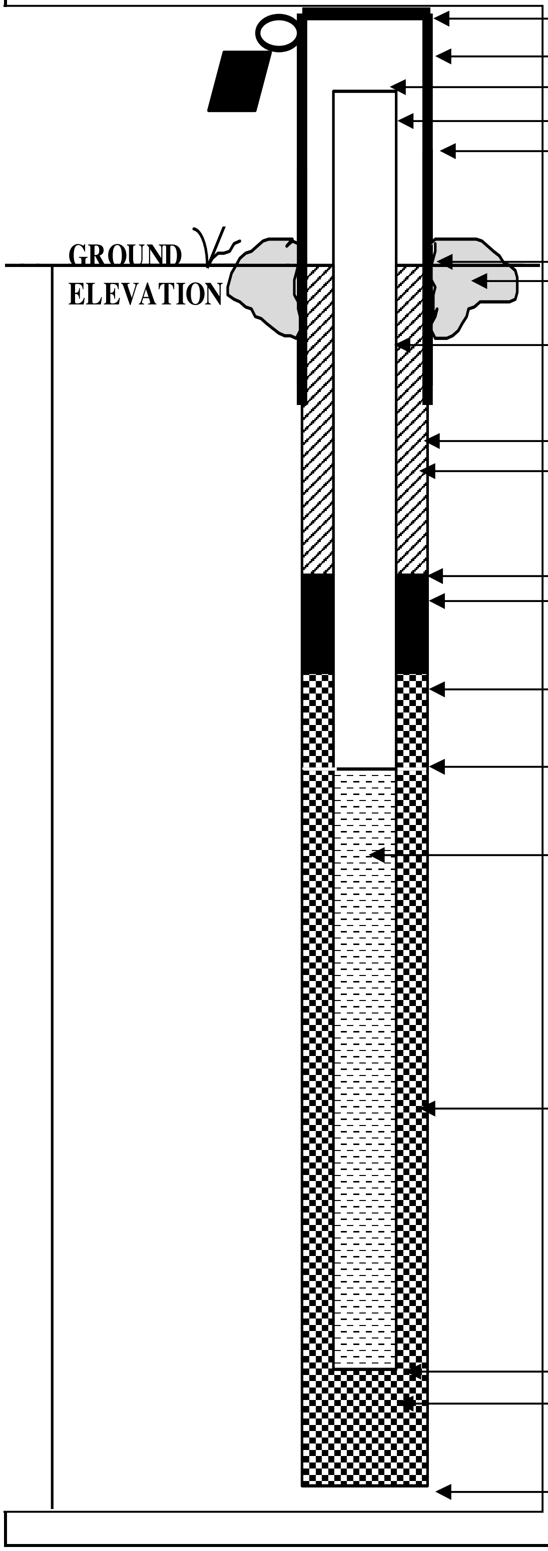


BORING NO.: GW-21

Tetra Tech, Inc.

GROUNDWATER MONITORING WELL SHEET

PROJECT:	CCR GW Installation	DRILLING Co.:	Eichelbergers	WELL No.:	GW-21
PROJECT No.:	112IC07852 Task 3.2	DRILLER:	Randy Hoffman	DATE COMPLETED:	6-Jul-16
SITE:	Pleasants Power	DRILLING METHOD:	Air Rotary	NORTHING:	316029.08
GEOLOGIST:	Scott Anderson	DEV. METHOD:	Surge, Bail	EASTING:	1469096.47



ELEVATION OF TOP OF SURFACE CASING: 1035.97

STICK -UP TOP OF SURFACE CASING: 2.96

ELEVATION OF TOP OF RISER PIPE: 1035.17

RISER STICK-UP ABOVE GROUND SURFACE: 2.16

I.D. OF SURFACE CASING: 6-inches

TYPE OF SURFACE CASING: Stainless Steel

GROUND ELEVATION: 1033.01

TYPE OF SURFACE SEAL: Cement

RISER PIPE I.D.: 2-inches

TYPE OF RISER PIPE: Schedule 40 PVC

BOREHOLE DIAMETER: 6-inches

TYPE OF SEAL: Cement-Bentonite Grout

ELEVATION / DEPTH OF SEAL: 827.1 / 206

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF FILTER PACK: 823.1 / 210

ELEVATION / DEPTH TOP OF SCREEN: 820.1 / 213

TYPE OF SCREEN: PVC

SLOT SIZE X LENGTH: 10 slot X 20 feet

I.D. OF SCREEN: 2-inches

TYPE OF FILTER PACK: US Standard Sieve size 20/40 (No. 0 clean silica sand)

ELEVATION / DEPTH BOTTOM OF SCREEN: 800.1 / 233

ELEVATION / DEPTH BOTTOM OF FILTER PACK: 799.6 / 233.5

TYPE OF BACKFILL BELOW WELL: Silica Sand (as above)

ELEVATION / DEPTH OF BOREHOLE: 799.6 / 233.5

LOG OF BORING GW-21

(Page 1 of 5)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

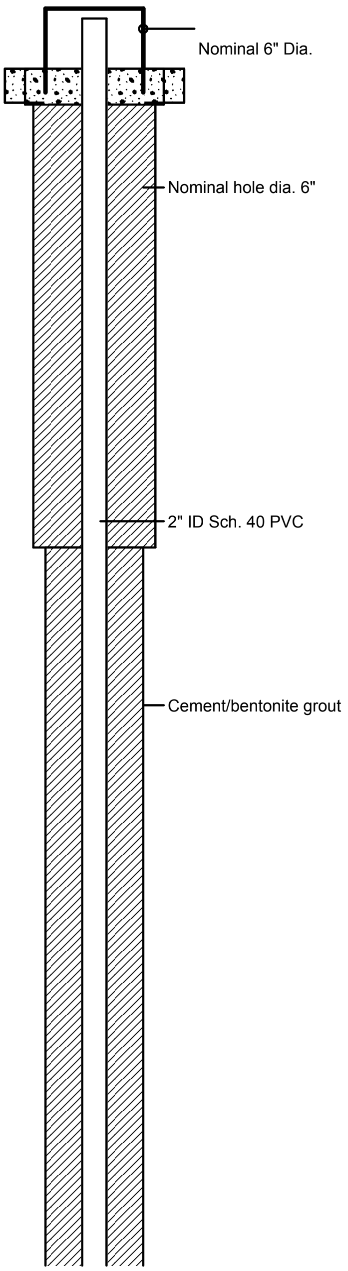
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/6/16	Ground Elevation	: 1033.01
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1469096.47	Northing	: 316029.08

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
0					Claystone, red, soft, dry, no effervescent	Clst
10					Sandstone, calcareous cement, tan, medium hard, dry, moderately effervescent	Sst
					Claystone, red, medium hard, dry, no effervescent	Clst
					Sandstone, tan, medium hard	Sst
20					Claystone, red, medium, dry, no effervescent	Clst
					Claystone, dark red, hard	Clst
30					Fine Sandstone, tan, hard	Sst
					Claystone, red, hard	Clst
					Sandstone, tan/red, hard	Sst
40					Claystone, red, hard	Clst
50					Limey Sandstone, tan/gray, medium	lmySst



TETRA TECH

LOG OF BORING GW-21

(Page 2 of 5)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

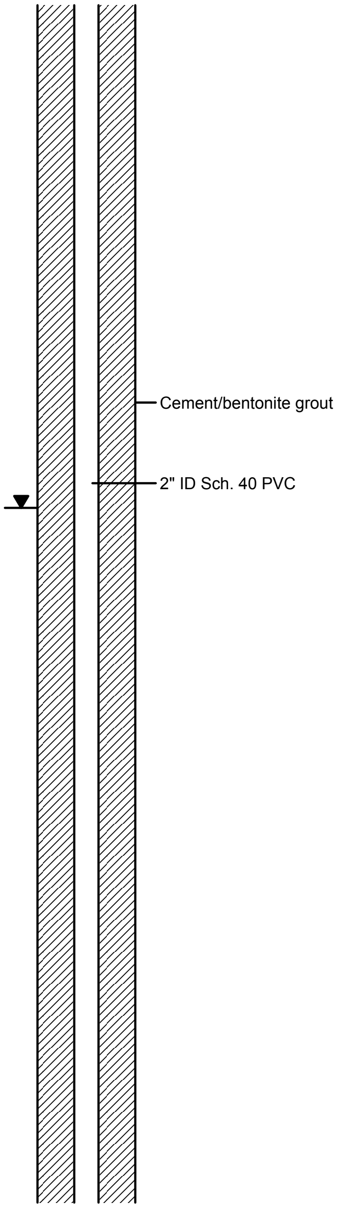
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/6/16	Ground Elevation	: 1033.01
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1469096.47	Northing	: 316029.08

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
50						lmySst
					Claystone, red, hard	Clst
60					Limey Sandstone, tan/gray, medium hard	lmySst
					Interbedded Claystone and Limey Sandstone, red/tan, hard	Clst Ls
					Limestone, gray, hard	
					Claystone, red, hard	Clst
70					Limestone and Limey Sandstone, gray, hard	Ls
					Sandstone, gray, hard, water at 71 feet (2-3 gpm)	Sst
					Carbonaceous Shale, black, hard	Sh
					Limey Sandstone, gray/tan, hard	lmySst
80					Shaley Sandstone, gray/green, medium hard	shSst
					As above grading to shale, gray/green, medium hard	Sh
90					Shaley Sandstone, gray/green, medium hard	shSst
100					Fine Sandstone with minor Shaley Sandstone, gray/green, medium hard	Sst



LOG OF BORING GW-21

(Page 3 of 5)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

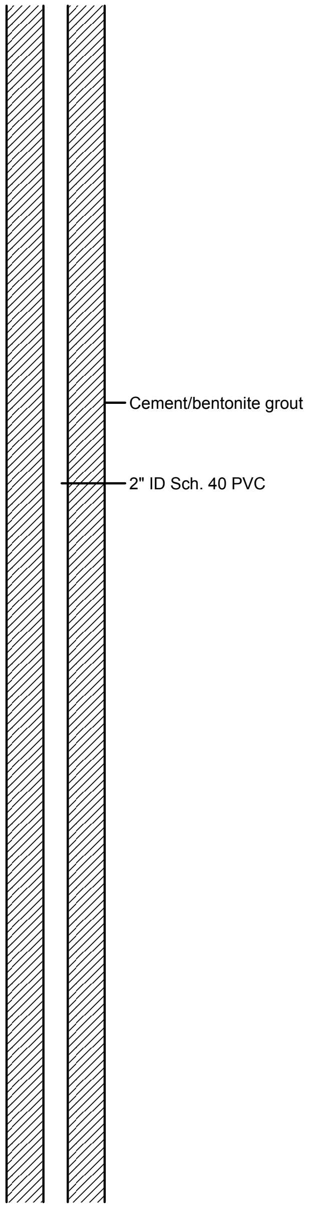
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/6/16	Ground Elevation	: 1033.01
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1469096.47	Northing	: 316029.08

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
100						Sst
					As above grading to Claystone, gray/green to red, medium hard	Clst
110 120					Dominantly Claystone, red with minor (<6") beds of Sandstone/Siltstone, grey/green, medium hard	Clst
					As above, >75% green, hard	Clst
130 140					Sandstone, fine-grained with interbedded green sandstone/siltsone, red/green, hard	Sst
150					Claystone, red, hard	Clst



TETRA TECH

LOG OF BORING GW-21

(Page 4 of 5)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

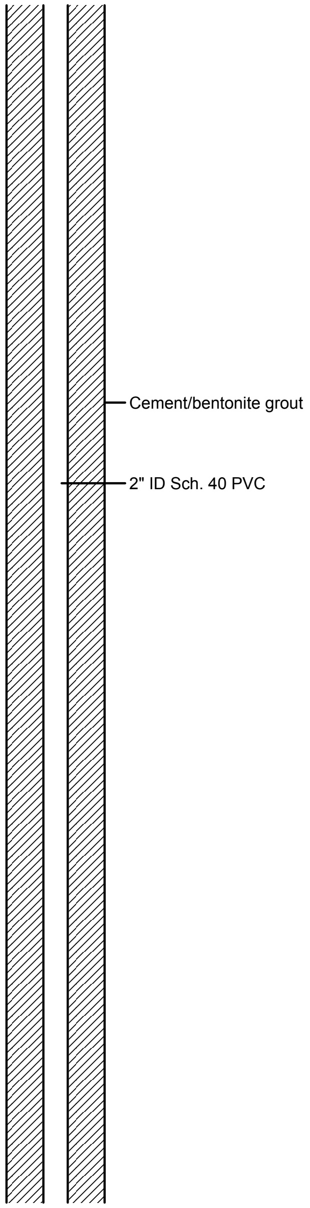
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/6/16	Ground Elevation	: 1033.01
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1469096.47	Northing	: 316029.08

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
150						Clst
					As above but with interbedded green sandstone/siltsone, red/green, hard	Clst
160					Sandstone fine-grained green with Siltstone and infrequent Claystones red, hard	Sst
170					Siltstone, green, hard	Sltst
					Interbedded Claystone red with Silstone green, hard	Clst/Sltst
180					>75% Siltstone green and 25% Claystone red, hard	Sltst
190 200					Shaley Sandstone green (mica/muscovite observed) portions more shaley, green, hard	shSst



TETRA TECH

LOG OF BORING GW-21

(Page 5 of 5)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

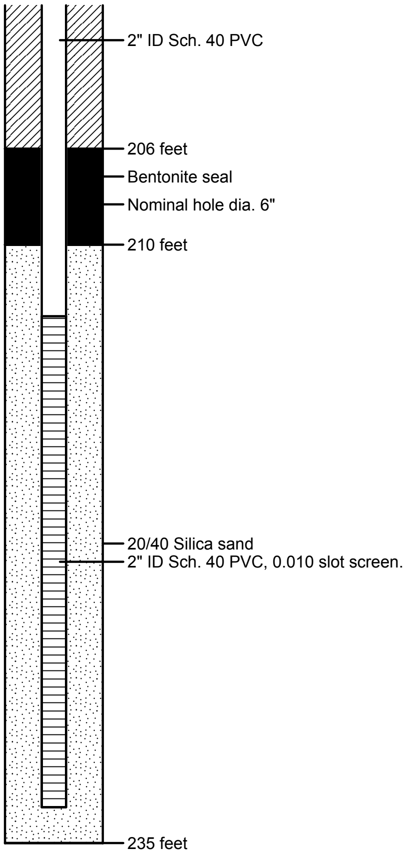
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/6/16	Ground Elevation	: 1033.01
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1469096.47	Northing	: 316029.08

Sample Type
- ⊠ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
200				🟩		shSst
210				▨	Interbedded Claystone red and Sandstone/Siltstone green	Clst
				🟫	Transition to Sandstone tan/purple	Sst
220				🟫	Sandstone fine grained, tan/purple-red, soft	Sst
230				🟫	Sandstone fine tan/purple with Limey Sandstone in areas red/white, soft, possible <1/4 gpm water	Sst
				🟩	Siltstone, green, hard	Sltst
					End of boring at 235	
240						
250						

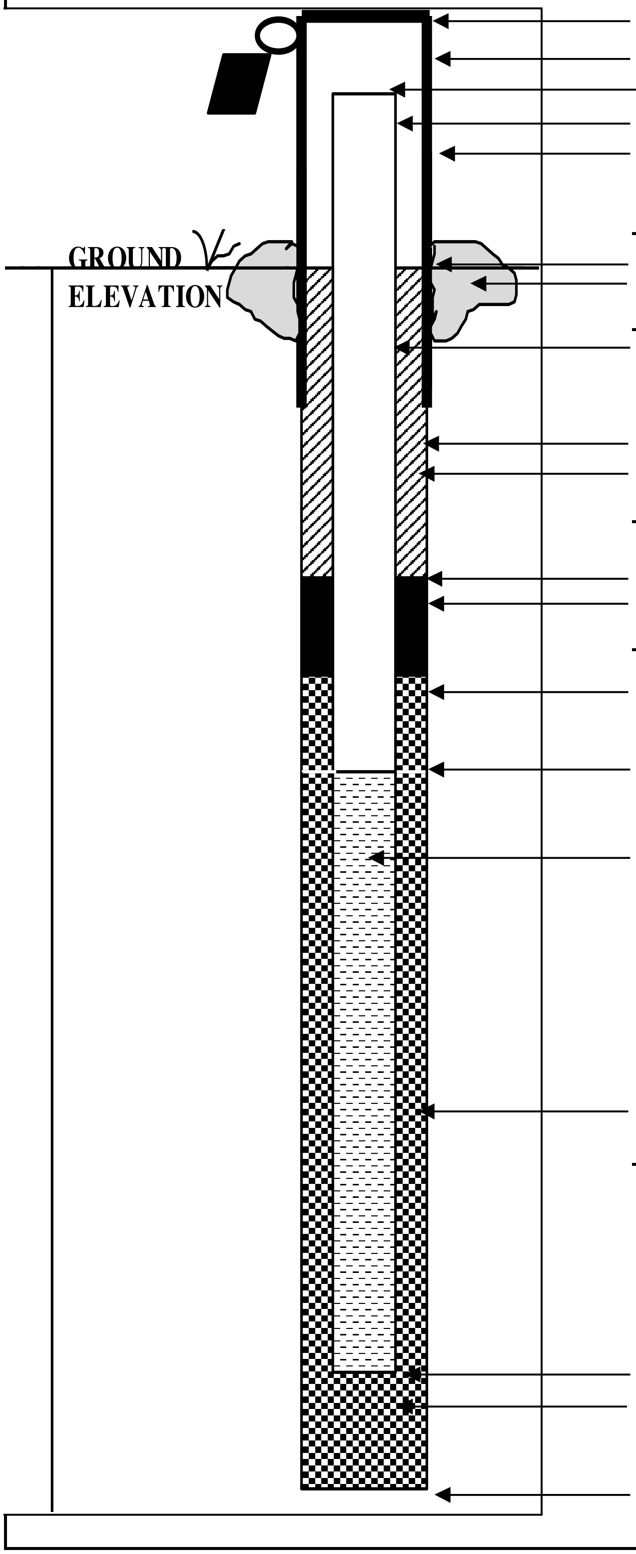


BORING NO.: GW-22

Tetra Tech, Inc.

GROUNDWATER MONITORING WELL SHEET

PROJECT:	CCR GW Installation	DRILLING Co.:	Eichelbergers	WELL No.:	GW-22
PROJECT No.:	112IC07852 Task 3.2	DRILLER:	Randy Hoffman	DATE COMPLETED:	27-Jul-16
SITE:	Pleasants Power	DRILLING METHOD:	Air Rotary	NORTHING:	316972.15
GEOLOGIST:	Scott Anderson	DEV. METHOD:	Surge, Waterra	EASTING:	1471704.15



ELEVATION OF TOP OF SURFACE CASING: 1047.89

STICK -UP TOP OF SURFACE CASING: 2.71

ELEVATION OF TOP OF RISER PIPE: 1047.12

RISER STICK-UP ABOVE GROUND SURFACE: 1.94

I.D. OF SURFACE CASING: 6-inches

TYPE OF SURFACE CASING: Stainless Steel

GROUND ELEVATION: 1045.18

TYPE OF SURFACE SEAL: Cement

RISER PIPE I.D.: 2.5-inches

TYPE OF RISER PIPE: Schedule 80 PVC

BOREHOLE DIAMETER: 6-inches

TYPE OF SEAL: Cement-Bentonite Grout

ELEVATION / DEPTH OF SEAL: 705.18 / 340

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF FILTER PACK: 700.18 / 345

ELEVATION / DEPTH TOP OF SCREEN: 695.18 / 350

TYPE OF SCREEN: PVC

SLOT SIZE X LENGTH: 10 slot X 20 feet

I.D. OF SCREEN: 2.5-inches

TYPE OF FILTER PACK: US Standard Sieve size 20/40 (No. 0 clean silica sand)

ELEVATION / DEPTH BOTTOM OF SCREEN: 675.18 / 370

ELEVATION / DEPTH BOTTOM OF FILTER PACK: 674.68 / 370.5

TYPE OF BACKFILL BELOW WELL: Silica Sand (as above)

ELEVATION / DEPTH OF BOREHOLE: 674.68 / 370.5

TETRA TECH

LOG OF BORING GW-22

(Page 1 of 8)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

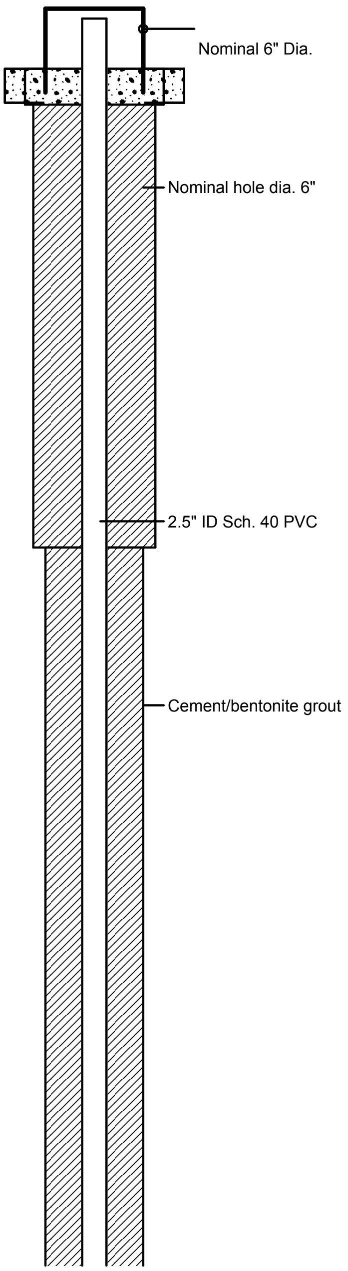
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/27/16	Ground Elevation	: 1045.18
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1471704.15	Northing	: 316972.15

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
0					Silty Clay, Brown, Stiff	SM/CL
					Clay with rock, tan, stiff	GC
					Clay or Claystone, orange tan/red, dry, hard	Clst
10					Clay or Claystone, brown, hard	Clst
					Claystone, red, soft	Clst
					Claystone, red, hard	Clst
					Siltstone to claystones, tan/gray, soft	Sltst
20 30					Siltstone to Claystone, red, soft	Sltst
40					Limestone and limey sandstone, gray, soft, Strong HCL reaction	Ls
50					Siltstone to Claystone, red, soft	Sltst



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TETRA TECH

LOG OF BORING GW-22

(Page 2 of 8)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

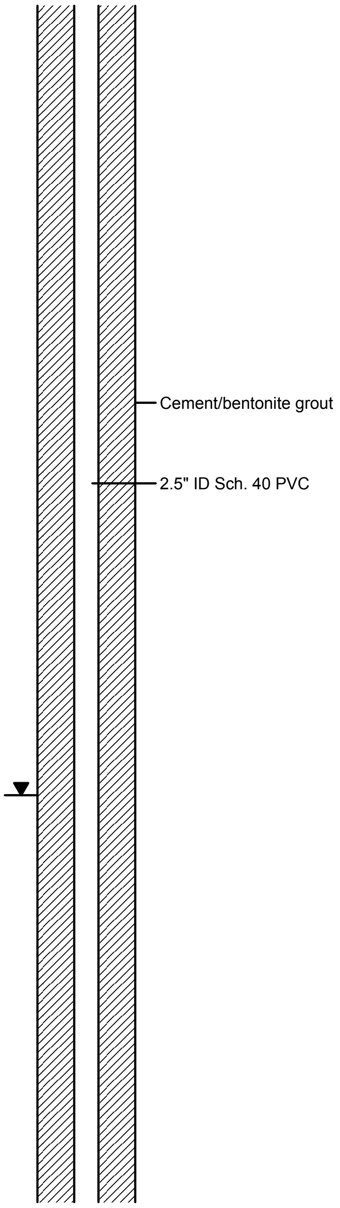
First Energy CCR, Pleasants Power

Project : 212C-SW-00069
Site : Pleasants Power
Date : 7/27/16
Drilling Method : Rotary Air Hammer
East : 1471704.15
Drilling Contractor : Eichelbergers
Logged By : Scott Anderson
Ground Elevation : 1045.18
Driller : Randy Hoffman
Northing : 316972.15

Sample Type
- ⊠ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
50						Sltst
					Siltstones to Claystones, red, soft	Sltst
60					Limestone, gray, soft, strong HCL reaction	Ls
					Claystone, grey/red, soft	Clst
					Silty limey Sandstone and Silty Limestone, gray/tan, soft, HCL reaction	Sst
70					Claystone, red, soft 6" green at 71'	Clst
80					Sandstone, green/tan, hard, with 6" Claystone seams at 81 and 87' No HCL reaction	Sst
					Claystone and Shaley Siltstone, red, soft No HCL reaction	Clst
90 100					Sandstone with interbedded black shales and limestones, green, tan, purple, hard. No reaction to HCL except with Limestone	Sst



TETRA TECH

LOG OF BORING GW-22

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Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

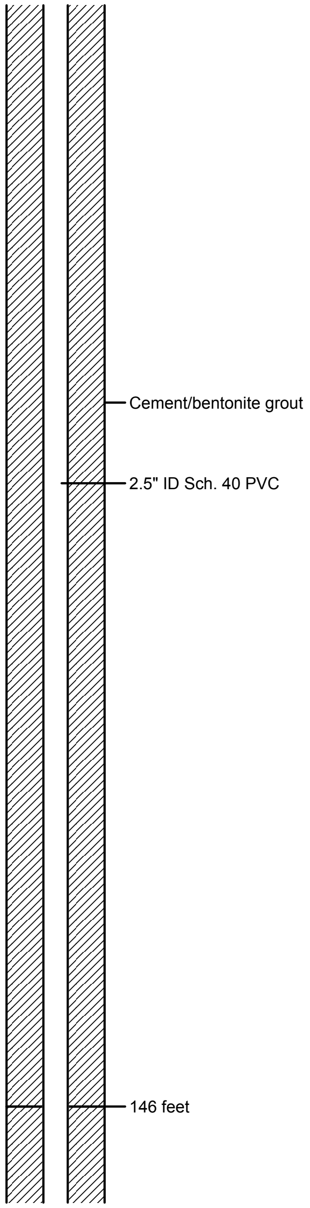
First Energy CCR, Pleasants Power

Project : 212C-SW-00069
Site : Pleasants Power
Date : 7/27/16
Drilling Method : Rotary Air Hammer
East : 1471704.15
Drilling Contractor : Eichelbergers
Logged By : Scott Anderson
Ground Elevation : 1045.18
Driller : Randy Hoffman
Northing : 316972.15

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
100				🟩		Sst
				▦	Water at 103, 1-2 gpm Limestone with silts (biotite) or/and limey Siltstone (micaceous), gray to tan, soft	
110				▦	Claystone, red at 118 and 120	
120				▦		Ls
130				▦		
140				▦		
				🟫	Sandstone, tan/purple with minor interbedded limestone red/brown, hard	Sst
150						



LOG OF BORING GW-22

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Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

First Energy CCR, Pleasants Power

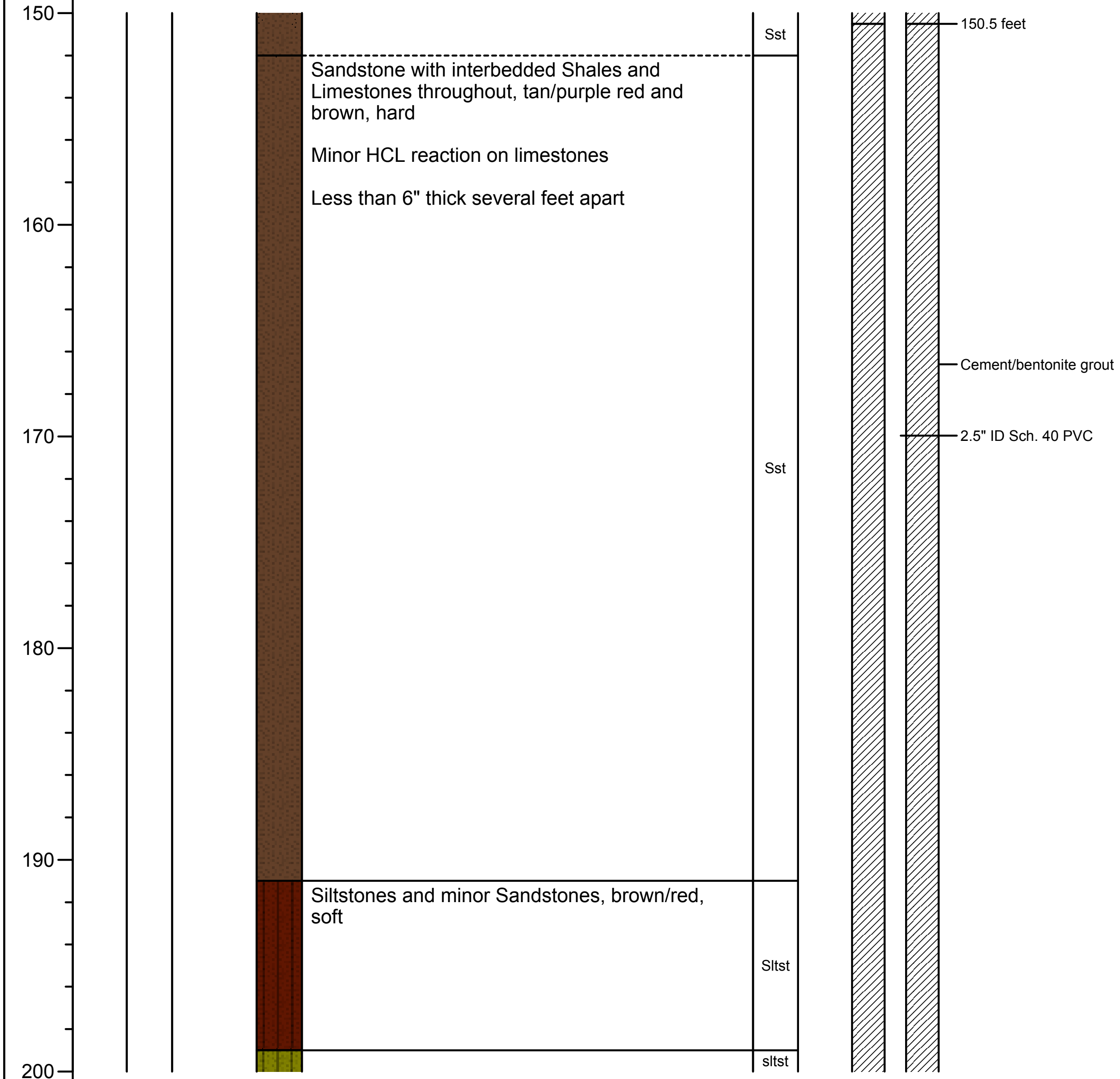
Project : 212C-SW-00069
Site : Pleasants Power
Date : 7/27/16
Drilling Method : Rotary Air Hammer
East : 1471704.15

Drilling Contractor : Eichelbergers
Logged By : Scott Anderson
Ground Elevation : 1045.18
Driller : Randy Hoffman
Northing : 316972.15

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion



Sandstone with interbedded Shales and Limestones throughout, tan/purple red and brown, hard

Minor HCL reaction on limestones

Less than 6" thick several feet apart

Siltstones and minor Sandstones, brown/red, soft

LOG OF BORING GW-22

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Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

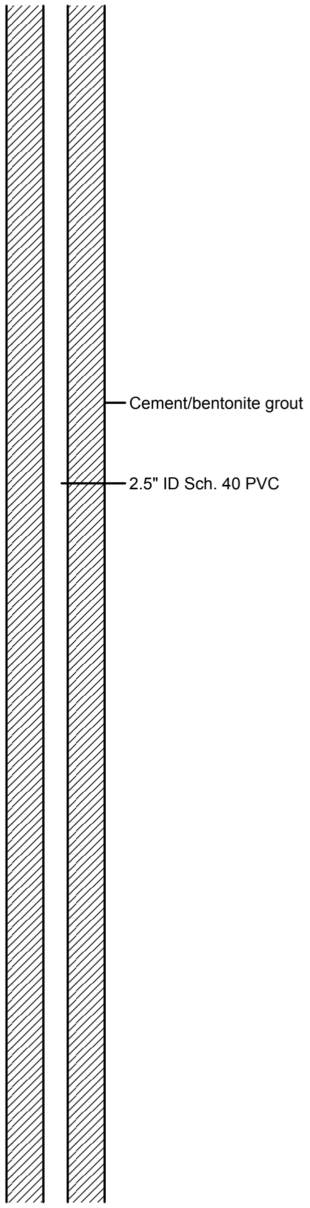
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/27/16	Ground Elevation	: 1045.18
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1471704.15	Northing	: 316972.15

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
200						sltst
					Siltstone and Shaley Siltstone, green/gray, soft Water at 199, 1-2 gpm	
					Shale, black, soft	Sh
210					Siltstone grading to silty sandstone, gray to gray/green, soft No HCL reaction	Sltst
220					Sandy siltsone to Silty Sandstone, gray/green, soft grading to hard No HCL reaction	Sltst
230						
					Silty sandstone with muscovite and biotite, grayish/green, hard No HCL reaction	Sst
240						
250						



Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

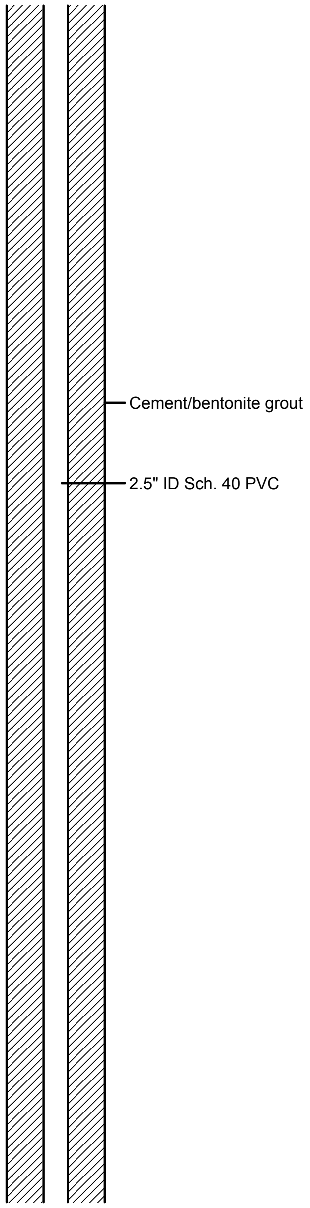
First Energy CCR, Pleasants Power

Project : 212C-SW-00069
Site : Pleasants Power
Date : 7/27/16
Drilling Method : Rotary Air Hammer
East : 1471704.15
Drilling Contractor : Eichelbergers
Logged By : Scott Anderson
Ground Elevation : 1045.18
Driller : Randy Hoffman
Northing : 316972.15

Sample Type
⊠ Split Spoon
▦ Air Hammer Drill Cuttings

Water Levels
▼ During Drilling
▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
250						Sltst
					Shaley Siltstone to Shale, green/gray, soft Grades to shale with depth	Sltst
260					Claystone, red, soft	Clst
270					Interbedded Claystones red, soft and Sandstones green/gray, hard Less than 6" each	Clst
280 290					Dominantly Silty Sandstone green/gray and minor Claystones red (interbedded), hard At 283, Shaley At 290, Claystone, red at 293, Shaley	Sst
300					Shaley Siltstone with Shale, Green/gray, soft No HCL reaction	Sltst



LOG OF BORING GW-22

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Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

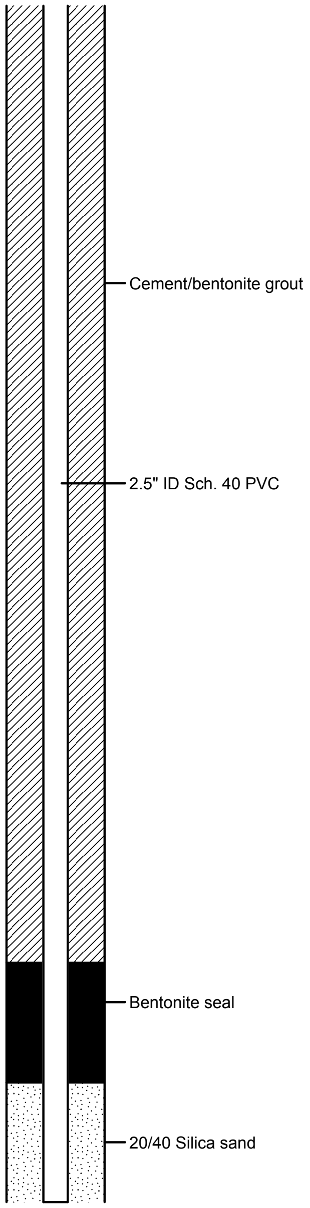
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/27/16	Ground Elevation	: 1045.18
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1471704.15	Northing	: 316972.15

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
300						Sltst
					Shales and Limestone, gray, soft Strong HCL reaction	Sh
310					Shale, red/green to gray/tan, soft No HCL reaction	Sh
320 330					Silty Sandstone with muscovite and biotite (micaseous Sandstone), green/gray, hard No HCL reaction	Sst
340					Shaley Siltstone, green to gray, soft Approximately 5 gpm total water production	Sltst
350					Siltstone and Sandstone, red/brown, hard	Sltst



LOG OF BORING GW-22

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Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/27/16	Ground Elevation	: 1045.18
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1471704.15	Northing	: 316972.15

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

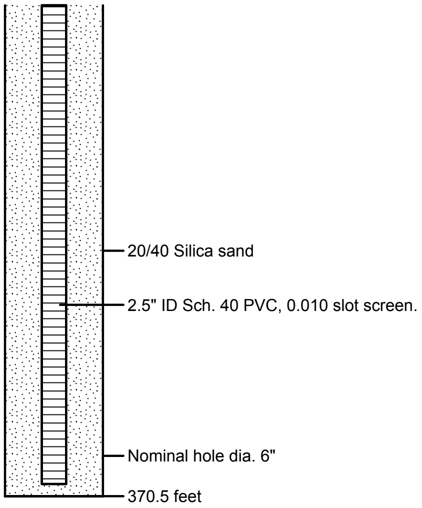
Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
350				🟫		Sltst
				🟫	Limey Shale and limey Sandstone to Sandstone tan, brown, purple, hard HCL reaction At 357 to 360 soft and more water Poor return but Sandstone	Sh
370				🟩	Siltstone, green, soft	Sltst

End of boring at 370.5 ft BGS

380

390

400

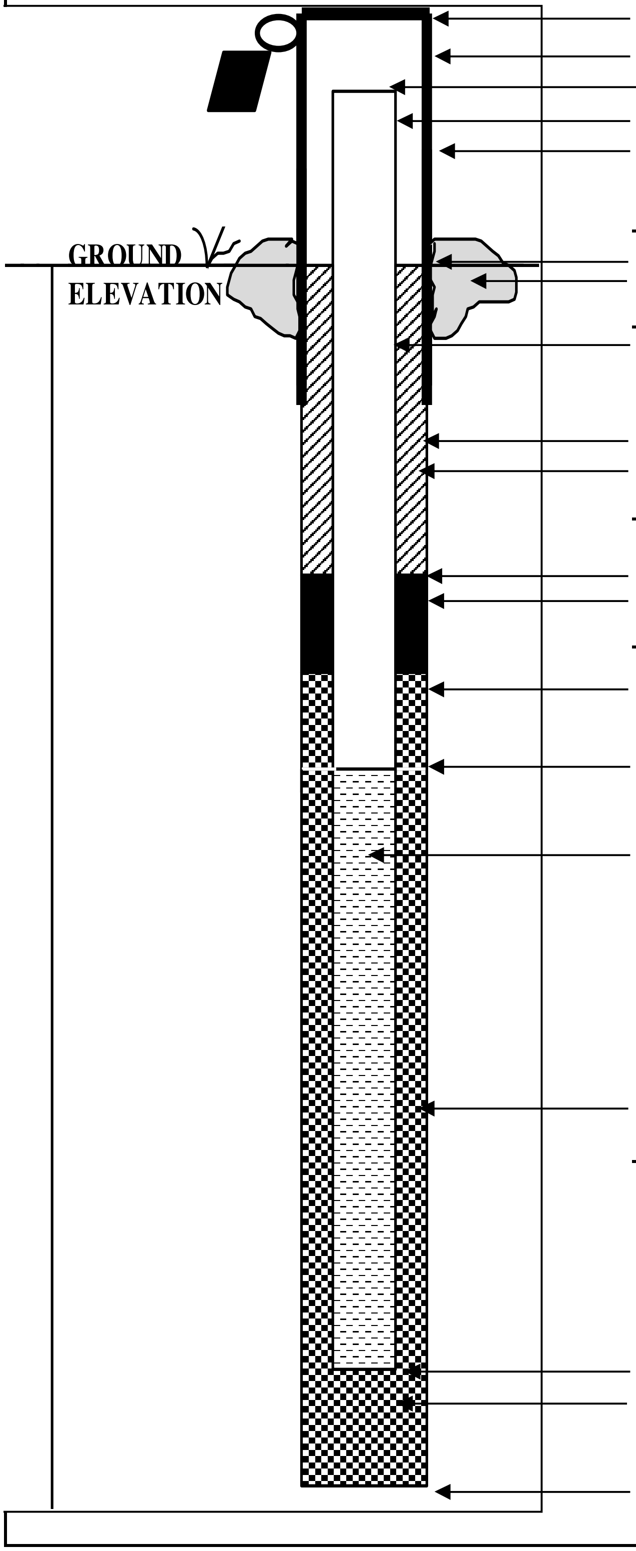


BORING NO.: GW-23

Tetra Tech, Inc.

GROUNDWATER MONITORING WELL SHEET

PROJECT:	CCR GW Installation	DRILLING Co.:	Eichelbergers	WELL No.:	GW-23
PROJECT No.:	112IC07852 Task 3.2	DRILLER:	Randy Hoffman	DATE COMPLETED:	26-Jul-16
SITE:	Pleasants Power	DRILLING METHOD:	Air Rotary	NORTHING:	320048.41
GEOLOGIST:	Scott Anderson	DEV. METHOD:	Surge, Bail	EASTING:	1471095.62



ELEVATION OF TOP OF SURFACE CASING: 977.41

STICK -UP TOP OF SURFACE CASING: 3.01

ELEVATION OF TOP OF RISER PIPE: 976.73

RISER STICK-UP ABOVE GROUND SURFACE: 2.33

I.D. OF SURFACE CASING: 6-inches

TYPE OF SURFACE CASING: Stainless Steel

GROUND ELEVATION: 974.4

TYPE OF SURFACE SEAL: Cement

RISER PIPE I.D.: 2.5-inches

TYPE OF RISER PIPE: Schedule 80 PVC

BOREHOLE DIAMETER: 6-inches

TYPE OF SEAL: Cement-Bentonite Grout

ELEVATION / DEPTH OF SEAL: 614.4 / 360

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF FILTER PACK: 609.4 / 365

ELEVATION / DEPTH TOP OF SCREEN: 604.4 / 370

TYPE OF SCREEN: PVC

SLOT SIZE X LENGTH: 10 slot X 20 feet

I.D. OF SCREEN: 2.5-inches

TYPE OF FILTER PACK: US Standard Sieve size 20/40 (No. 0 clean silica sand)

ELEVATION / DEPTH BOTTOM OF SCREEN: 584.4 / 390

ELEVATION / DEPTH BOTTOM OF FILTER PACK: 581.9 / 392.5

TYPE OF BACKFILL BELOW WELL: Silica Sand (as above)

ELEVATION / DEPTH OF BOREHOLE: 581.9 / 392.5

LOG OF BORING GW-23

(Page 1 of 8)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

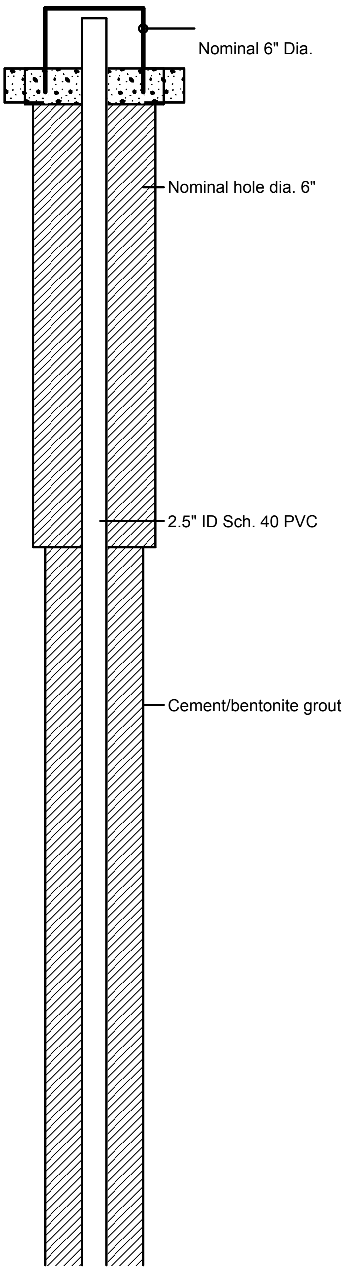
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/26/16	Ground Elevation	: 977.41
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1471095.62	Northing	: 320048.41

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
0					Silty Clay with wood at 3 inches, red/orange stiff, damp	SM
					Silty Clay, brown, stiff	SM
					Clay with rocks, tan, stiff, dry	GC
					Clay with rock, red, stiff	GC
10					Silts or Siltstone, tan/gray, stiff	SM
					Siltstone, gray tan, soft	Sltst
					Sandstone/Siltston, purple, soft	Sst
					Claystone, red, soft	Clst
20					Sandstone, green/brown, hard No HCL reaction	Sst
30					Claystone, red, soft	Clst
					Siltstone to Sandstone, green, soft	Slst
40					Interbedded Claystones red to Sitstones green, soft At 41-42 Siltsone At 44.5 to 45 Silstone, green Minor HCL reaction	Clst
50					Sandstone and Shaley Sandstone, green, hard	Sst



Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

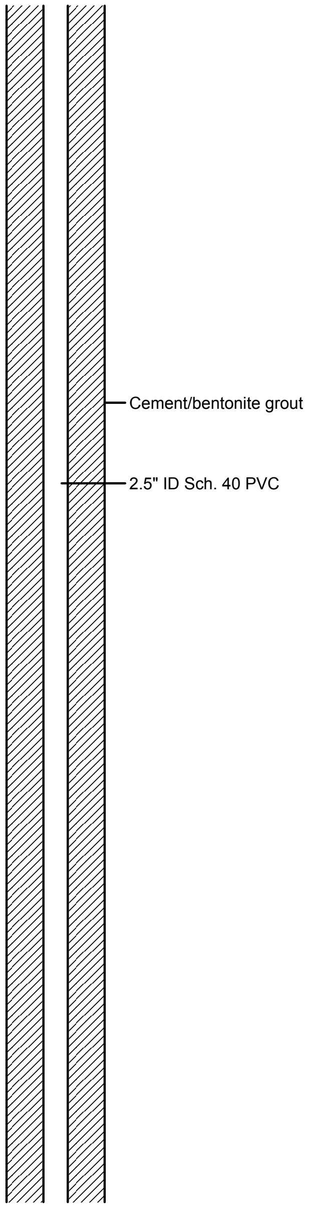
First Energy CCR, Pleasants Power

Project : 212C-SW-00069
Site : Pleasants Power
Date : 7/26/16
Drilling Method : Rotary Air Hammer
East : 1471095.62
Drilling Contractor : Eichelbergers
Logged By : Scott Anderson
Ground Elevation : 977.41
Driller : Randy Hoffman
Northing : 320048.41

Sample Type
☒ Split Spoon
▦ Air Hammer Drill Cuttings

Water Levels
▼ During Drilling
▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
50				🟩		Sst
60				🟥	Claystone to Siltstone, red, soft	Clst
				🟩	Sandstone, green, hard	Sst
70				🟥	Claystone to Siltstone, red, soft	Clst
				🟩	Sandstone to Siltstone, green with red, soft to hard 6 inch red beds	Sst
80				▤	Shale and Shaley Siltstone, gray, soft	Sh
					Shale, red, hard	Sh
90					Interbedded Shale red and Shale green with Siltstone and Claystone, medium hard No HCL reaction	Sh
100				🟥	Shaley Siltsone and Shales, red, soft	Sltst



TETRA TECH

LOG OF BORING GW-23

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

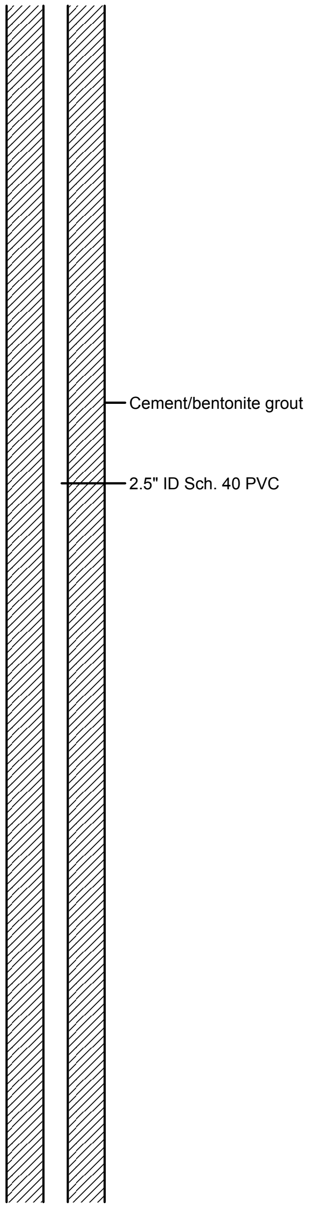
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/26/16	Ground Elevation	: 977.41
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1471095.62	Northing	: 320048.41

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
100						Sltst
					Siltstone to Sandstone and Limestones, gray, soft Vigours HCL reaction	Slst
110 120					Shaley Siltstone, red/tan/gray, very soft Pulverized by bit	Sh
130 140					Sandstone with biotite and muscovite, gray/gree, hard No HCL reaction More Shaley with depth At 142-144 Shale	Sst
150					Shaley Siltstone red, with Siltstone green, soft	Sltst



Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

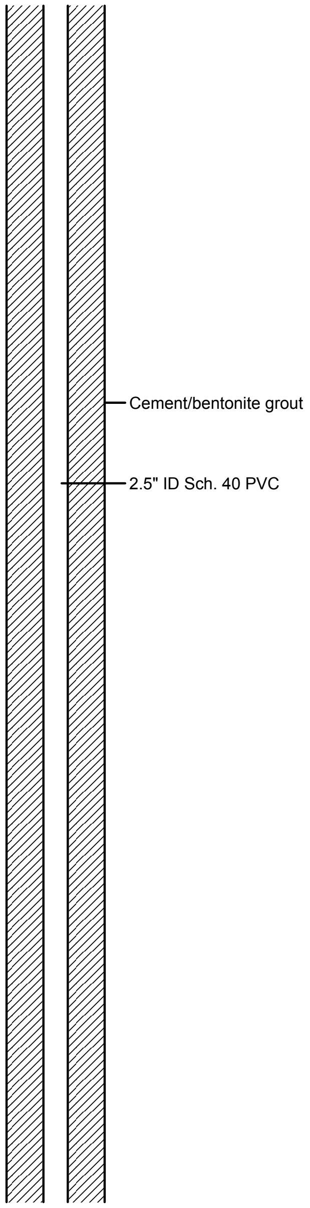
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/26/16	Ground Elevation	: 977.41
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1471095.62	Northing	: 320048.41

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
150						Sltst
					Shale, green, soft No HCL reaction	Sh
160						
					Shale and Shaley Siltstone, red, soft	Sh
170						
					Shaley Siltstone with minor Sandstones, green, medium hard No HCL reaction	Sltst
					Shale and Shaley Siltstone, red, soft No HCL reaction	Sh
180						
190					Shaley Siltstone grading to Shales at 194, green, soft	Sh
200						



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LOG OF BORING GW-23

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Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

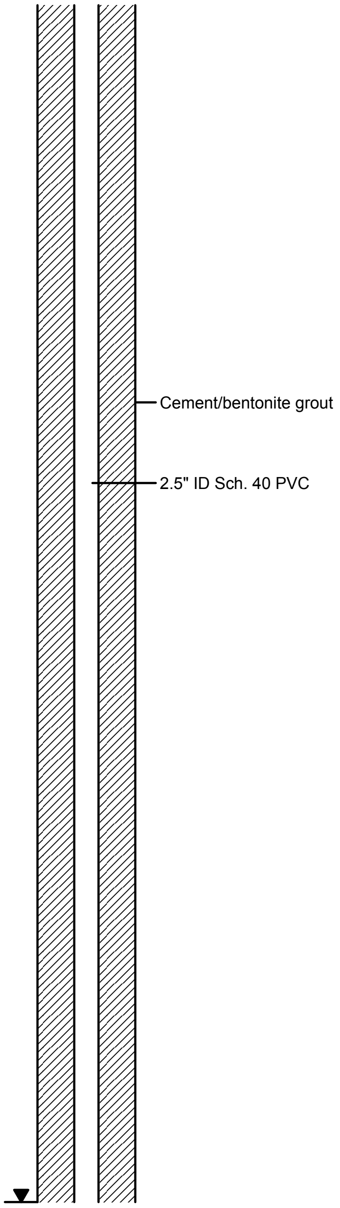
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/26/16	Ground Elevation	: 977.41
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1471095.62	Northing	: 320048.41

Sample Type
☒ Split Spoon
▦ Air Hammer Drill Cuttings

Water Levels
▼ During Drilling
▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
200						Sh
					Limestones green with Shale gray/red, soft Strong HCL reaction Interbedded but mostly Limestone	Ls
210						
					Shale and Shaley Siltstone, red/brown, soft No HCL reaction	Sh
220						
					Limestones and fine grained Sandstones with calcite cement and pyrite, gray to green, soft Strong HCL reaction	Ls
230						
					Sandstone and Limestones, tan, purple, red, hard	Sst/Ls
240						
					At 250 water 0.5 gpm	Sltst
250						



LOG OF BORING GW-23

(Page 6 of 8)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

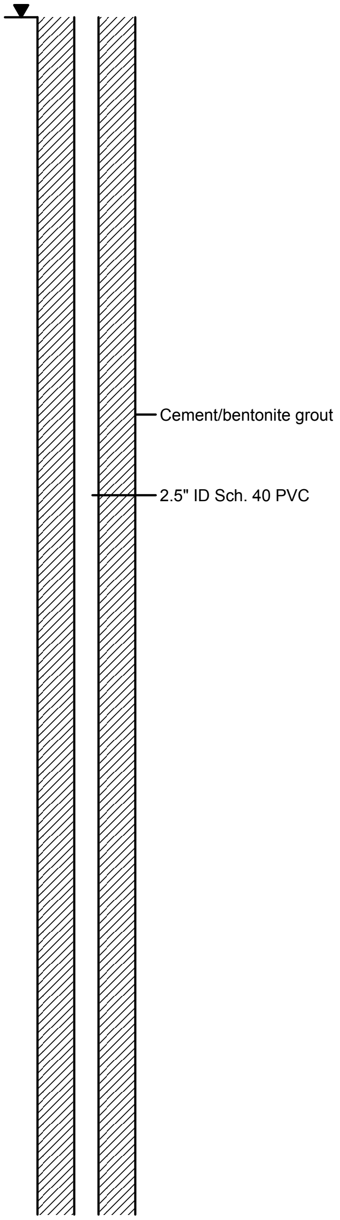
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/26/16	Ground Elevation	: 977.41
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1471095.62	Northing	: 320048.41

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
250						Sltst
					Sandy Siltstone, Sandstone and Limestone, red to brown, soft HCL reaction in Limestone and Sandstones At 262 grading to Shaley Siltstone and with depth	
260						Sltst
270					Sandstone with Limestone, red, purple, tan, hard Greater than 2 feet intervals, but still interbedded	
						Sst
280						
					Limey Siltstone red and Claystones with green Siltstone, soft	
290						Sltst
300						



TETRA TECH

LOG OF BORING GW-23

(Page 7 of 8)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

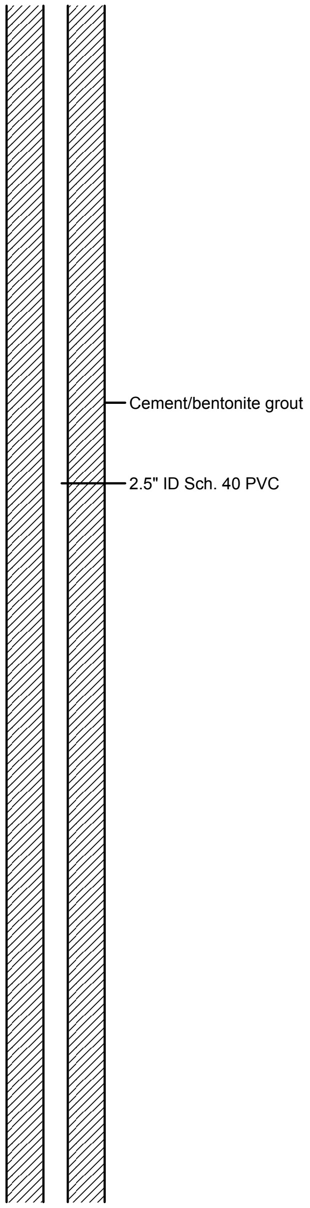
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/26/16	Ground Elevation	: 977.41
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1471095.62	Northing	: 320048.41

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
300				🟩	Sandy Siltstone to Sandstone, green, mostly hard with soft areas	
310				🟩		
320				🟩		
				🟩	At 323 more Silty Sandstone	
				🟩		Sltst
330				🟩		
340				🟩		
				🟩	At 342-349 more Shaley	
350				🟩		



TETRA TECH

LOG OF BORING GW-23

(Page 8 of 8)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

First Energy CCR, Pleasants Power

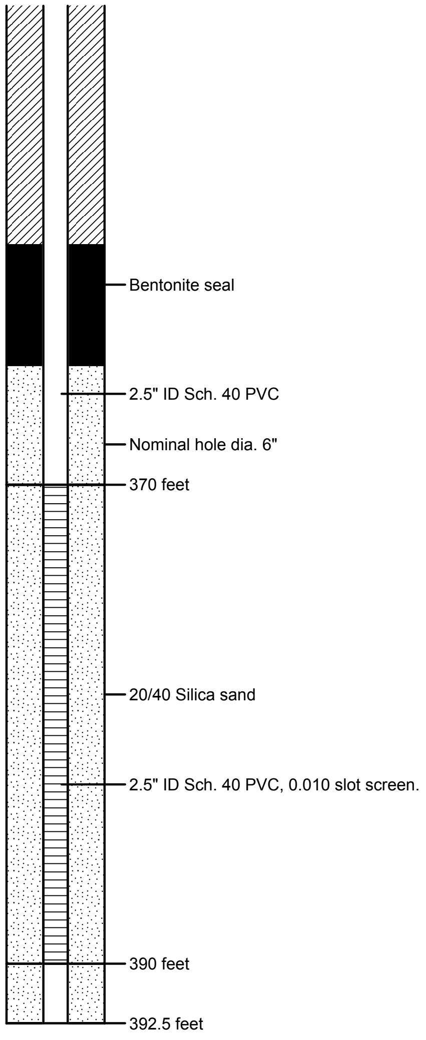
Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/26/16	Ground Elevation	: 977.41
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1471095.62	Northing	: 320048.41

Sample Type
- ⊠ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
350				🟩		Sltst
				🟩	Shaley Siltstone to Sandstone, green, mostly hard with soft areas	Sltst
360				🟩	Shaley Siltstone green, transitioning with depth to Sandstone green, hard	Sltst
370				🟫	Sandstone and Silty Sandstone, tan/green, hard Micaceous Pyrite At 392 ft Ames Limestone	Sst
380						
390						
400						

End of boring at 392 ft BGS



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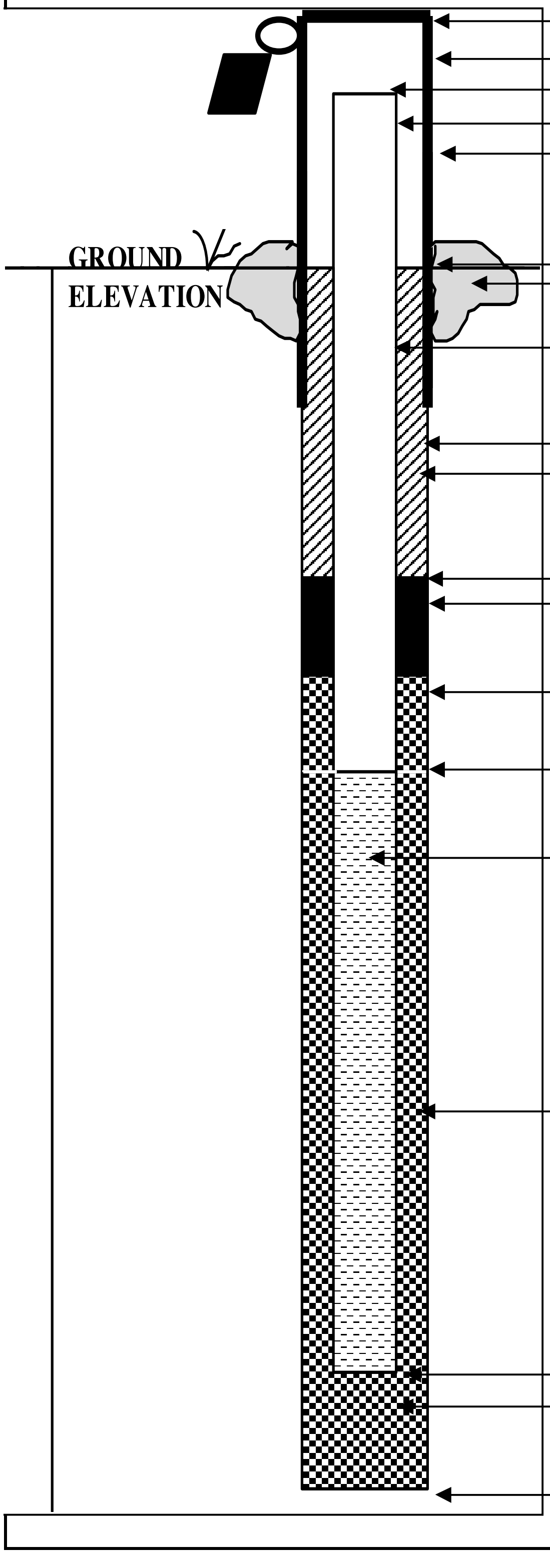
BORING NO.: GW-24

Tetra Tech, Inc.

GROUNDWATER MONITORING WELL SHEET

PROJECT:	CCR GW Installation	DRILLING Co.:	Eichelbergers	WELL No.:	GW-24
PROJECT No.:	112IC07852 Task 3.2	DRILLER:	Randy Hoffman	DATE COMPLETED:	12-Jul-16
SITE:	Pleasants Power	DRILLING METHOD:	Air Rotary	NORTHING:	320797.11
GEOLOGIST:	Scott Anderson	DEV. METHOD:	Surge, Bail	EASTING:	1469894.54



ELEVATION OF TOP OF SURFACE CASING: 944.56

STICK -UP TOP OF SURFACE CASING: 3.01

ELEVATION OF TOP OF RISER PIPE: 944.1

RISER STICK-UP ABOVE GROUND SURFACE: 2.55

I.D. OF SURFACE CASING: 6-inches

TYPE OF SURFACE CASING: Stainless Steel

GROUND ELEVATION: 941.55

TYPE OF SURFACE SEAL: Cement

RISER PIPE I.D.: 2-inches

TYPE OF RISER PIPE: Schedule 40 PVC

BOREHOLE DIAMETER: 6-inches

TYPE OF SEAL: Cement-Bentonite Grout

ELEVATION / DEPTH OF SEAL: 701.55 / 240

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF FILTER PACK: 695.55 / 246

ELEVATION / DEPTH TOP OF SCREEN: 691.55 / 250

TYPE OF SCREEN: PVC

SLOT SIZE X LENGTH: 10 slot X 20 feet

I.D. OF SCREEN: 2-inches

TYPE OF FILTER PACK: US Standard Sieve size 20/40 (No. 0 clean silica sand)

ELEVATION / DEPTH BOTTOM OF SCREEN: 671.55 / 270

ELEVATION / DEPTH BOTTOM OF FILTER PACK: 670.55 / 271

TYPE OF BACKFILL BELOW WELL: Silica Sand (as above)

ELEVATION / DEPTH OF BOREHOLE: 670.55 / 271

TETRA TECH

LOG OF BORING GW-24

(Page 1 of 6)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

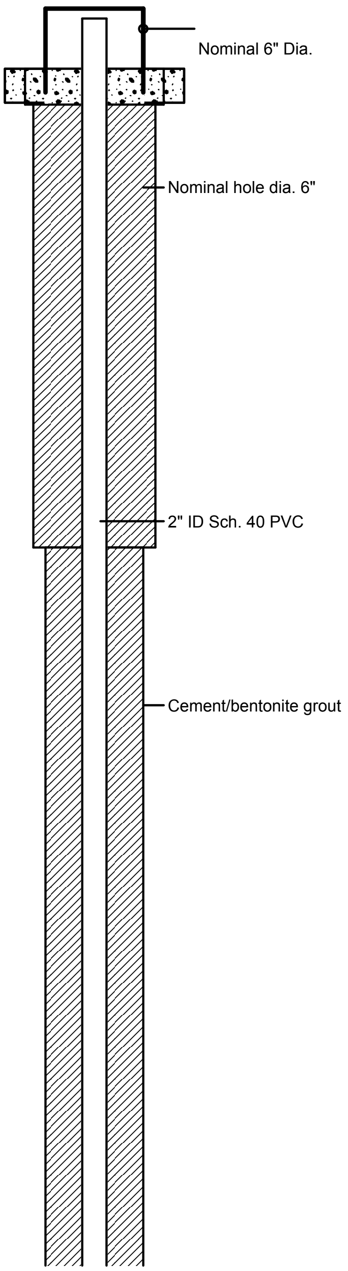
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/12/16	Ground Elevation	: 944.56
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1469894.54	Northing	: 320797.11

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
0					Silty Clay, red/brown, stiff	Cl
					Clay orange/tan with rocks grading to clay red with rocks	Cl
					Clay or Claystone, red/brown, stiff	Clst
10					Weathered Siltstone, tan/brown, stiff	Sltst
					Claystone, red, hard	Clst
					Sandstone, gray, soft	Sst
					Sandstone, brown, hard	Sst
20					Siltstone and Claystone, red, soft No HCL reaction	Sltst
					Siltstone, gray/green, soft	Sltst
					Claystone, red, soft	Clst
30					Siltstone, gray/green, soft No HCL reaction	Sltst
40					Claystone, red, soft	Clst
					Siltstone, gray/green, soft	Sltst
50					Sandstone, Shale, gray, hard	Sst



Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

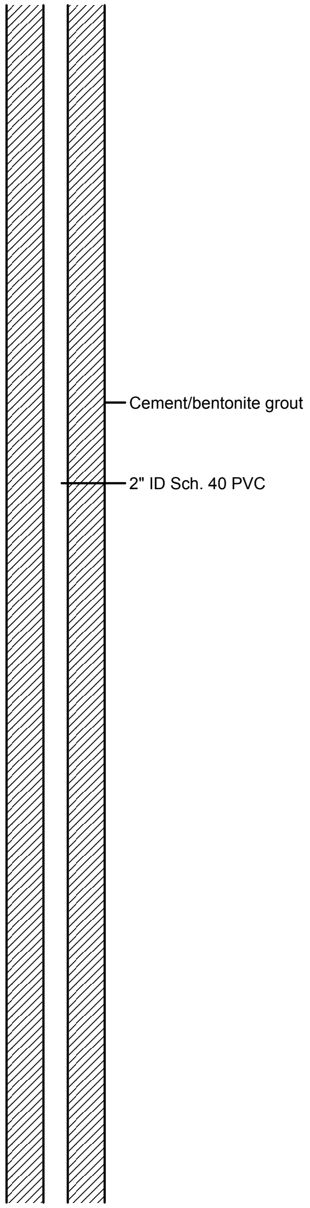
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/12/16	Ground Elevation	: 944.56
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1469894.54	Northing	: 320797.11

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
50						Sst
					Claystone, red/gray, soft No HCL Reaction	Clst
					Siltstone, green, soft No HCL reaction	Sltst
					Shale, red, soft No HCL reaction	Sh
60 70					Siltstone, green, soft No HCL reaction	Sltst
					At 73 0.25 gpm water, hydrocarbon odor Sandstone w/Pyrite, green, hard	Sst
80					Siltstone to Sandstone, brown/red, soft No HCL reaction	Sltst
					Sandstone to Siltstone, green/gray, hard No HCL reaction	Sst
90 100					Shaley Siltstone, red, soft No HCL reaction	Sltst



TETRA TECH

LOG OF BORING GW-24

(Page 3 of 6)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

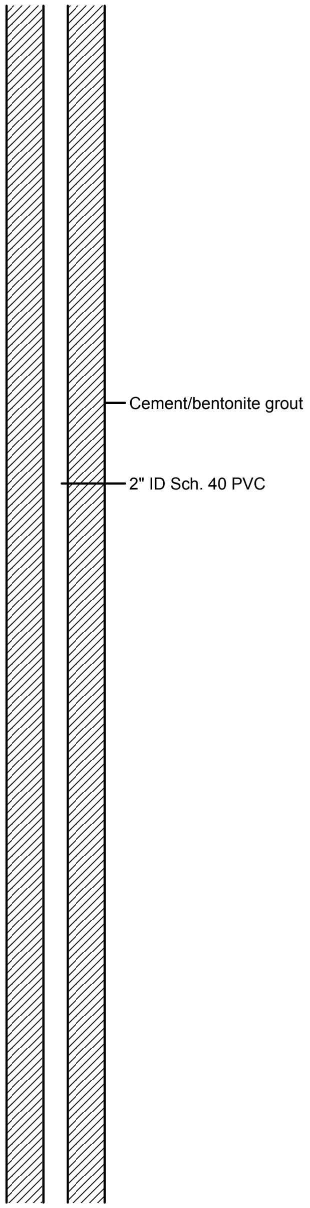
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/12/16	Ground Elevation	: 944.56
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1469894.54	Northing	: 320797.11

Sample Type
- ⊠ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
100				🟩	Sandstone to Siltstone, green, hard	Sst
				🟥	Siltstone, red, soft	Sltst
				🟩	Shaley Siltstone and Sandstone (interbedded), green, soft	Sh
110				🟥	Siltstone/Claystone, red, soft	Sltst
120				🟨	Interbedded Siltstone, Sandstone with Pyrite and Limestone, gray/green, soft HCL reaction in Limestone	Sltst
130 140 150				🟥	Sandstone with Calcite cement, Claystone, Siltstone, red and green, medium hard to soft HCL reaction At 144-145 Sandstone, green	Sst



LOG OF BORING GW-24

(Page 4 of 6)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

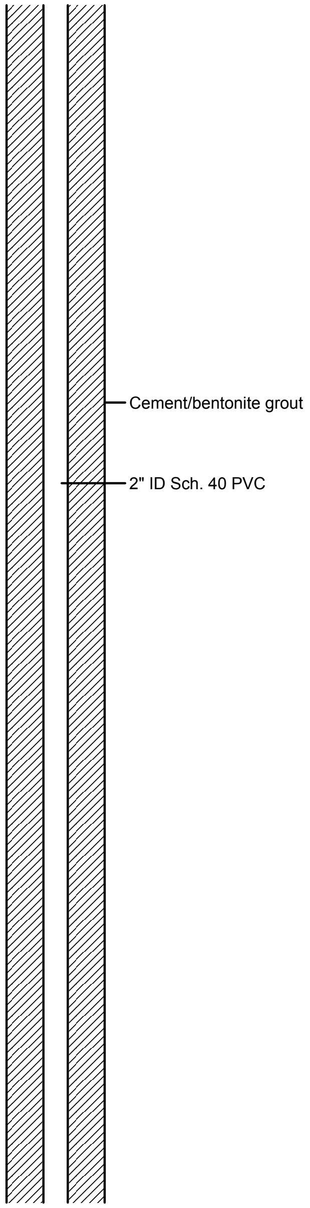
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/12/16	Ground Elevation	: 944.56
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1469894.54	Northing	: 320797.11

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
150						Sst
160 170					At 158-159 Sandstone, green At 163-164 Sandstone, green At 167-168 Sandstone, green At 171-172 Sandstone, green	Sst
					Sandstone, red, hard No HCL reaction	Sst
180					Shaley Sandstone with Pyrite green with minimal Siltstone, hard No HCL reaction	Sst
190 200					Sandstone with interbedded Shales, green, hard	Sst



TETRA TECH

LOG OF BORING GW-24

(Page 5 of 6)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

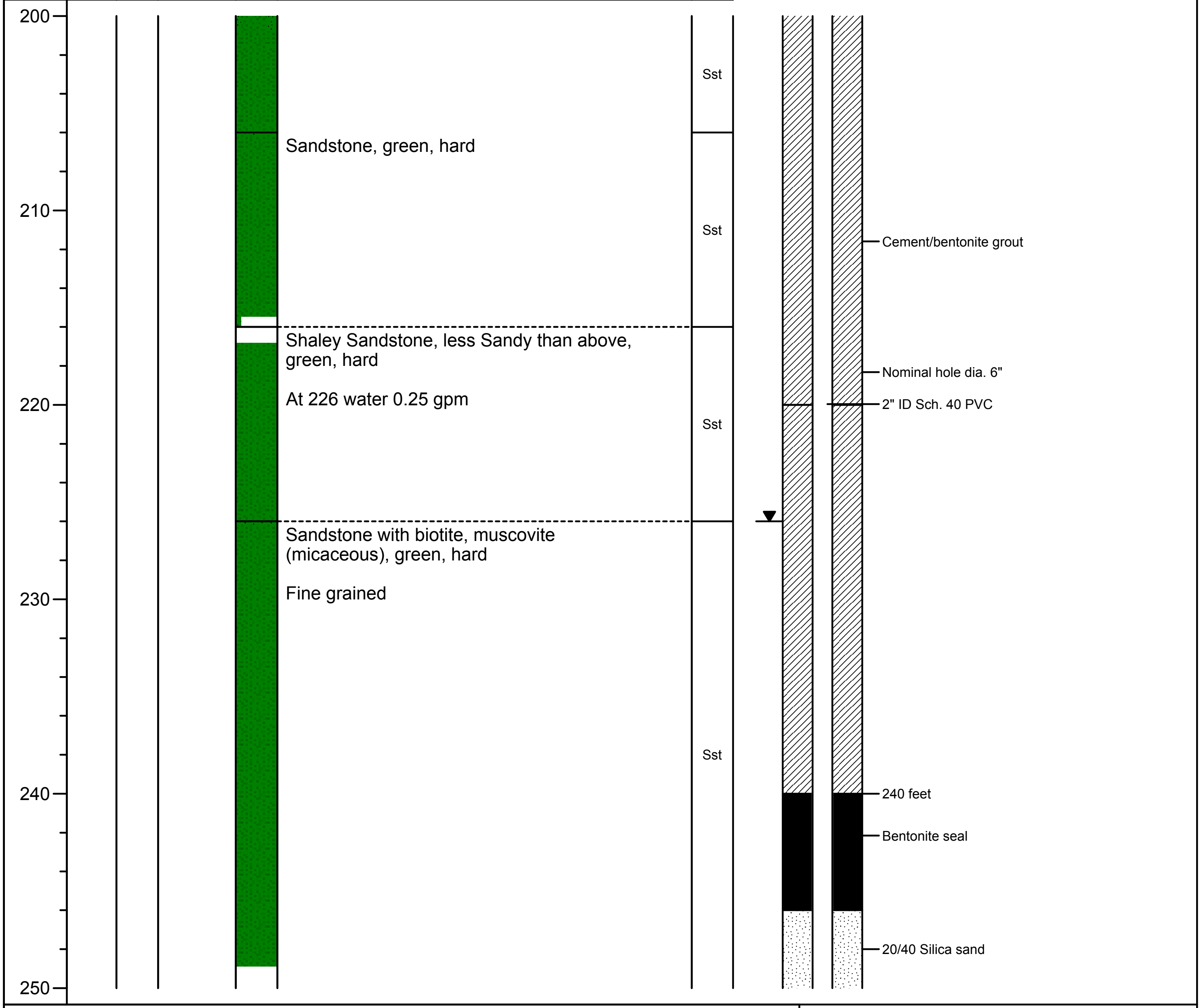
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/12/16	Ground Elevation	: 944.56
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1469894.54	Northing	: 320797.11

Depth in Feet | Sample Type | Rec. % | Blow Count | GRAPHIC | DESCRIPTION | USCS or Rock type

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion



Sandstone, green, hard

Shaley Sandstone, less Sandy than above, green, hard

At 226 water 0.25 gpm

Sandstone with biotite, muscovite (micaceous), green, hard

Fine grained

TETRA TECH

LOG OF BORING GW-24

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Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

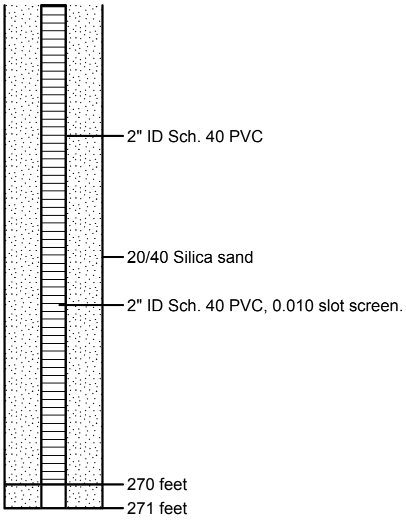
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/12/16	Ground Elevation	: 944.56
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1469894.54	Northing	: 320797.11

Sample Type
- ⊠ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
250				🟩		Sst
				🟩	As above	Sst
				🟩	Fine-grained Sandstone, green, medium hard to soft	Sst
260						
270						
					End of boring at 271 feet BGS	
280						
290						
300						

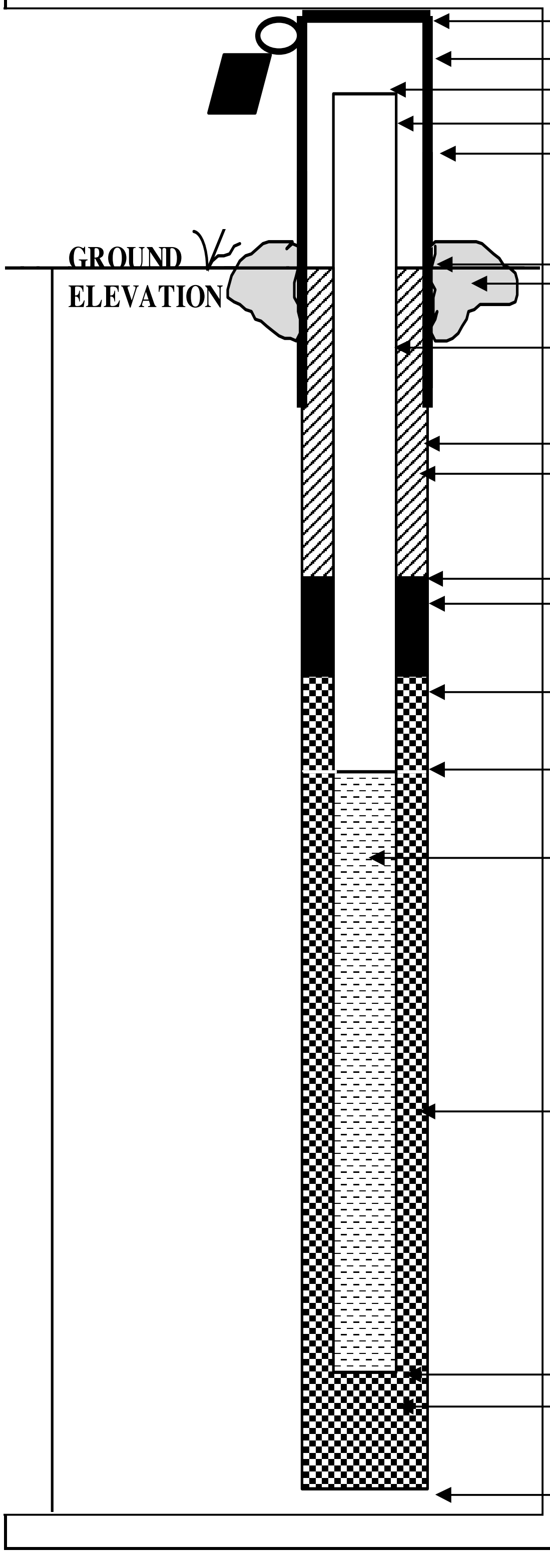


BORING NO.: GW-25

Tetra Tech, Inc.

GROUNDWATER MONITORING WELL SHEET

PROJECT:	CCR GW Installation	DRILLING Co.:	Eichelbergers	WELL No.:	GW-25
PROJECT No.:	112IC07852 Task 3.2	DRILLER:	Randy Hoffman	DATE COMPLETED:	25-Jul-16
SITE:	Pleasants Power	DRILLING METHOD:	Air Rotary	NORTHING:	321494.03
GEOLOGIST:	Scott Anderson	DEV. METHOD:	Surge, Bail	EASTING:	1468884.46



ELEVATION OF TOP OF SURFACE CASING: 1009.13
STICK -UP TOP OF SURFACE CASING: 2.91
ELEVATION OF TOP OF RISER PIPE: 1008.53
RISER STICK-UP ABOVE GROUND SURFACE: 2.31
I.D. OF SURFACE CASING: 6-inches
TYPE OF SURFACE CASING: Stainless Steel

GROUND ELEVATION: 1006.22
TYPE OF SURFACE SEAL: Cement

RISER PIPE I.D.: 2-inches
TYPE OF RISER PIPE: Schedule 40 PVC

BOREHOLE DIAMETER: 6-inches
TYPE OF SEAL: Cement-Bentonite Grout

ELEVATION / DEPTH OF SEAL: 734.22 / 272
TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF FILTER PACK: 729.22 / 277

ELEVATION / DEPTH TOP OF SCREEN: 722.22 / 284

TYPE OF SCREEN: PVC

SLOT SIZE X LENGTH: 10 slot X 20 feet

I.D. OF SCREEN: 2-inches

TYPE OF FILTER PACK: US Standard Sieve size 20/40 (No. 0 clean silica sand)

ELEVATION / DEPTH BOTTOM OF SCREEN: 702.22 / 304
ELEVATION / DEPTH BOTTOM OF FILTER PACK: 701.22 / 305
TYPE OF BACKFILL BELOW WELL: Silica Sand (as above)
ELEVATION / DEPTH OF BOREHOLE: 701.22 / 305

TETRA TECH

LOG OF BORING GW-25

(Page 1 of 7)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

First Energy CCR, Pleasants Power

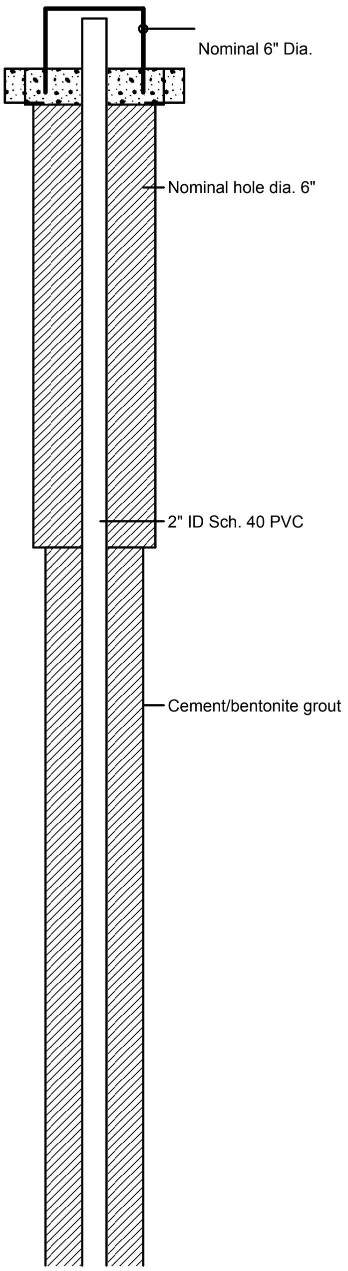
Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/25/16	Ground Elevation	: 1009.13
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1468884.46	Northing	: 321494.03

Sample Type
- ⊠ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet: 0, 10, 20, 30, 40, 50

Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
				Silty Clay with rocks, red/tan, stiff, dry	CL
				Silty Clay to Clay with rocks, tan, stiff	Cl
				Silty Clay to Clay, tan/brown, stiff	Cl
				Claystone Clay, red, stiff	Cl
				Clay and Siltstone, green/gray, stiff	Cl
				Claystone, Siltstone, red, soft	Cl
				Claystone, red, soft	Cl
				Siltstone, red/gray, soft	Sltst
				Claystone red and Limestone tan/gray, soft Interbedded, less than 6 inch each layer HCL reaction	Cl
				Limestone and Shale, gray, soft Reacts to HCL	Ls
				Claystone and Siltstone darker with depth and transitions to Sandstone, red/purple, soft No HCL reaction	Clst
				Siltstones and Shales with Claystone, gray/green, soft	Sltst



TETRA TECH

LOG OF BORING GW-25

(Page 2 of 7)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

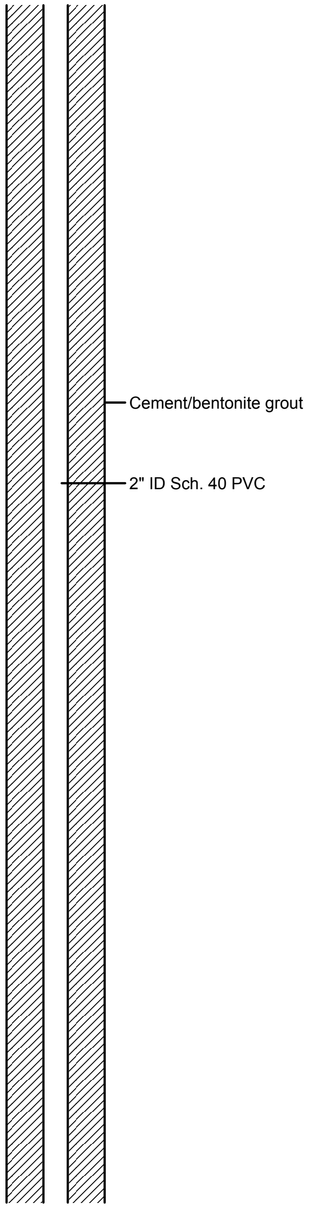
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/25/16	Ground Elevation	: 1009.13
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1468884.46	Northing	: 321494.03

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
50 60					Silstones and Shale gray with minor interbeds of Claystone red and Limestones gray No HCL reaction except in Limestone	Sltst
70 80					Similar to above but also very fine Sandstone and Silty Sandstones, red, soft to hard Minor HCL reaction At 80 Shaley	Sltst
90					Claystone with minor Siltstone, red, soft No HCL reaction	Clst
100					Shaley very fine Sandstone, green/gray, hard No HCL reaction	Sh



TETRA TECH

LOG OF BORING GW-25

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

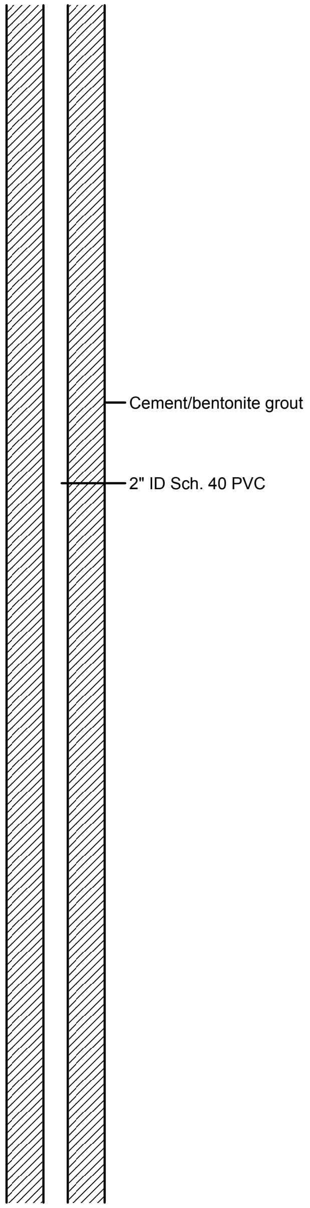
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/25/16	Ground Elevation	: 1009.13
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1468884.46	Northing	: 321494.03

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
100						Sh
110					Shaley very fine Sandstone, green/gray, hard No HCL reaction	Sh
120					Very fine to fine Sandstone, green to gray, hard No HCL reaction	Sst
130					Shaley Limestone red/brown grading to Limestone gray, soft Vigourous HCL reaction	Ls
140					Claystone and Siltstones, red, soft No HCL reaction	Clst
150					Limestone tan, with interbedded Claystones red, soft No distict layering of Claystone Strong HCL reactions	Ls



TETRA TECH

LOG OF BORING GW-25

(Page 4 of 7)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

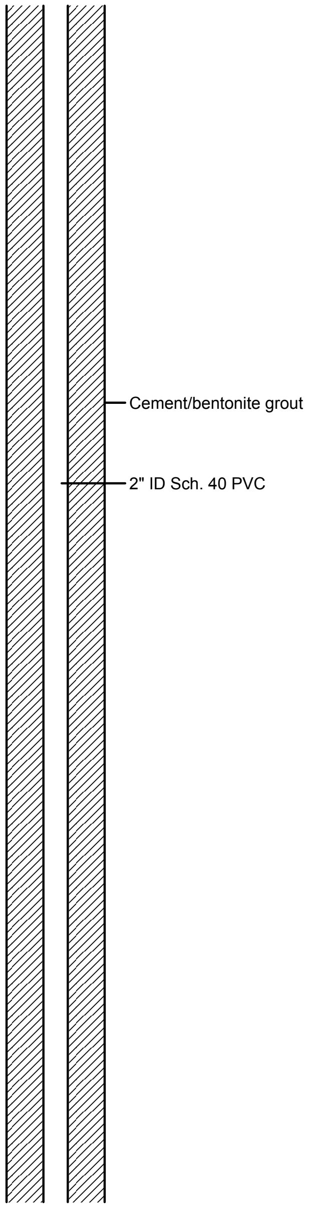
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/25/16	Ground Elevation	: 1009.13
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1468884.46	Northing	: 321494.03

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
150						Ls
					Limestone tan, with interbedded Claystones red, soft No distict layering of Claystone Strong HCL reactions	Ls
160						
					Sandstone purple/red with Siltstones gray, and Limestones gray/tan, hard to soft HCL reactions in Limestones	Sst
170						
180						
					Similar to above but 50% Sandstone and 50% Limestone, purple red to tan and gray, hard and soft Probably thinly bedded	Sst/Ls
190						
					As above but interbedded 1-2 feet, gray and red, soft to hard	Sst
200						



TETRA TECH

LOG OF BORING GW-25

(Page 5 of 7)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

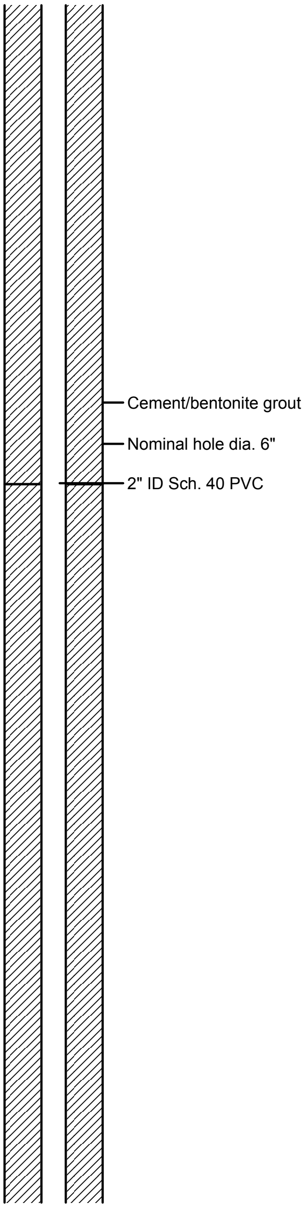
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/25/16	Ground Elevation	: 1009.13
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1468884.46	Northing	: 321494.03

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
200						Sst
					Sandstone, Limestone, Shale, purple/red, hard	Sst
210					Limestone green/gray with Claystones red, soft Strong HCL reaction At 214-215 Claystone red At 216-216.5 Claystone red	LS
220						
					Very fine Sandstone green/gray and Siltstone, hard No HCL reaction At 230 Hydrocarbon odor Below 235, more Shaley Increasing Sandstone with depth to 250	Sst
230						
240						
250						



TETRA TECH

LOG OF BORING GW-25

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Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

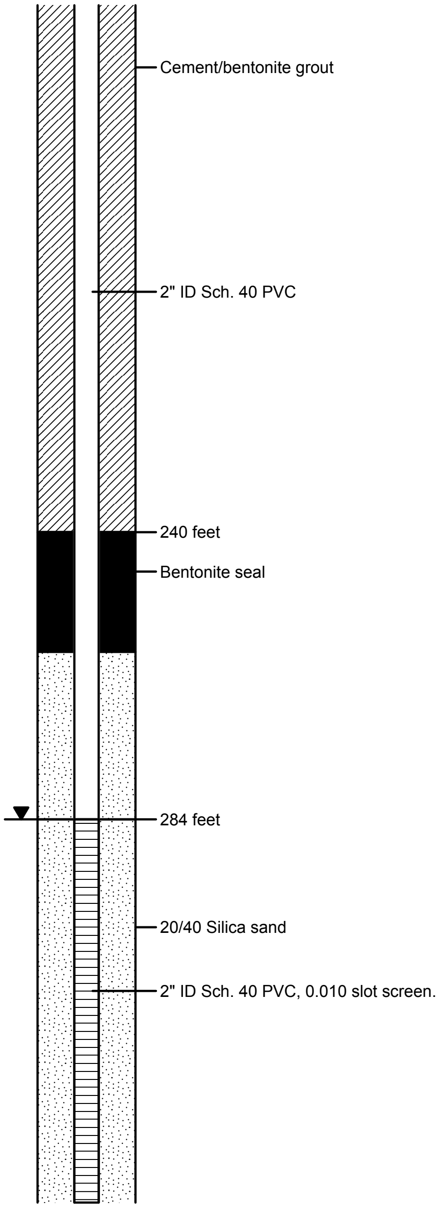
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/25/16	Ground Elevation	: 1009.13
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1468884.46	Northing	: 321494.03

Sample Type
- ⊠ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
250					Sandstone and Limestone red/purple with Shales, hard	Sst
					Very fine Silty Sandstone green/gray with biotite and muscovite (micacous), hard No HCL reactions	Sst
260						
270						
280					At 280 Hydrocarbon odor At 284 possible water less than 0.125 gpm Fine Sandstone as above (coarser) gray/green, medium hard	Sst
290						
300						



LOG OF BORING GW-25

(Page 7 of 7)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

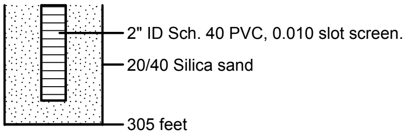
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/25/16	Ground Elevation	: 1009.13
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1468884.46	Northing	: 321494.03

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
300						Sst
					At 301 Hydrocarbon odor	Sst
					End of boring at 304 feet BGS	
310						
320						
330						
340						
350						

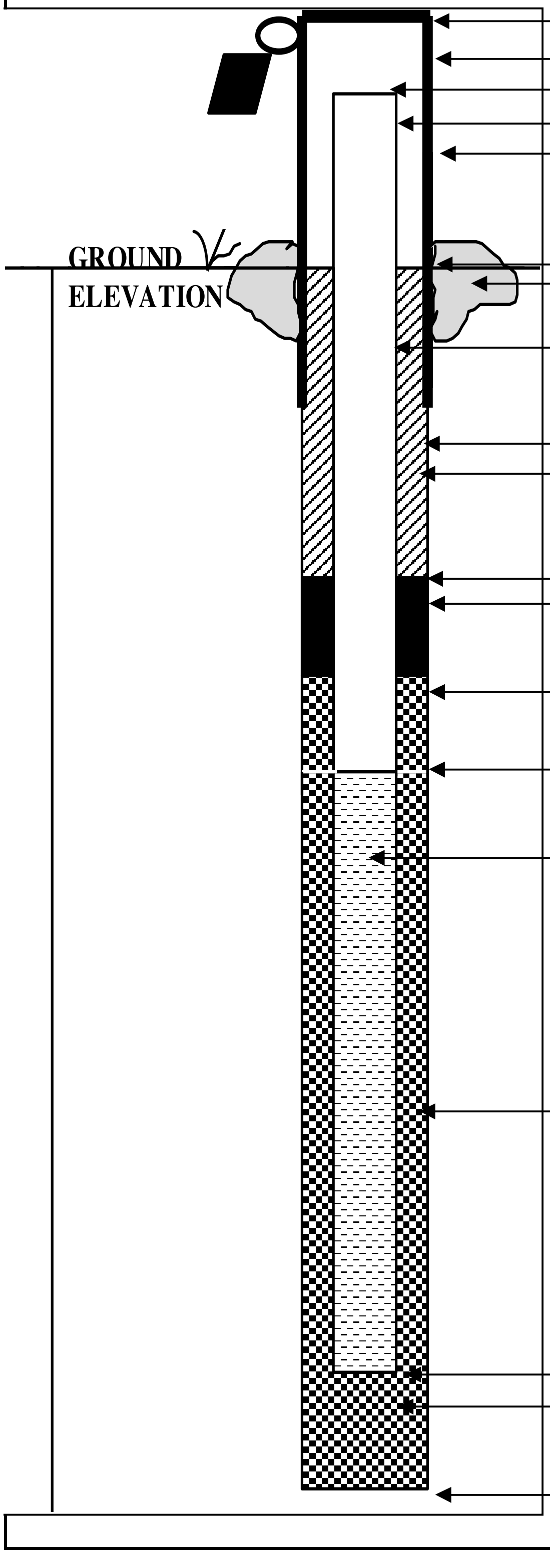


Tetra Tech, Inc.

GROUNDWATER MONITORING WELL SHEET

BORING NO.: GW-26

PROJECT:	CCR GW Installation	DRILLING Co.:	Eichelbergers	WELL No.:	GW-26
PROJECT No.:	112IC07852 Task 3.2	DRILLER:	Randy Hoffman	DATE COMPLETED:	20-Jul-16
SITE:	Pleasants Power	DRILLING METHOD:	Air Rotary	NORTHING:	322070.73
GEOLOGIST:	Scott Anderson	DEV. METHOD:	Surge, Waterra	EASTING:	1467783.60



ELEVATION OF TOP OF SURFACE CASING: 986.92

STICK -UP TOP OF SURFACE CASING: 2.76

ELEVATION OF TOP OF RISER PIPE: 986.45

RISER STICK-UP ABOVE GROUND SURFACE: 2.29

I.D. OF SURFACE CASING: 6-inches

TYPE OF SURFACE CASING: Stainless Steel

GROUND ELEVATION: 984.16

TYPE OF SURFACE SEAL: Cement

RISER PIPE I.D.: 2-inches

TYPE OF RISER PIPE: Schedule 40 PVC

BOREHOLE DIAMETER: 6-inches

TYPE OF SEAL: Cement-Bentonite Grout

ELEVATION / DEPTH OF SEAL: 726.66 / 257.5

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF FILTER PACK: 721.66 / 262.5

ELEVATION / DEPTH TOP OF SCREEN: 717.16 / 267

TYPE OF SCREEN: PVC

SLOT SIZE X LENGTH: 10 slot X 20 feet

I.D. OF SCREEN: 2-inches

TYPE OF FILTER PACK: US Standard Sieve size 20/40 (No. 0 clean silica sand)

ELEVATION / DEPTH BOTTOM OF SCREEN: 697.16 / 287

ELEVATION / DEPTH BOTTOM OF FILTER PACK: 694.16 / 290

TYPE OF BACKFILL BELOW WELL: Silica Sand (as above)

ELEVATION / DEPTH OF BOREHOLE: 694.16 / 290

LOG OF BORING GW-26

(Page 1 of 6)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

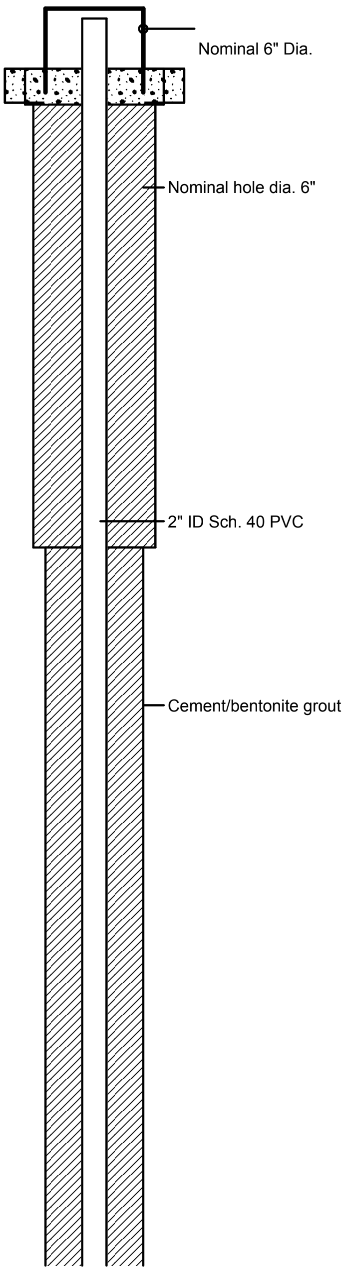
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/20/16	Ground Elevation	: 986.92
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1467783.60	Northing	: 322070.73

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ During Drilling
- ◆ During Drilling

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
0					Sily Clay with rocks, brown/tan, stiff	SC
					Silty Clay to clay with Sanstone, tan/gray, stiff	SC
					Clay with rocks, gray, stiff	Cl
					Clay with rocks, red, stiff	Cl
10					Silty Clay and rocks, tan, stiff	SC
					Rock-Limestone, gray, soft,HCL reactions	Ls
					Siltstone, red, soft	Sltst
					Very fine to fine limey Sandsand, tan, soft HCL reaction	Sst
20					Limestone, tan to gray, soft HCL reaction	Ls
30					Silstones and Claystones with interbedded Limestones, red to brown, soft	Sltst
40					Siltstones and Shales, red to gray, soft No HCL reaction	Sltst
					Siltstone, gray with green, soft	Sltst
50					Siltstone and Shale, red, soft	Sltst



LOG OF BORING GW-26

(Page 2 of 6)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

First Energy CCR, Pleasants Power

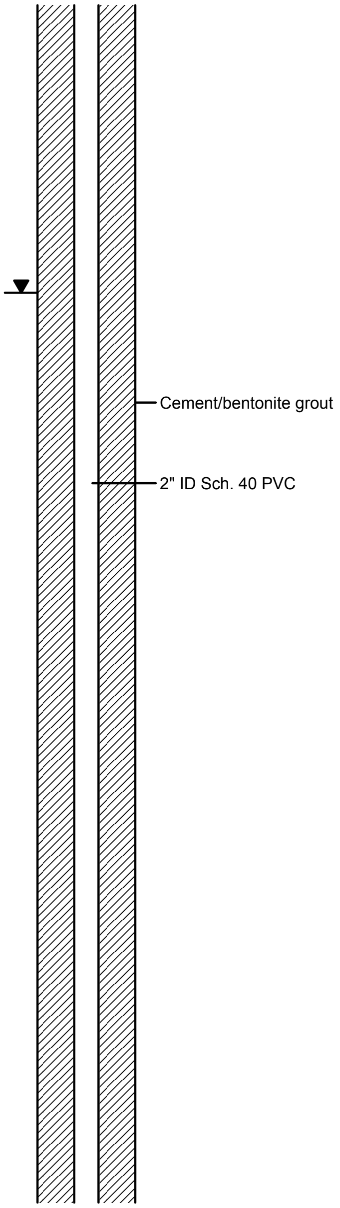
Project : 212C-SW-00069
Site : Pleasants Power
Date : 7/20/16
Drilling Method : Rotary Air Hammer
East : 1467783.60

Drilling Contractor : Eichelbergers
Logged By : Scott Anderson
Ground Elevation : 986.92
Driller : Randy Hoffman
Northing : 322070.73

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ During Drilling
- ◆ During Drilling

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
50					Siltstones and very fine Sandstone, gray/green, hard, No HCL reaction	Sltst
					Siltstone Shale, Claystone, red, soft No HCL reaction	Sltst
60					Siltstone and Sandstone, gray/green, soft to hard No HCL reaction	Sltst
					At 62 water approximately 1 GPM Shale and Limestone, gray to tan, soft	Sh/Ls
70 80					Sandstone very fine to Sandy Siltstone, gray green, soft No HCL reaction	Sst
					As above but more Shaley , gray/green, soft No HCL reaction	Sst
90 100					Sandstone with Shaley area, green, hard, muscovite and biotite No HCL reaction	Sst



LOG OF BORING GW-26

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

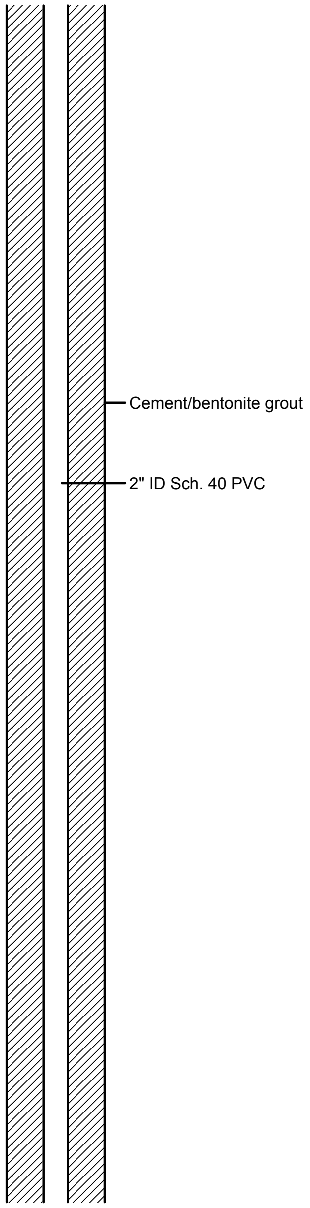
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/20/16	Ground Elevation	: 986.92
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1467783.60	Northing	: 322070.73

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ During Drilling
- ◆ During Drilling

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
100				🟩		Sst
110				▨	Fine Sandtone, similar to above (softer), green/gray, hard Strong hydrocarbon odor at 110, minor water No HCL reaction	Sst
120						
				🟫	Limestone with Siltstone and very fine Sandstone, gray to red, soft Strong HCL reaction	Ls/Sltst
130						
140						
				🟥	Sandstone, red/purple with Shale Siltstone gray, and Limestone gray, soft to hard	Sst
150						



TETRA TECH

LOG OF BORING GW-26

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Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

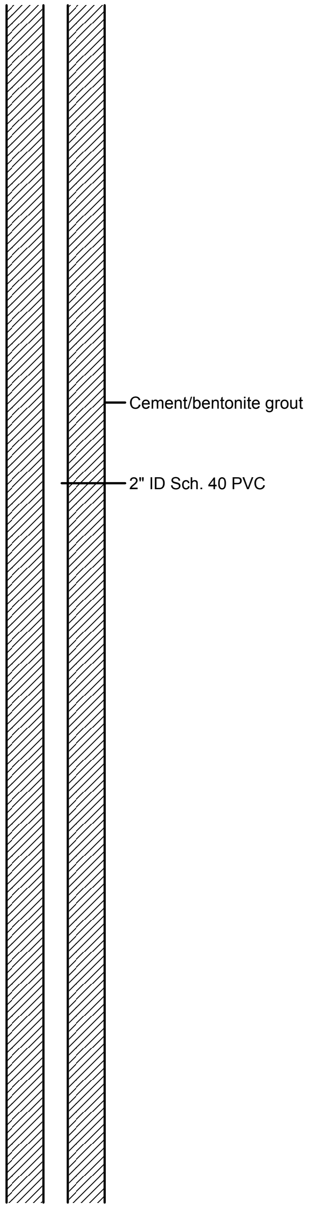
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/20/16	Ground Elevation	: 986.92
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1467783.60	Northing	: 322070.73

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ During Drilling
- ◆ During Drilling

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
150						Sst
					Interbedded Siltstone red and Limestone green, soft	Sltst/Ls
160 170 180 190 200					Interbedded Sandstone red/purple with Shales gray, Siltstone green/gray, and Limestone Increasing Limestone with depth No distinct beds, fairly uniform mixture in return	Sst



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LOG OF BORING GW-26

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Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

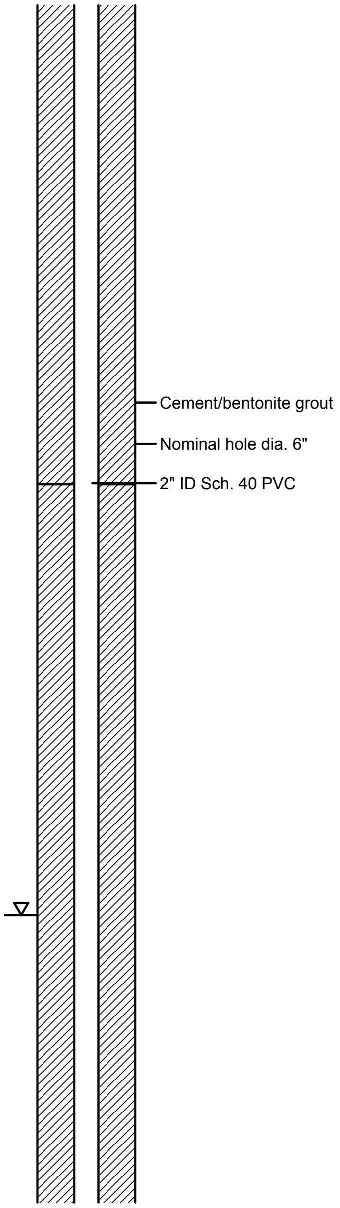
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/20/16	Ground Elevation	: 986.92
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1467783.60	Northing	: 322070.73

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ During Drilling
- ◆ During Drilling

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
200						Sst
205					(See Previous Page)	Sst
210						
215					Limestone gray/green with minor interbeds of Claystone red, soft Strong HCL reaction	Ls
220						
230					Siltstone green grading to Silty Sandstone with Calcite cement, soft to hard Weak HCL reactions	Sltst
240						
245					Similar to above but grading to Shaley Siltstone, green, soft	Sltst
250						



LOG OF BORING GW-26

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Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

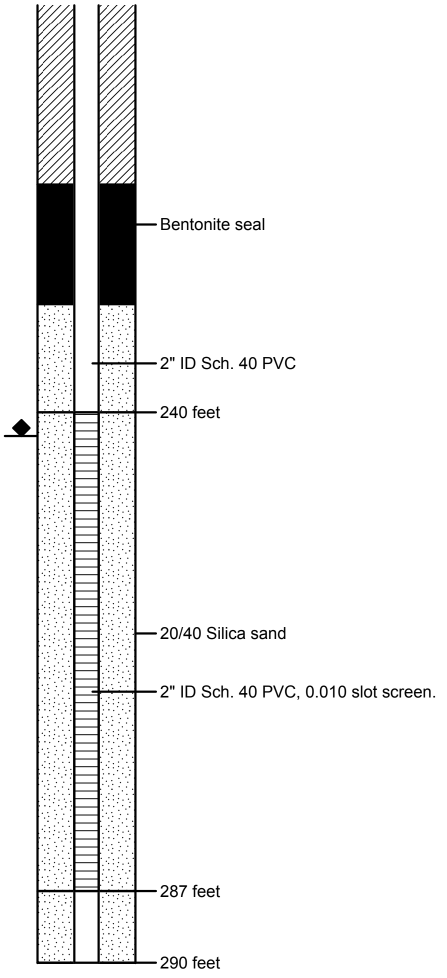
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/20/16	Ground Elevation	: 986.92
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1467783.60	Northing	: 322070.73

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ During Drilling
- ◆ During Drilling

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
250						Sltst
260					Limestone green, Siltstone red, soft Interbedded but mostly Limestone Strong HCL reaction	Ls
					Sandstone to Siltstone, green, hard Minor HCL reaction At 268 water, 3-5 GPM	Sst
270 280					Very fine Sandstone green, with biotite and muscovite to Siltstone, green, hard No HCL reaction At 280 Shaley At 289 soft	Sst
290 300					End of boring	

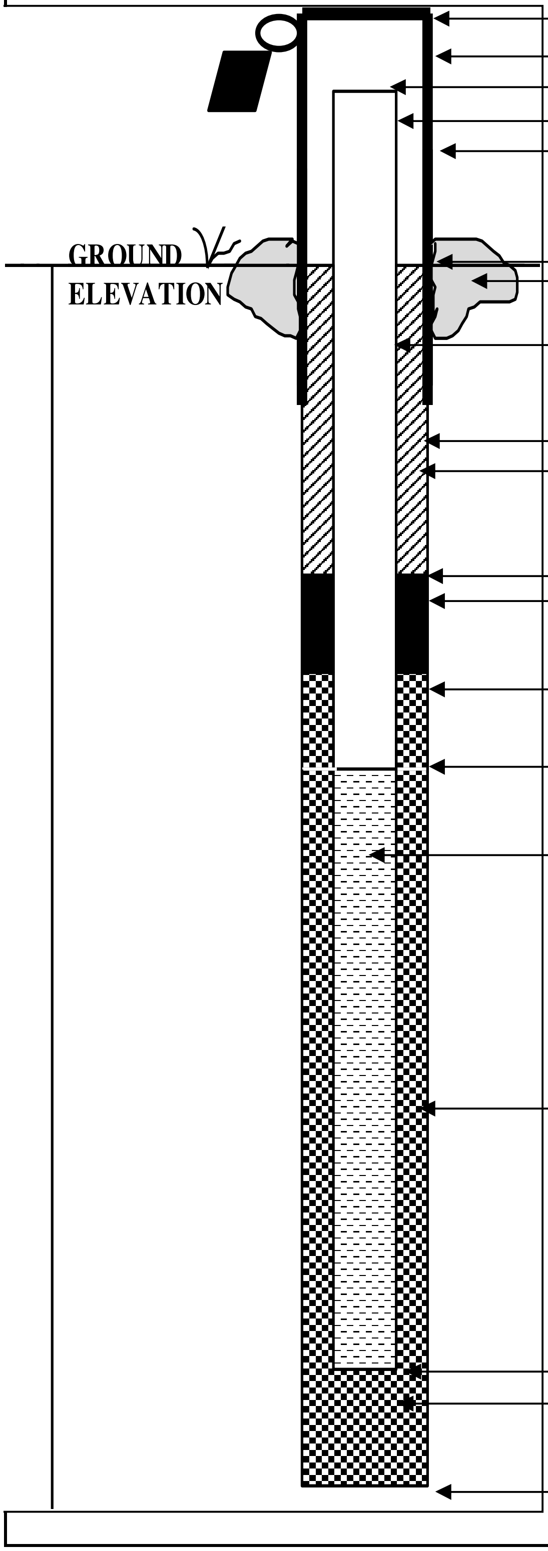


BORING NO.: GW-27

Tetra Tech, Inc.

GROUNDWATER MONITORING WELL SHEET

PROJECT:	CCR GW Installation	DRILLING Co.:	Eichelbergers	WELL No.:	GW-27
PROJECT No.:	112IC07852 Task 3.2	DRILLER:	Randy Hoffman	DATE COMPLETED:	27-Jun-16
SITE:	Pleasants Power	DRILLING METHOD:	Air Rotary	NORTHING:	320829.65
GEOLOGIST:	Scott Anderson	DEV. METHOD:	Surge, Air Lift	EASTING:	1465535.93



ELEVATION OF TOP OF SURFACE CASING: 678.31
STICK -UP TOP OF SURFACE CASING: 3.01
ELEVATION OF TOP OF RISER PIPE: 677.76
RISER STICK-UP ABOVE GROUND SURFACE: 2.46
I.D. OF SURFACE CASING: 6-inches
TYPE OF SURFACE CASING: Stainless Steel

GROUND ELEVATION: 675.3
TYPE OF SURFACE SEAL: Cement

RISER PIPE I.D.: 2-inches
TYPE OF RISER PIPE: Schedule 40 PVC

BOREHOLE DIAMETER: 6-inches
TYPE OF SEAL: Cement-Bentonite Grout

ELEVATION / DEPTH OF SEAL: 643.8 / 31.5
TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF FILTER PACK: 640.3 / 35

ELEVATION / DEPTH TOP OF SCREEN: 637.3 / 38

TYPE OF SCREEN: PVC

SLOT SIZE X LENGTH: 10 slot X 10 feet

I.D. OF SCREEN: 2-inches

TYPE OF FILTER PACK: US Standard Sieve size 20/40 (No. 0 clean silica sand)

ELEVATION / DEPTH BOTTOM OF SCREEN: 627.3 / 48
ELEVATION / DEPTH BOTTOM OF FILTER PACK: 624.3 / 51
TYPE OF BACKFILL BELOW WELL: Cement-Bentonite Grout, Bentonite
ELEVATION / DEPTH OF BOREHOLE: 605.3 / 70

TETRA TECH

LOG OF BORING GW-27

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Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

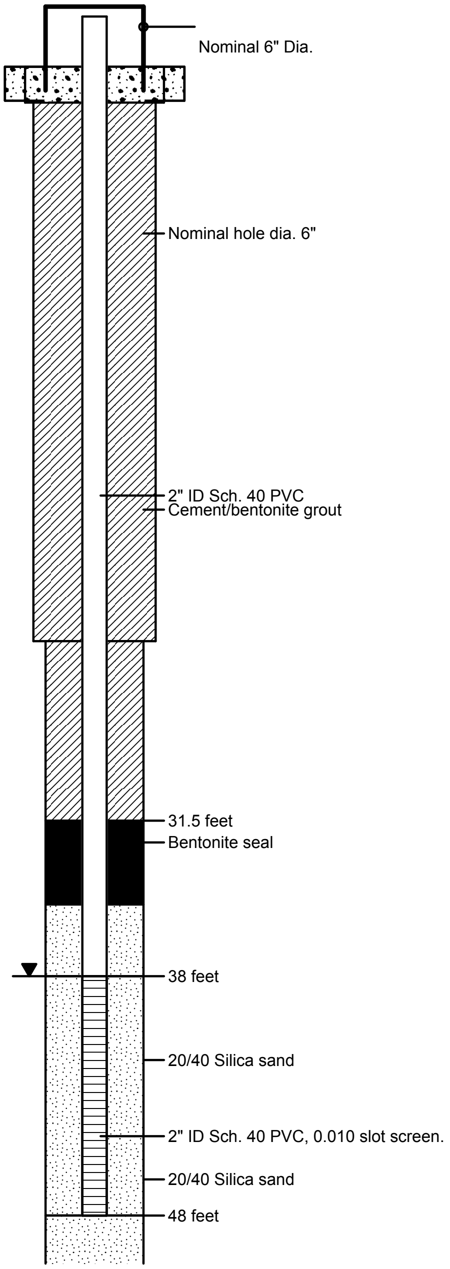
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/27/16	Ground Elevation	: 675.3
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1465535.93	Northing	: 320829.65

Sample Type
☒ Split Spoon
▦ Air Hammer Drill Cuttings

Water Levels
▼ During Drilling
▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
0					Silty Clay to Clayey Silt with minor/trace Sands and rock fragments (<0.5"), red/brown, stiff, Dry to damper with depth	Cl
10					Sandy Clayey Silt with gravel, rocks, brown/tan, stiff, damp	Ml
					Claystone, tan to red, soft (Pittsburgh Redbeds) No HCL reaction	Clst
20 30					Claystone red with minor beds of Siltstone tan (<6" thick), soft or medium hard (Pittsburgh Redbeds) No HCL reaction	Clst
					Claystone red and Siltstone gray approximately 1 foot interbedded, soft to medium hard Alternating Pittsburgh Redbeds No HCL reaction	Clst
40					At 38 feet water approximatly 5 GPM Siltstone gray/green, soft, breaks easily, crumbles No HCL Reaction	Sltst
					Sandstone fine-grained, gray/green, medium hard No additional water	Sst
50					Siltstone as above, gray/green, soft No additional water	Sltst



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LOG OF BORING GW-27

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Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

First Energy CCR, Pleasants Power

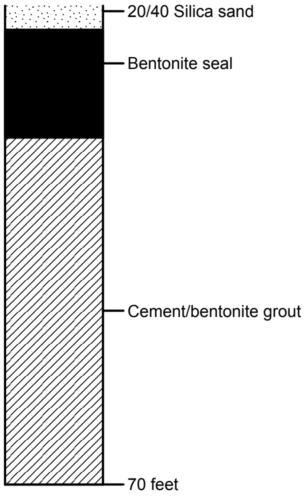
Project : 212C-SW-00069
Site : Pleasants Power
Date : 7/27/16
Drilling Method : Rotary Air Hammer
East : 1465535.93

Drilling Contractor : Eichelbergers
Logged By : Scott Anderson
Ground Elevation : 675.3
Driller : Randy Hoffman
Northing : 320829.65

Sample Type
⊠ Split Spoon
▦ Air Hammer Drill Cuttings

Water Levels
▼ During Drilling
▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
50						Sltst
					As above 46-54, no additional water	Sltst
					Limey Claystone, tan, soft Strong HCL reaction	Clst
60					Claystone, red, soft No additional water No HCL reaction	Clst
					Claystone to Siltstones gray/green, soft Approximately 6 inches to 1 foot beds No additional water	Clst
70					Sandstone fine-grained, gray/green, medium hard	Sst
					End of boring at 70 feet BGS	
80						
90						
100						



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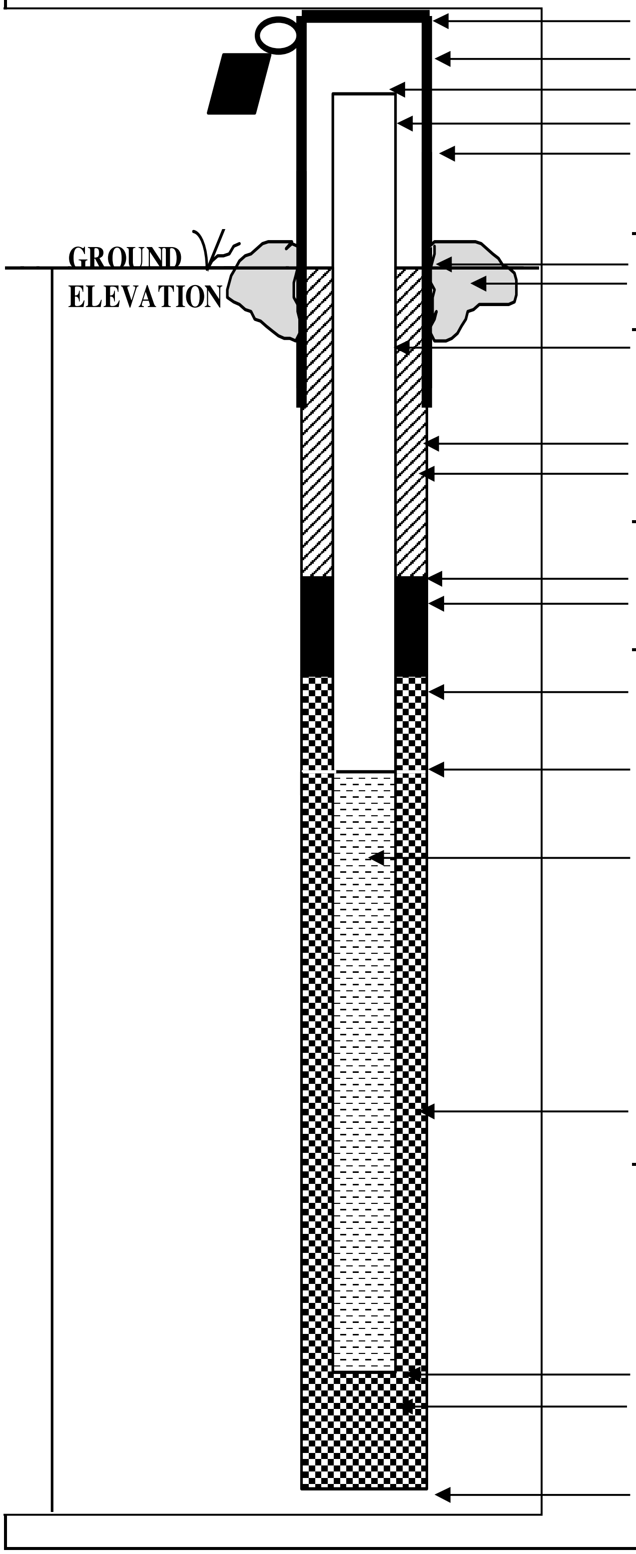
BORING NO.: GW-28

Tetra Tech, Inc.

GROUNDWATER MONITORING WELL SHEET

PROJECT:	CCR GW Installation	DRILLING Co.:	Eichelbergers	WELL No.:	GW-28
PROJECT No.:	112IC07852 Task 3.2	DRILLER:	Randy Hoffman	DATE COMPLETED:	30-Jun-16
SITE:	Pleasants Power	DRILLING METHOD:	Air Rotary	NORTHING:	320230.57
GEOLOGIST:	Scott Anderson	DEV. METHOD:	Surge, Waterra	EASTING:	1465756.87



ELEVATION OF TOP OF SURFACE CASING: 804.64

STICK -UP TOP OF SURFACE CASING: 2.69

ELEVATION OF TOP OF RISER PIPE: 804.38

RISER STICK-UP ABOVE GROUND SURFACE: 2.43

I.D. OF SURFACE CASING: 6-inches

TYPE OF SURFACE CASING: Stainless Steel

GROUND ELEVATION: 801.95

TYPE OF SURFACE SEAL: Cement

RISER PIPE I.D.: 2-inches

TYPE OF RISER PIPE: Schedule 40 PVC

BOREHOLE DIAMETER: 6-inches

TYPE OF SEAL: Cement-Bentonite Grout

ELEVATION / DEPTH OF SEAL: 646.75 / 155.2

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF FILTER PACK: 641.45 / 160.5

ELEVATION / DEPTH TOP OF SCREEN: 636.95 / 165

TYPE OF SCREEN: PVC

SLOT SIZE X LENGTH: 10 slot X 10 feet

I.D. OF SCREEN: 2-inches

TYPE OF FILTER PACK: US Standard Sieve size 20/40 (No. 0 clean silica sand)

ELEVATION / DEPTH BOTTOM OF SCREEN: 626.95 / 175

ELEVATION / DEPTH BOTTOM OF FILTER PACK: 626.05 / 175.9

TYPE OF BACKFILL BELOW WELL: Silica Sand (as above)

ELEVATION / DEPTH OF BOREHOLE: 626.05 / 175.9

LOG OF BORING GW-28

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Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

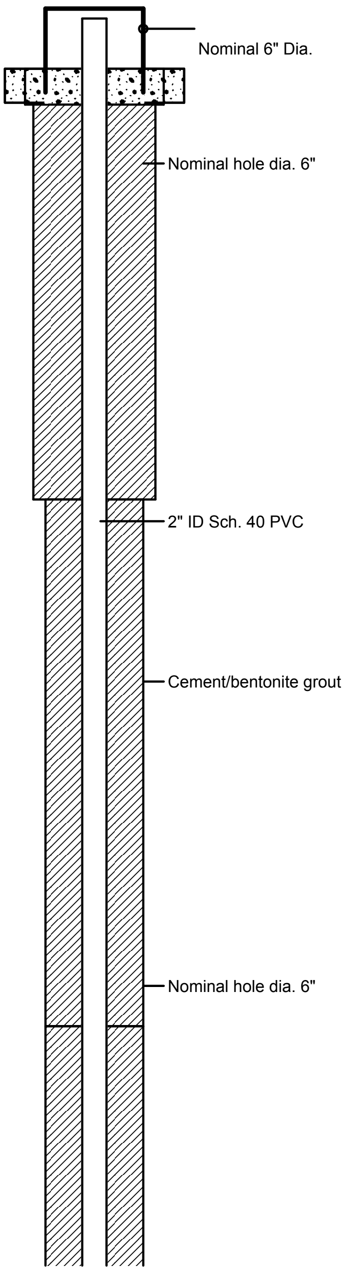
First Energy CCR, Pleasants Power

Project : 212C-SW-00069
Site : Pleasants Power
Date : 6/30/16
Drilling Method : Rotary Air Hammer
East : 1465756.87
Drilling Contractor : Eichelbergers
Logged By : Scott Anderson
Ground Elevation : 801.95
Driller : Randy Hoffman
Northing : 320230.57

Sample Type
☒ Split Spoon
▦ Air Hammer Drill Cuttings

Water Levels
▼ During Drilling
▽ After Drilling

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
0					Silty Clay tan/red with rock fragments, stiff, disturbed	SC
					Silty Clay to Clay, tan, stiff	SC
					Siltstone or weathered rock residual, gray/green hard At 9' plastic	Sltst
10					Siltstone to Claystone, tan/yellow, hard	Sltst
					Siltstone grading to Sandstone at 16' BGS, gray/green, hard, more competent than above	Sltst
20					Siltstone, gray/green, moderate hard	Sltst
30					Claystone, red, moderately hard	Clst
					Limey Sandstone, tan/brown, moderately hard	Sst
40					Siltstone, green, moderately hard	Sltst
					Sandstone, very fine grained, green, hard	Sst
					Siltstone, green, hard	Sltst
					Limey Sandstone, tan/brown, hard	Sst
50					Siltstone, green, moderately hard	Sltst



TETRA TECH

LOG OF BORING GW-28

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Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

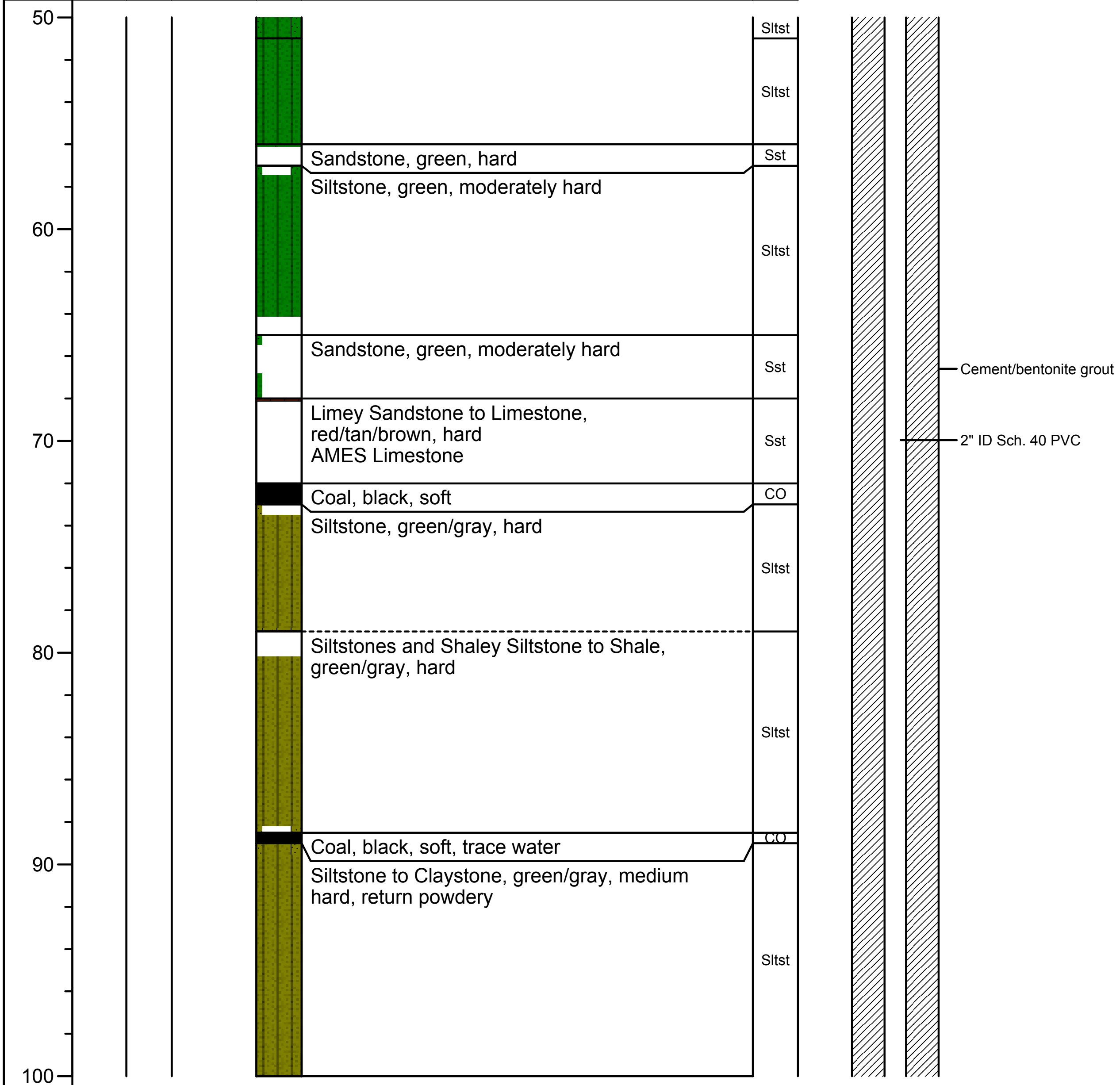
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 6/30/16	Ground Elevation	: 801.95
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1465756.87	Northing	: 320230.57

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Drilling

Depth in Feet | Sample Type | Rec. % | Blow Count | GRAPHIC | DESCRIPTION | USCS or Rock type



DESCRIPTION	USCS or Rock type
	Sltst
	Sltst
Sandstone, green, hard	Sst
Siltstone, green, moderately hard	Sltst
Sandstone, green, moderately hard	Sst
Limey Sandstone to Limestone, red/tan/brown, hard AMES Limestone	Sst
Coal, black, soft	CO
Siltstone, green/gray, hard	Sltst
Siltstones and Shaley Siltstone to Shale, green/gray, hard	Sltst
Coal, black, soft, trace water	CO
Siltstone to Claystone, green/gray, medium hard, return powdery	Sltst

LOG OF BORING GW-28

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Pittsburgh, PA 15220

First Energy CCR, Pleasants Power

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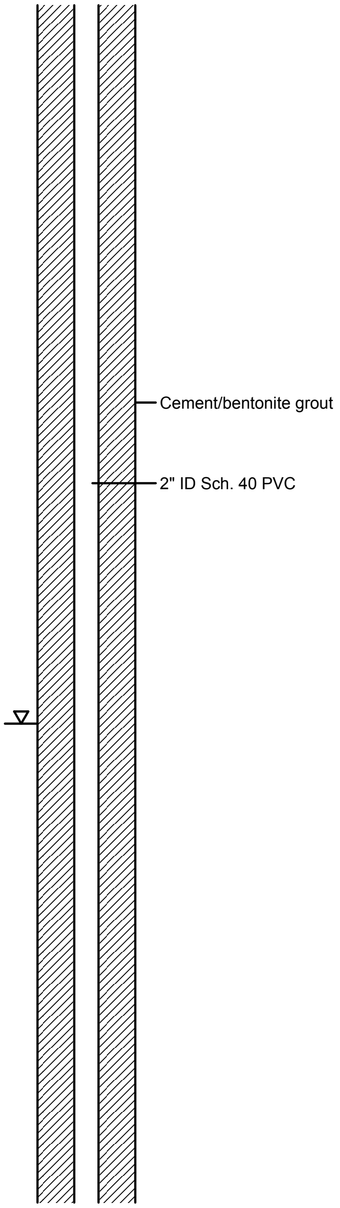
Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Drilling

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
100				🟩	Sandstone, green, Hard	Sst
					Siltstone, green, hard	Sltst
					Sandstone, green, hard	Sst
110					Siltstone, green, hard	Sltst
					Claystone, red, hard	Clst
120					Siltstone, green, hard	Sltst
					Claystone, red, hard	Clst
130					Siltstone, green, hard	Sltst
140					Alternating 0.5 foot to 1 foot layers of Siltstone green hard and Claystone red medium hard	Sltst
150						Sltst



LOG OF BORING GW-28

(Page 4 of 4)

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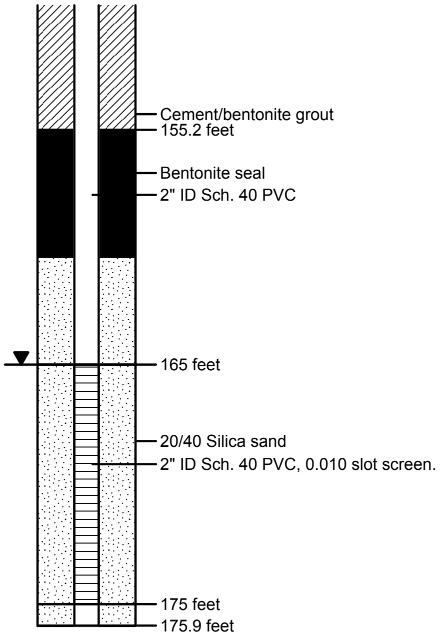
Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Drilling

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
150						Sltst
					Siltstone green to gray, hard to moderately hard, fines with depth to Shaley Siltstone to Shale	Sltst
160					Limey Sandstone, tan/brown, hard	Sst
					Siltstone, green, hard	Sltst
					Limey Sandstone, tan/brown, hard	Sst
170					Siltstone with more very fine Sandstone, gray/green, hard to moderately hard At 165 water approximately 1.5 GPM	Sltst
					End of boring at 175 feet BGS	
180						
190						
200						



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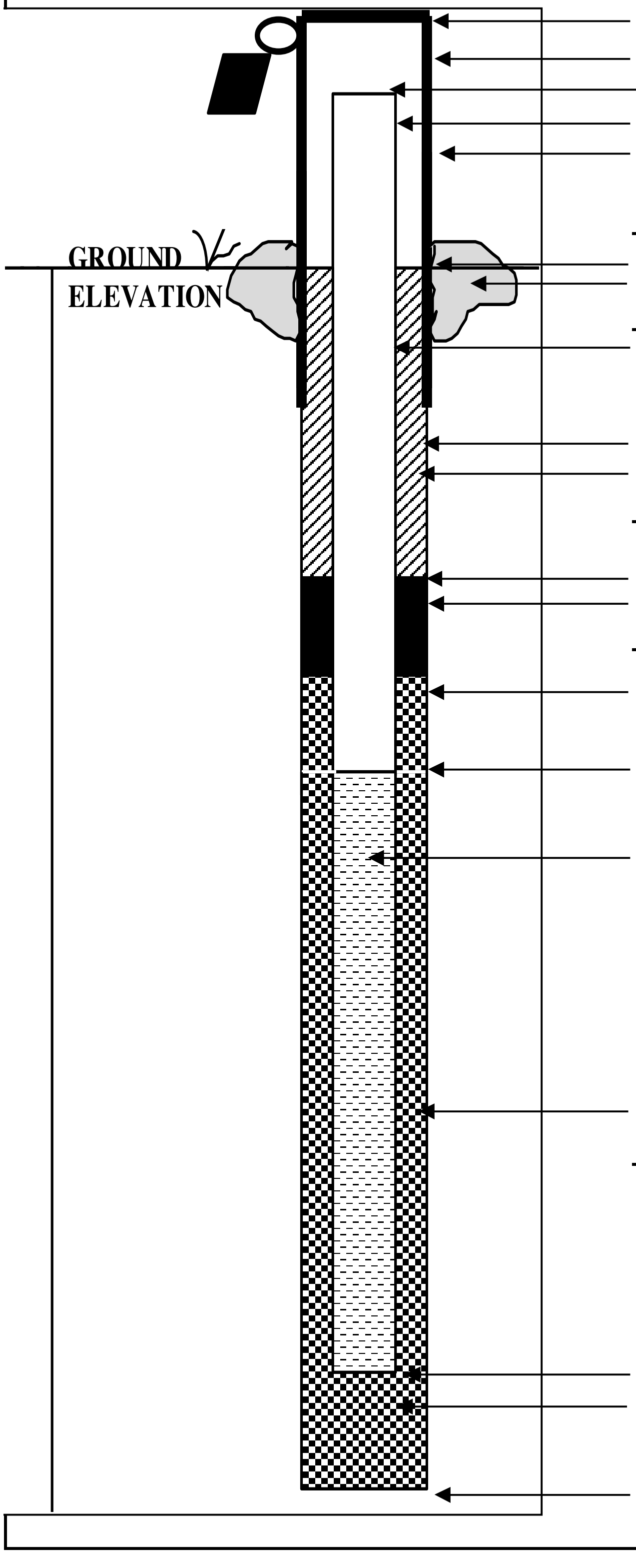
BORING NO.: GW-29

Tetra Tech, Inc.

GROUNDWATER MONITORING WELL SHEET

PROJECT:	CCR GW Installation	DRILLING Co.:	Eichelbergers	WELL No.:	GW-29
PROJECT No.:	112IC07852 Task 3.2	DRILLER:	Randy Hoffman	DATE COMPLETED:	30-Jun-16
SITE:	Pleasants Power	DRILLING METHOD:	Air Rotary	NORTHING:	319339.17
GEOLOGIST:	Scott Anderson	DEV. METHOD:	Surge, Air Lift	EASTING:	1465597.29



ELEVATION OF TOP OF SURFACE CASING: 931.6

STICK -UP TOP OF SURFACE CASING: 3.11

ELEVATION OF TOP OF RISER PIPE: 931.15

RISER STICK-UP ABOVE GROUND SURFACE: 2.66

I.D. OF SURFACE CASING: 6-inches

TYPE OF SURFACE CASING: Stainless Steel

GROUND ELEVATION: 928.49

TYPE OF SURFACE SEAL: Cement

RISER PIPE I.D.: 2-inches

TYPE OF RISER PIPE: Schedule 40 PVC

BOREHOLE DIAMETER: 6-inches

TYPE OF SEAL: Cement-Bentonite Grout

ELEVATION / DEPTH OF SEAL: 782.49 / 146

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF FILTER PACK: 777.99 / 150.5

ELEVATION / DEPTH TOP OF SCREEN: 772.49 / 156

TYPE OF SCREEN: PVC

SLOT SIZE X LENGTH: 10 slot X 10 feet

I.D. OF SCREEN: 2-inches

TYPE OF FILTER PACK: US Standard Sieve size 20/40 (No. 0 clean silica sand)

ELEVATION / DEPTH BOTTOM OF SCREEN: 762.49 / 166

ELEVATION / DEPTH BOTTOM OF FILTER PACK: 762.49 / 166

TYPE OF BACKFILL BELOW WELL: Silica Sand (as above)

ELEVATION / DEPTH OF BOREHOLE: 762.49 / 166

TETRA TECH

LOG OF BORING GW-29

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Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

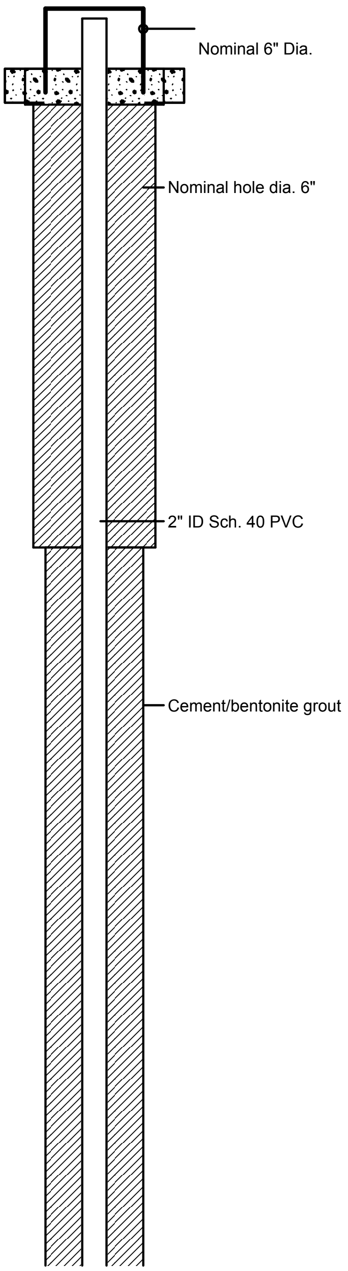
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/30/16	Ground Elevation	: 928.49
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1465597.29	Northing	: 319339.17

Sample Type
▨ Split Spoon
▦ Air Hammer Drill Cuttings

Water Levels
▼ During Drilling
▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
0				🟫	Silty Clay to Silt, red, stiff	CL
				🟫	Silty clay with rocks, tan/red, stiff	CL
				🟫	Silty Clay with rocks and coarse sands, red/brown, stiff	CL
10				⬜	Siltstone weathered, grey, hard	Sltst
				🟥	Claystone, red, hard	Clst
				🟩	Siltstone, green, hard	Sltst
				🟥	Claystone, red, hard	Clst
20				🟩	Siltstone with some Sandstone layers throughout (<1 foot), green, hard to medium hard	Sltst
30 40				🟥	Claystone red with several 6" to 1' layers of Sandy Claystone, red, hard to medium hard	Clst
				🟩	Siltstone, green, hard	Sltst
				🟥	Claystone, red, hard	Clst
50				🟫	Claystone tan with Sandstone to Siltstone green, hard	Clst



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Sample Type
- ☒ Split Spoon
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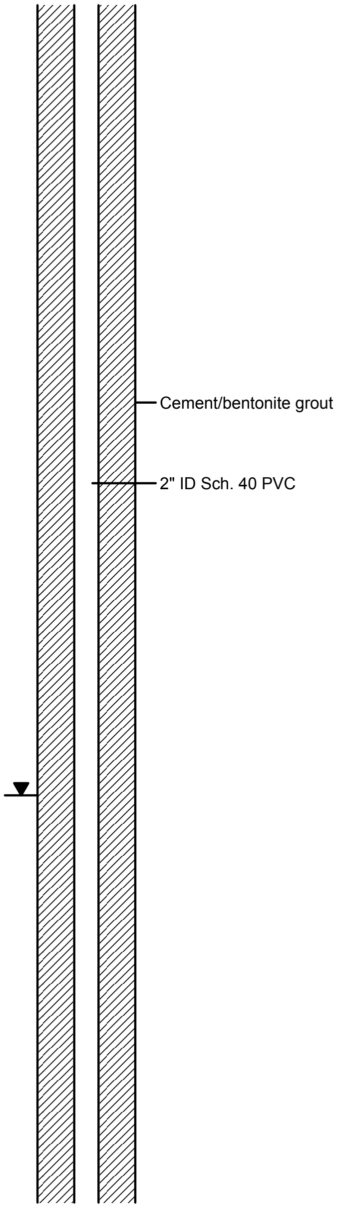
Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
50						Clst
					Claystone with minor (<6") areas of sandstone, red, hard	Clst
60						
					Limey Sandstone, tan, hard	lmySst
					Siltstone, gray/green, hard	Sltst
					Claystone, red, hard	Clst
70						
80					Fine to very fine-grained Sandstone gray with Claystone red At 83 ft minor water few mm/min	Sst
					Claystone, red, hard	Clst
90					Fine to very fine grained Sandstone, gray, hard	Sst
100						



LOG OF BORING GW-29

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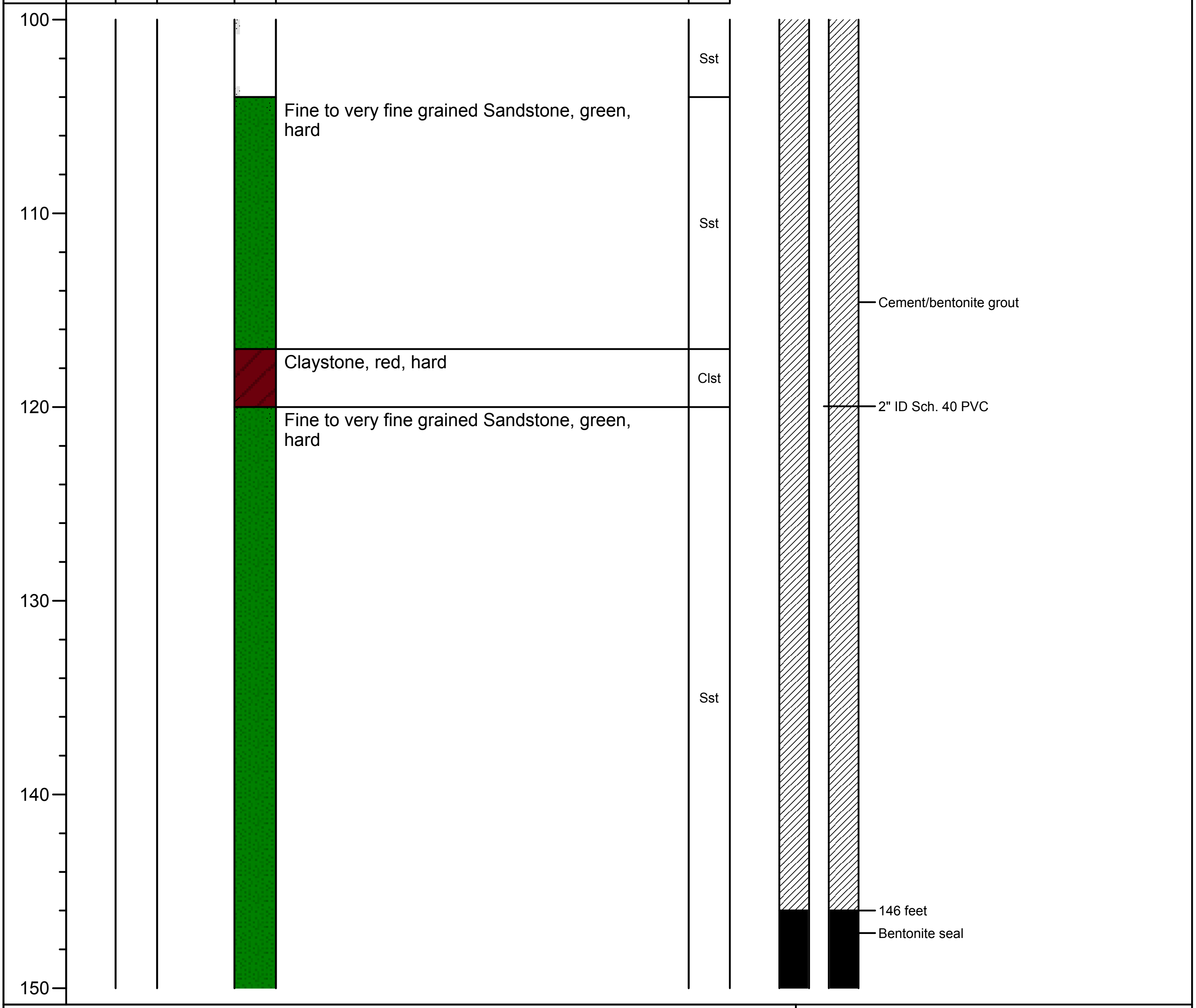
Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	Sample Type ☒ Split Spoon ▦ Air Hammer Drill Cuttings	Water Levels ▼ During Drilling ▽ After Completion	USCS or Rock type
					DESCRIPTION		



Fine to very fine grained Sandstone, green, hard

Claystone, red, hard

Fine to very fine grained Sandstone, green, hard

LOG OF BORING GW-29

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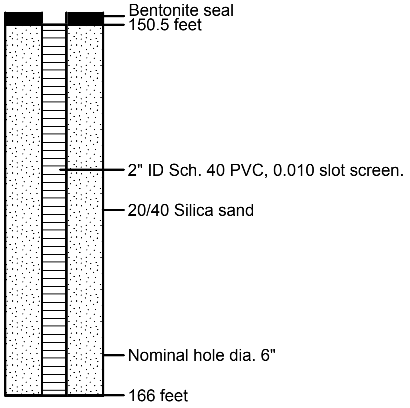
Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
150						Sst
					Very fine to fine grained Sandstone, green, hard	Sst
					Shale to Shaley Sandstone, green, hard Water at 156' pungent odor 2-3 gpm Recharge 1.5 gallons in 3 minutes	Sh
160						
					End of boring at 166 feet BGS	
170						
180						
190						
200						



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ATTACHMENT 3-2

Annual Groundwater Monitoring and Corrective Action Reports (2017, 2018, and 2019)

Disposal of Coal Combustion Residuals from Electric Utilities Rule

ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

PREFACE

Report Requirements

This report documents the status of the groundwater monitoring and corrective action program in place under the federal Coal Combustion Residuals (CCR) Rule. Containing data for the previous calendar year, it must be placed in the facility operating record by January 31 and posted publicly by March 2. It summarizes key actions completed, describes any challenges and how they were addressed, and projects key activities for the upcoming year. It must include a map or diagram depicting the CCR unit and all the wells in the monitoring network, identifying any that were decommissioned or installed in the previous year. In addition, it contains the monitoring data summary, a narrative discussing any transitions between detection monitoring and assessment monitoring and the reasons for those transitions.

What the Report Is

This report describes the first step in a phased, prescriptive process for monitoring groundwater near CCR storage facilities. It is a snap shot in time, showing how the data obtained during the report year compare to all the background data that have been obtained to date, and whether further monitoring for additional substances should be performed based on that comparison.

What the Report Is Not

The report does not make any determinations regarding potential environmental impact to or contamination of groundwater, and neither the raw data nor the initial statistical analysis should be independently or collectively interpreted in that way.

Report Methodology

Data comparison is done through a test to determine if monitoring results from wells adjacent to the CCR facility are statistically higher than background levels for that site. Therefore, as the data set increases over time, so does the confidence that any one result represents a statistically significant increase (SSI) over the background data. Groundwater moves slowly and both natural and man-made sources can impact groundwater. Therefore, the federal rule uses a phased approach with data verification steps in between. In this initial annual report, if a data result yields an SSI, the groundwater monitoring effort transitions from the detection program (measuring substances that move most rapidly in groundwater to identify a potential impact) to the assessment program (measuring substances that are of more concern including several that have regulatory standards).

2017 ANNUAL CCR GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

McELROY's RUN COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY

Pleasants Power Station
Pleasants County, West Virginia

Prepared for:

FirstEnergy

800 Cabin Hill Drive
Greensburg, PA 15601

Prepared by:

Tetra Tech, Inc.

400 Penn Center Boulevard, Suite 200
Pittsburgh, PA 15235
Phone: (412) 829-3600
Fax: (412) 829-3260

Tetra Tech Project No. 212C-SW-00070

January 2018

2017 ANNUAL CCR GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

McELROY's RUN COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY

PLEASANTS POWER STATION
PLEASANTS COUNTY, WEST VIRGINIA

Prepared for:

FirstEnergy

800 Cabin Hill Drive
Greensburg, PA 15601

Prepared by:

Tetra Tech, Inc.
400 Penn Center Boulevard, Suite 200
Pittsburgh, PA 15235
Phone: (412) 829-3600
Fax: (412) 829-3260

Tetra Tech Project No. 212C-SW-00070

January 2018

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TABLES

FIGURES

1.0 INTRODUCTION

This 2017 Annual Coal Combustion Residuals (CCR) Groundwater Monitoring and Corrective Action Report was prepared by Tetra Tech, Inc. (Tetra Tech) on behalf of FirstEnergy (FE), for the McElroy's Run Coal Combustion Byproduct Disposal Facility (CCBDF or "CCR unit") at the Pleasants Power Station (hereinafter referred to as the "Station"). The Station is located in Pleasants County, West Virginia. The report was developed to comply with requirements of 40 CFR § 257.90(e).

1.1 BACKGROUND AND SITE CHARACTERISTICS

CCRs produced at the Station are placed in the facility's captive CCBDF, which is located approximately one mile east-southeast of the Station. The facility consists of both a wet disposal area (impoundment) and dry disposal area (landfill) developed in the McElroy's Run watershed. Taken together, the landfill and impoundment are regulated under West Virginia Department of Environmental Protection (WVDEP) Solid Waste/National Pollutant Discharge Elimination System (NPDES) Water Pollution Control Permit No. WV0079171. A WVDEP groundwater monitoring program for the landfill has been in effect since 1994. As per the CCR Rule, the landfill and impoundment are considered two separate, existing CCR units that share a common boundary (i.e., the impoundment dam). As provided by the CCR Rule, a multiunit groundwater monitoring system has been established for the CCBDF.

The impoundment is situated in the upper portion of the watershed, is unlined, and has been in continuous use since the late 1970s. The landfill is situated in the lower portion of the watershed (adjacent to, and overlying, the impoundment dam), is lined, and has been in continuous use since the early 1990s. At the current water level, the surface impoundment area is about 250 acres. The impoundment dam was constructed with a clay-filled cutoff trench at the upstream toe and a clay blanket on the upstream slope for a low permeability barrier. The downstream portion of the dam was constructed using compacted fly ash and periodic layers of bottom ash for blanket drains connected to sloping chimney drains that collect seepage to discharge pipes for monitoring. The downstream face of the dam is covered by the landfill facility which WVDEP considers to be a buttress to the dam. The landfill consists of three primary development stages (I, II, and III in the original permit drawings and now referred to as 1, 2, and 3) which are further subdivided into construction subareas (e.g., Stage 1G, 2A, etc.). At this time, development and disposal operations have only been performed in the Stage 1 and 2 areas while the Stage 3 area remains undeveloped. Up until 2009, all of the landfill subareas were constructed with a compacted clay liner system that included an underlying combined groundwater underdrain/leak detection system and overlying leachate collection system. However, since 2009 (in subareas 1G and 2B), a composite geosynthetic liner system (geosynthetic clay liner and geomembrane) has been utilized that also includes an underlying combined groundwater underdrain/leak detection system and overlying leachate collection system. For all portions of the landfill that overlie the downstream face of the impoundment dam, a bottom ash blanket drain layer has also been utilized. Leachate and contact stormwater runoff from the Stage 1 and 2 disposal areas are managed in Sedimentation Pond Nos. 1 and 2, which are lined impoundments located immediately down-valley of the future Stage 3 landfill development area.

Groundwater in the CCBDF area occurs primarily within fractured bedrock, principally in the following sandstone units (in descending order): Morgantown sandstone, Grafton sandstone, Jane Lew sandstone, and the Saltsburg sandstone. Groundwater has also been identified in the Ames limestone and Harlem Coal (in association with the Jane Lew sandstone), and, to a lesser extent, the redbed units at the site. Generally, fine-grained rock units (e.g., redbeds) typically serve as aquitards to limit vertical groundwater migration, while coarser grained rock units (e.g., sandstones) typically have more well-developed and open fracture systems and are the primary conduits for groundwater migration. The fractured bedrock of multiple sandstone units, including the Morgantown sandstone, Grafton sandstone, Jane Lew sandstone, and Saltsburg sandstone, has been collectively identified as the uppermost aquifer for CCR Rule groundwater monitoring for the combined landfill and impoundment units.

Historic and recent groundwater level data indicate groundwater flow at the CCBDF as being primarily controlled by topography (more important for vertical migration across groundwater flow units along valley margins near where the units outcrop) with limited, secondary control by orientation (strike and dip) of the rock units (i.e. migration down-dip within a groundwater flow unit). Groundwater is interpreted to flow north from the topographically higher areas located to the south and southeast of the impoundments. West and northwest of the impoundment dam, topography may be the dominant influence on groundwater flow, as the multiple sandstone units underlying the site are eroded and discontinuous across the valley. Groundwater flow northwest of the dam and under the landfill is in the downstream direction of McElroy’s Run toward the west. Flow in all of the rock units exhibit very little seasonal and temporal fluctuations. A representative set of water level data from the current reporting period (2017) were used for contouring groundwater flow patterns at the site as shown on Figure 2-1. A more detailed discussion of the site’s geologic and hydrogeologic characteristics is provided in Section 2.0 of this report.

1.2 REGULATORY BASIS

As required by § 257.90(e), of the CCR Rule, Owners or Operators of existing CCR landfills and surface impoundments must prepare an Annual Groundwater Monitoring and Corrective Action Report no later than January 31, 2018 and annually thereafter. According to the subject section, "For the preceding calendar year, the annual report must document the status of the groundwater monitoring and corrective action program for the CCR unit, summarize key actions completed, describe any problems encountered, discuss actions to resolve the problems, and project key activities for the upcoming year."

This report has been developed to meet the general requirements above and the specific requirements of § 257.90(e)(1) through (5), which include:

> "(1) A map, aerial image, or diagram showing the CCR unit and all background (or upgradient) and downgradient monitoring wells, to include the well identification numbers, that are part of the groundwater monitoring program for the CCR unit (see Figure 2-1);
>
> (2) Identification of any monitoring wells that were installed or decommissioned during the preceding year, along with a narrative description of why those actions were taken (see Section 2.1.1);
>
> (3) In addition to all the monitoring data obtained under §§ 257.90 through 257.98, a summary including the number of groundwater samples that were collected for analysis for each background and downgradient well, the dates the samples were collected, and whether the sample was required by the Detection Monitoring or Assessment Monitoring programs (see Sections 2.1.3 and 2.1.5 and Table 3-1);
>
> (4) A narrative discussion of any transition between monitoring programs (e.g., the date and circumstances for transitioning from Detection Monitoring to Assessment Monitoring in addition to identifying the constituent(s) detected at a statistically significant increase over background levels) (see Section 2.3); and

> (5) Other information required to be included in the annual report as specified in §§ 257.90 through 257.98.”

In addition, the Owner and Operator must place the report in the facility's operating record as required by § 257.105(h)(1), provide notification of the report’s availability to the appropriate State Director within 30 days of placement in operating record as required by § 257.106(h)(1), and place the report on the facility’s publically accessible website, also within 30 days of placing the report in the operating record.

1.3 OVERVIEW OF REPORT CONTENTS

Section 1.0 of this report provided an overview of the CCR unit characteristics, regulatory basis, and a summary of the requirements for CCR Annual Groundwater Monitoring and Corrective Action Reports. Section 2.0 summarizes the status of key actions pertaining to CCR groundwater monitoring completed during 2017 for the CCBDF and plans for the upcoming year. Section 3.0 presents Detection Monitoring results from groundwater sampling events completed in 2017.

2.0 GENERAL INFORMATION

This section provides an overview of the status of the CCR groundwater monitoring program through 2017 and key activities planned for 2018.

2.1 STATUS OF THE GROUNDWATER MONITORING AND CORRECTIVE ACTION PROGRAM

During calendar years 2016 and 2017, the following key actions were completed with regard to the CCR groundwater monitoring program for the CCBDF.

2.1.1 Establishing a CCR Groundwater Monitoring Well System

Tetra Tech was contracted by FirstEnergy to review existing groundwater monitoring system information and site hydrogeologic data for the CCBDF to evaluate the suitability of the existing system, determine whether additional monitoring wells were needed, and to install and develop any new wells to establish a system that meets the applicable requirements and performance standards for groundwater monitoring under 40 CFR §257.91.

Upon completing this review, nine additional groundwater monitoring wells were installed in July and August of 2016 to fill data gaps and to develop a network in compliance with CCR Rule requirements. The CCR monitoring well network consists of three upgradient (background) wells (GW-7, -21, and -22), six downgradient wells to monitor the northern side of the combined CCR units (GW-19, -20, -23, -24, -25, and -26), and four downgradient wells to monitor the western side of the combined CCR units (GW-9, -27, -28, and -29), as summarized in attached Table 2-1 and shown on attached Figure 2-1. A CCR Groundwater Monitoring System Evaluation Report (Tetra Tech, Inc., October, 2017), which discusses the basis for development of the monitoring well network and includes detailed information on the site geology, hydrogeology, and well completion records, was placed in the facility's Operating Record.

As required by § 257.91(f), the CCR groundwater monitoring well network was certified by a Professional Engineer to be in compliance with the applicable requirements of § 257.91. The subject certification was placed in both the facility's Operating Record and on the publically accessible website (http://ccrdocs.firstenergycorp.com/) on October 17, 2017.

2.1.2 Development of a Groundwater Monitoring Plan

On behalf of FE, Tetra Tech prepared a "Groundwater Monitoring Plan" to comply with applicable requirements of the CCR Rule. The document provides the sampling and analytical methodologies and procedures for collecting and reporting representative groundwater quality data from CCR monitoring wells at the CCBDF. As required by § 257.93(a), the document provides procedures and techniques for the following:

- Sample collection;
- Sample preservation and shipment;
- Analytical procedures;
- Chain-of-custody control; and
- Quality assurance (QA) and quality control (QC).

In addition, the document includes the statistical plan describing the process for evaluating groundwater monitoring data developed from the CCR sampling and analysis program [§ 257.93(f)].

2.1.3 Completion of Background Groundwater Sampling

To fulfill the applicable requirements of § 257.94(b), eight independent rounds of background groundwater samples for analyzing all Appendix III and IV parameters from each of the CCR monitoring wells were collected prior to October 17, 2017. The sampling events were conducted on the following dates:

Sampling Event	Dates
1	10/25 to 11/7/16
2	1/4 to 1/16/17
3	2/28 to 3/13/17
4	4/6 to 4/17/17
5	5/16 to 5/24/17
6	6/20 to 6/27/17
7	7/19 to 7/26/17
8	8/21 to 8/24/17

2.1.4 Selection of Statistical Methods

Based on the attributes of the data set from the eight rounds of background sampling, statistical methods were selected among the available methods referenced in § 257.93(f) which met the performance standards referenced in § 257.93(g). Data from the first eight rounds of groundwater analytical results collected at the upgradient and downgradient CCR network wells at the site were evaluated in terms of percent non-detects and data distributions to select the appropriate statistical method for each parameter to identify any Statistically Significant Increases (SSIs) over background concentrations [§ 257.93(h)].

As required by § 257.91(f)(6), the statistical method selection was certified by a Professional Engineer as currently appropriate for evaluating the groundwater monitoring data for the CCBDF at the Pleasants Power Station and as meeting the applicable requirements of § 257.93(f). The subject certification was placed in both the facility's Operating Record and on the publically accessible website on October 17, 2017.

2.1.5 Initial Detection Monitoring Sampling Event

In accordance with § 257.94, FirstEnergy collected the first round of Detection Monitoring samples from the upgradient and downgradient CCR groundwater monitoring wells from September 26 to October 3, 2017 as summarized in the table below. The samples were analyzed for Appendix III parameters, with the laboratory analyses completed by October 17, 2017. The laboratory results are discussed in Section 3.0 of this report.

Monitoring Well	Location	Date Sampled	Purpose
GW-21	Upgradient/Background - Northern Boundary	9/26/17	Not Sampled – Insufficient Water
GW-22		10/3/17	Detection Monitoring
GW-7	Upgradient/Background - Western Boundary	9/27/17	Detection Monitoring
GW-19	Downgradient – Northern Boundary	10/3/17	Detection Monitoring
GW-20		10/2/17	Detection Monitoring
GW-23		10/2/17	Detection Monitoring
GW-24		10/2/17	Detection Monitoring
GW-25		9/26/17	Not Sampled – Insufficient Water
GW-26		9/26/17	Not Sampled – Insufficient Water
GW-9	Downgradient – Western Boundary	9/28/17	Detection Monitoring
GW-27		9/28/17	Detection Monitoring
GW-28		9/28/17	Detection Monitoring
GW-29		9/27/17	Detection Monitoring

2.2 PROBLEMS ENCOUNTERED/RESOLVED

During the eight background sampling events, having sufficient recoverable volumes of groundwater from one of the new upgradient (GW-21) and three of the new downgradient (GW-23, -24, and -25) wells was found to be increasingly problematic as each subsequent sampling event occurred. These four wells were noted to have low to very low yields during their installation and development which was anticipated given that historical well borings drilled at the site under the WVDEP groundwater monitoring program were abandoned over time due to a lack of water in the same rock units. In order to eliminate improper construction and development as a reason behind the increasingly low groundwater yields, all of the aforementioned wells were redeveloped in May of 2017 by completing multiple cycles (six minimum) of surging and purging with potable water. These redevelopment activities resulted in marginal increases in the groundwater yields from the wells. During the initial Detection Monitoring sampling event, sufficient recoverable groundwater volumes were found to be available in GW-23 and -24 but an insufficient sampling volume was also found for downgradient well GW-26.

It’s believed that the sampling frequency (approximately every four to six weeks) required to obtain the eight background and initial Detection Monitoring samples in time to meet the CCR groundwater compliance milestone date of October 17, 2017 overstressed the low yield wells at the site. It’s also believed that some or all of these wells remain viable for use in the site’s CCR groundwater monitoring system as the required sampling frequency under the CCR Rule (semi-annual) is now in effect. As such, and since the remaining CCR monitoring system still exceeds the minimum required number of upgradient and downgradient wells, the water levels in the low yield wells and well GW-26 will be monitored on a quarterly basis during 2018. This additional water level data will be used to determine the viability of using GW-21, -23, -24, and -25 as part of the site’s CCR groundwater monitoring system and, if necessary, help establish the basis for preparing a demonstration - in accordance with § 257.94(d) - that the low yield wells (and also possibly well GW-26) must be sampled at a frequency between six months and one year in order to have recoverable groundwater volumes available. If such a demonstration needs to be prepared it will be placed in the landfill’s operating record when complete, and included as part of the 2018 CCR Groundwater Monitoring and Corrective Action Report.

Other than the low yield wells noted above, there were no other significant problems (e.g., quality control issues) encountered during 2017 with regard to the CCR groundwater monitoring program.

2.3 TRANSITION BETWEEN MONITORING PROGRAMS (IF ANY)

During 2016 and 2017, the eight rounds of background sampling for all Appendix III and IV parameters were conducted followed by initiation of Detection Monitoring with collection of the first Detection Monitoring samples in September and October of 2017. There was no transition between monitoring programs (e.g., Detection to Assessment Monitoring) during 2017.

2.4 KEY ACTIVITIES PLANNED FOR THE UPCOMING YEAR

The following are the key CCR groundwater compliance activities planned for 2018:

- Complete the statistical evaluation of the initial round of Detection Monitoring data to determine if there are any Appendix III parameter concentrations in downgradient wells exhibiting SSIs above background.
- If there are no SSIs, then continue with Detection Monitoring by conducting two semi-annual rounds of sampling and analysis for Appendix III constituents [per § 257.94(c)].
- If any SSIs are identified, then potentially conduct an Alternate Source Determination (ASD) [per § 257.94(e)(2)] to determine if a source other than the CCR unit may be causing the SSIs.
- If any SSI’s are identified and an ASD indicates that an alternate source is not responsible for all the SSI’s identified, then initiate Assessment Monitoring for Appendix IV constituents [per § 257.94(e)(1)].
- Obtain quarterly water levels in low yield wells GW-21, -23, -24, and -25 to determine if one or more of the wells are viable for use in the CCR groundwater monitoring system and if any of the wells require a sampling frequency of between six months and one year. Should it be determined that a demonstration for a modified sampling frequency is needed, it will be prepared in accordance with § 257.94(d).
- Obtain quarterly water levels in well GW-26 to determine if it may also require a sampling frequency of between six months and one year and, if so, prepare a demonstration of the need for such a modified sampling frequency in accordance with § 257.94(d).

3.0 DETECTION MONITORING INFORMATION

3.1 GROUNDWATER ANALYTICAL RESULTS SUMMARY

As referenced above, the CCR groundwater sampling and analysis program implemented through the end of 2017 consists of the eight background sampling rounds conducted between August 2016 and August 2017 for all Appendix III and IV parameters, and the initial Detection Monitoring round of sampling conducted in September 2017 for all Appendix III parameters. Table 3-1 presents the analytical results for these events. As previously noted, statistical evaluation of the Appendix III Detection Monitoring data in Table 3-1 remains in-progress as of the end of the 2017 reporting period (lab results were received in the fourth quarter of 2017 and a 90 day period is allowed by the CCR Rule for statistical evaluation which falls in the first quarter of 2018). If any Appendix III SSIs are identified, ASD or Assessment Monitoring activities will be undertaken as appropriate, and associated recordkeeping, notification, and reporting will be performed in accordance with the applicable requirements of 40 CFR §§ 257.94, 95, 105, 106, and 107.

TABLES

TABLE 2-1
CCR RULE GROUNDWATER MONITORING SYSTEM WELL SUMMARY
McELROY's RUN CCB DISPOSAL FACILITY – 2017 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

Well	Year Installed	Formation Monitored	Ground Surface Elevation (ft MSL)	Total Well Depth (ft bgs)	Monitored Interval (ft bgs)	Monitored Interval (ft MSL)	Casing ID and Material
Upgradient (Background)							
GW-7	1994	Grafton SS, Ames LS	918.40	101.2	75.7 – 100.7	817.70 – 842.70	4" - Sch. 40 PVC
GW-21	2016	Morgantown SS	1033.01	234.2	214.2 – 234.2	798.77 – 818.77	2" - Sch. 40 PVC
GW-22	2016	Morgantown SS	1045.18	370.2	350.2 – 370.2	675.02 – 695.02	2.5" - Sch. 80 PVC
Downgradient							
GW-9	1994	Ames LS, Jane Lew SS, Pittsburgh RB	797.42	177.7	137.2 – 177.2	620.22 – 660.22	4" - Sch. 40 PVC
GW-19	1995	Birmingham RB, Grafton SS, Ames LS	920.64	238.9	198.9 – 238.9	681.74 – 721.74	2" - Sch. 40 PVC
GW-20	1995	Lower Clarksburg RB	923.00	150.5	100.5 – 150.5	772.50 – 822.50	2" - Sch. 40 PVC
GW-23	2016	Grafton SS	974.40	392.9	372.9 – 392.9	581.53 – 601.53	2.5" - Sch. 80 PVC
GW-24	2016	Grafton SS	941.55	271.1	251.1 – 271.1	670.50 – 690.50	2" - Sch. 40 PVC
GW-25	2016	Grafton SS	1006.22	303.7	283.7 – 303.7	702.53 – 722.53	2" - Sch. 40 PVC
GW-26	2016	Grafton SS	984.16	288.2	268.2 – 288.2	695.95 – 715.95	2" - Sch. 40 PVC
GW-27	2016	Saltsburg SS	675.30	48.3	38.3 – 48.3	626.96 – 636.96	2" - Sch. 40 PVC
GW-28	2016	Saltsburg SS	801.95	175.6	165.6 – 175.6	626.38 – 636.38	2" - Sch. 40 PVC
GW-29	2016	Grafton SS	928.49	166.0	156.0 – 166.0	762.45 – 772.45	2" - Sch. 40 PVC

Notes: SS = sandstone LS = limestone RB = red beds MSL = mean sea level bgs = below ground surface ID = inside diameter
PVC = polyvinyl chloride

TABLE 3-1
CCR RULE GROUNDWATER MONITORING ANALYTICAL RESULTS SUMMARY
McELROY's RUN CCB DISPOSAL FACILITY - 2017 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

			APPENDIX III (all Chemical Constituents sampled as TOTAL RECOVERABLE)[1]							APPENDIX IV (all Chemical Constituents sampled as TOTAL RECOVERABLE)[1]														
SAMPLING EVENT NO.[2]	WELL ID[3]	SAMPLE DATE	BORON METALS MG/L	CALCIUM METALS MG/L	CHLORIDE MISC MG/L	FLUORIDE MISC MG/L	PH MISC S.U.	SULFATE MISC MG/L	TDS MISC MG/L	ANTIMONY METALS MG/L	ARSENIC METALS MG/L	BARIUM METALS MG/L	BERYLLIUM METALS MG/L	CADMIUM METALS MG/L	CHROMIUM METALS MG/L	COBALT METALS MG/L	LEAD METALS MG/L	LITHIUM METALS MG/L	MERCURY METALS MG/L	MOLYBDENUM METALS MG/L	SELENIUM METALS MG/L	THALLIUM METALS MG/L	RADIUM-226 RADIOCHEM PCI/L	RADIUM-228 RADIOCHEM PCI/L
1	MW-07	11/3/2016	0.318	2.8	101	7.66	7.9	0.499	1255	0.00042 J	0.0005 J	0.08871	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.02214 J	0.00004 U	0.00442 J	0.0022 U	0.000175 U	0.551 U	0.636 U
2	MW-07	1/11/2017	0.337	2.63	98.1	7.83	8	0.228	1250	0.000175 U	0.00131 J	0.08731	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.02061 J	0.00004 U	0.00192 J	0.0044 U	0.000175 U	0.265 U	0.55 U
3	MW-07	3/2/2017	0.364	2.64	101	8.64	8.17	0.233	1250	0.000175 U	0.00075 U	0.07669	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.02027 J	0.00004 U	0.00092 J	0.0055 U	0.000175 U	0.128	0.46
4	MW-07	4/6/2017	0.354	3.08	100	8.5	8.2	0.109 J	1260	0.000175 U	0.004 U	0.07763	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.02108 J	0.00004 U	0.00056 J	0.0044 U	0.000175 U	0.103	0.246 U
5	MW-07	5/16/2017	0.33	2.61	103	8.49	8.27	0.174 J	1240	0.00018 J	0.0006 U	0.08027	0.00022 U	0.00017 U	0.005 U	0.00047 U	0.00052 U	0.02173 J	0.00006 J	0.00051 J	0.0044 U	0.00017 U	0.0981 U	0.486 U
6	MW-07	6/22/2017	0.317	2.68	102	8.39	8.29	0.174 J	1195	0.00017 U	0.0015 U	0.07678	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01862 J	0.00004 U	0.00094 J	0.0044 U	0.00017 U	0.0294 U	-0.289 U
7	MW-07	7/19/2017	0.303	2.62	104	8.48	8.13	0.166 J	1260	0.00024 J	0.0006 U	0.07542	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01998 J	0.00004 U	0.00057 J	0.0044 UJ	0.00017 U	0.136	-0.28 U
8	MW-07 (D)	8/21/2017	0.307	2.72	100	8.13	8.2	0.185 J	1240	0.00017 U	0.0006 U	0.08609	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.02002 J	0.00004 U	0.00039 J	0.0044 UJ	0.00017 UJ	1 U	0.0419 U
8	MW-07	8/21/2017	0.311	2.6	101	8.13	8.19	0.173 J	1230	0.00017 U	0.0006 U	0.07132	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01929 J	0.00004 U	0.00043 J	0.0044 U	0.00017 U	1 U	0.344 U
9 (DM-1)	MW-07	9/27/2017	0.28	2.5	85.6	7.28	8.17	0.151 J	1235	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1	MW-09	11/7/2016	0.121 J	18	8.43	0.213	7.7	135	764	0.000175 U	0.00054 J	0.06275	0.00022 U	0.000175 U	0.00111 J	0.000475 U	0.00052 U	0.01559 J	0.00004 U	0.00049 J	0.0011 U	0.000175 U	0.354 U	0.617 U
2	MW-09	1/16/2017	0.113 J	18.1	8.57	0.214	7.59	136	768	0.000175 U	0.001 U	0.061	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.01678 J	0.00007 J	0.0003 J	0.0011 UJ	0.000175 U	0.511 U	0.708 U
3	MW-09	3/13/2017	0.128 J	16.4	8.14	0.194	7.63	125	748	0.0009 U	0.0003 J	0.06358	0.00022 U	0.000175 U	0.00006 U	0.000475 U	0.00052 U	0.01498 J	0.00004 U	0.000285 U	0.0011 U	0.000175 U	0.13 U	0.19 U
4	MW-09	4/17/2017	0.133 J	16.2	7.92	0.191 J-	7.75	135	752	0.000175 U	0.001 U	0.06053	0.00022 U	0.000175 U	0.005 U	0.000475 U	0.00052 U	0.01558 J	0.00004 U	0.000285 U	0.0011 UJ	0.000175 U	0.249	-0.102 U
5	MW-09	5/22/2017	0.134 J	18.3	8.1	0.207 J-	7.72	128	796	0.00017 U	0.0005 J	0.06343	0.00022 U	0.00017 U	0.0003 U	0.00047 U	0.00052 U	0.01412 J	0.00009 J	0.00028 U	0.0011 U	0.00017 U	0.0416 U	-0.264 U
6	MW-09	6/27/2017	0.113 J	16.8	8.21	0.211	7.79	130	748	0.00017 U	0.00031 J	0.05359	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01518 J	0.00004 U	0.00028 U	0.0011 U	0.00017 U	0.153	0.19 U
7	MW-09 (D)	7/26/2017	0.105 J	15.8	8.09	0.213	7.74	128	816	0.00017 U	0.0004 J	0.05524	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01457 J	0.00004 U	0.00028 U	0.0011 U	0.00017 U	0.112 U	0.33 U
7	MW-09	7/26/2017	0.109 J	16.3	8.17	0.213	7.8	131	820	0.00017 U	0.00053 J	0.05722	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01428 J	0.00004 U	0.00028 U	0.0011 U	0.00017 U	1 U	0.608
8	MW-09	8/23/2017	0.0686 J	16.5	7.96	0.211	7.64	127	764	0.00017 U	0.00038 J	0.06068	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01523 J	0.00004 U	0.00034 J	0.0011 UJ	0.00017 UJ	0.288	0.115 U
9 (DM-1)	MW-09	9/28/2017	0.0945 J	15.3	7.54	0.221	7.68	119	744	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1	MW-19	11/2/2016	0.262	10.1	563	1.59	7.52	1.07	2280	0.00042 J	0.17397	0.98084	0.00022 U	0.000175 U	0.001 J	0.00065 J	0.00144 J	0.01434 J	0.00004 U	0.00588	0.0022 U	0.000175 U	1.39	1.35
2	MW-19	1/12/2017	0.262	9.85	552	1.59	7.51	0.248	2300	0.000175 U	0.18781	1.13883	0.00022 U	0.000175 U	0.001 J	0.000475 U	0.00052 U	0.01309 J	0.00004 U	0.00125 J	0.0022 U	0.000175 U	1.56	1.33
3	MW-19	3/13/2017	0.274	9.02	573	1.66	7.65	0.031 U	2233	0.000175 U	0.03236	0.03738	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.01241 J	0.00004 U	0.000285 U	0.0044 U	0.000175 U	1.29	1.03
4	MW-19	4/17/2017	0.267	9.4	569	1.55 J-	7.48	0.036 J	2287	0.000175 U	0.15901	1.21077	0.00022 U	0.000175 U	0.00611 U	0.000475 U	0.00052 U	0.01355 J	0.00004 U	0.000285 U	0.0022 UJ	0.000175 U	1.14	0.694
5	MW-19	5/22/2017	0.287	10.3	595	1.62 J-	7.66	0.031 U	2413	0.00122 U	0.16641	0.98867	0.00088 J	0.00092	0.00183 J	0.00009 U	0.00111 J	0.01337 J	0.00009 J	0.00143 J	0.0044 U	0.00092	1.54	0.846
6	MW-19	6/26/2017	0.272	9.97	579	1.44	7.63	0.309	2140	0.00017 U	0.20142	1.08053	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.0125 J	0.00007 J	0.00028 U	0.0011 U	0.00017 U	0.945	1.01
7	MW-19	7/26/2017	0.245	9.56	604	1.56	7.68	0.056 J	2300	0.0009 U	0.17467	1.08362	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01248 J	0.00004 U	0.00028 U	0.0044 U	0.00017 U	1.2 U	1.29
8	MW-19	8/24/2017	0.201	9.59	567	1.57	7.56	0.046 J	2307	0.00017 U	0.17972	1.24456	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01397 J	0.00004 U	0.00028 U	0.0044 UJ	0.00017 UJ	1.22	2.26
9 (DM-1)	MW-19	10/3/2017	0.226	10.1	571	1.47	7.63	0.14 J	2320	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1	MW-20	11/1/2016	0.241	5.46	419	5.92	7.96	32.4 J-	1656	0.00024 J	0.00236	0.21385 J+	0.00022 U	0.0002 J	0.0003 U	0.000475 U	0.00135 J	0.01448 J	0.00004 U	0.09706	0.01343	0.000175 U	0.501 U	0.604 U
2	MW-20	1/12/2017	0.265	4.88	411	4.65	8.06	31.8	1707	0.00072 J	0.0033	0.19684	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.01307 J	0.00004 U	0.09588	0.01487	0.000175 U	0.331 U	0.515 U
3	MW-20	3/7/2017	0.284	4.91	410	5.52	8.03	33.1	1580	0.00045 J	0.00217	0.19691	0.00006 J	0.000175 UJ	0.0038 J	0.000475 U	0.00052 U	0.01463 J	0.00004 U	0.10306	0.01028	0.000175 U	0.162	0.205 U
4	MW-20	4/10/2017	0.294	5.46	403	5.79	7.89	32.6	1733	0.00021 J	0.00204	0.19017	0.00022 U	0.00019 J	0.00041 J	0.000475 U	0.00064 J	0.01403 J	0.00004 U	0.0903	0.01619	0.000175 U	0.147	0.493 U
5	MW-20	5/23/2017	0.261	5.27	429	4.81	7.83	33.1	1700	0.00017 U	0.00217	0.1772	0.00004 U	0.00026 J	0.00129 J	0.00047 U	0.00055 J	0.0112 J	0.0001 J	0.09763	0.0148	0.00017 U	0.173	0.748 U
6	MW-20	6/22/2017	0.26	5.26	420	5.22	8.03	32	1700	0.00033 J	0.0023	0.20642	0.00022 U	0.00017 J	0.00179 J	0.0006 J	0.00123 J	0.01284 J	0.00004 U	0.09076	0.015	0.00017 U	0.29	0.281 U
7	MW-20	7/20/2017	0.242	5.3	431	5.78	7.88	31.8	1853	0.00042 J	0.00185	0.20735	0.00023 J	0.00026 J	0.00335 J	0.00053 J	0.00065 J	0.01257 J	0.00004 U	0.09094	0.01271	0.00017 U	0.15	0.451
8	MW-20	8/23/2017	0.225	5.15	431	5.36	7.97	31.2	1773	0.0009 U	0.00187	0.21416	0.00022 U	0.00028 J	0.00221 J	0.00057 J	0.00119 J	0.01417 J	0.00004 U	0.08857	0.01485 J-	0.00017 UJ	0.223	0.593
9 (DM-1)	MW-20	10/2/2017	0.229	5.38	490	4.8	8.11	28.6	1785	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1	MW-21	11/3/2016	0.2 J	32.9	232	2.84	7.6	919	2056	0.00124	0.05619	0.11122	0.00022 U	0.00021 J	0.00317 J	0.00095 J	0.00057 J	0.00525 J	0.00004 J	0.36496	0.08361	0.000175 U	0.918	1.38 U
2	MW-21	1/12/2017	0.209	23.8	112	1.76	7.99	1000	2167	0.00039 J	0.05553	1.53945	0.0022 U	0.00025 J	0.01458 J	0.01541 J	0.01386	0.05 U	0.00007 J	0.18621	0.04304	0.0002 J	1.46	1.61 U
3	MW-21	3/6/2017	0.212	21.9	316	2.55	7.92	776	2100	0.0009 U	0.03574	0.14417	0.00022 U	0.000175 U	0.00064 J	0.00144 J	0.00272	0.00541 J	0.00004 U	0.15886	0.0178	0.000175 U	1.23	1.03
4	MW-21	4/12/2017	0.219	20	351	2.27	8.1	780	2140	0.0003 J	0.03709	1.22841	0.00044 U	0.00028 J	0.00726 J	0.0074 J	0.00747	0.02 U	0.00004 U	0.20387	0.01731	0.000175 U	2.17	1.52 U
1	MW-22	11/7/2016	0.19 J	4.49	199	2.2	8.2	50.9	876	0.00022 J	0.09745	0.03812 J	0.00022 U	0.000175 U	0.00303 J	0.000475 U	0.00056 J	0.005 U	0.00004 U	0.09985	0.0011 U	0.000175 U	0.288 U	0.617 U
2	MW-22	1/16/2017	0.197 J	3.5	197	2.24	8.3	46.7	892	0.0009 U	0.10626	0.02433	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.005 U	0.00004 U	0.09002	0.0011 UJ	0.000175 U	0.374 U	0.617 U
3	MW-22	3/6/2017	0.126 J	11.5	29.1	0.688	7.71	36.8	432	0.00241	0.21283	0.0547	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.007 J	0.00004 U	0.03931	0.0011 U	0.000175 U	0.0468 U	0.303 U
4	MW-22 (D)	4/13/2017	0.139 J	11.4	25.8	0.651	7.76	37.3	468	0.00259 U	0.22822 J+	0.06053	0.00022 U	0.0009 U	0.005 U	0.000475 U	0.00052 UJ	0.00676 J	0.00004 U	0.04238	0.0011 U	0.000175 UJ	0.163 U	0.0301 U
4	MW-22	4/13/2017	0.145 J	11.3	26.6	0.652	7.83	37.2	468	0.00224 U	0.22961 J+	0.05299	0.00022 U	0.0018 U	0.005 U	0.000475 U	0.00052 UJ	0.00753 J	0.00004 U	0.03597	0.0011 U	0.000175 UJ	0.0478 U	-0.0943 U
5	MW-22	5/23/2017	0.133 J	14	30.6	0.655	7.85	38	464	0.00191 U	0.20788	0.08089	0.00022 U	0.00017 J	0.0003 U	0.00047 U	0.00052 U	0.0067 J	0.00009 J	0.05066	0.0011 U	0.00017 U	0.128 U	0.0561 U
6	MW-22	6/26/2017	0.163 J	8.6	158	1.6	8.29	31.1	772	0.00177 U	0.17934	0.05998	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.00535 J	0.00004 U	0.05692	0.0011 U	0.00017 U	0.132	0.0762 U
7	MW-22	7/25/2017	0.175 J	5.62	208	1.94 J	8.4	27.1	904	0.0004 J	0.12182	0.03805	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.005 U	0.00004 U	0.06065	0.0011 UJ	0.00017 U	0.0342 U	0.277 U
8	MW-22	8/24/2017	0.141 J	6.1	153	1.55	8.52	78	1084	0.00027 J	0.08907	0.0527	0.00027 J	0.00017 U	0.00045 U	0.00047 J	0.00083 J	0.00865 J	0.00004 U	0.08717	0.0011 UJ	0.00017 UJ	0.542	4.15
9 (DM-1)	MW-22	10/3/2017	0.173 J	4.91	303	1.93	8.58	63.5 J-	1080	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1	MW-23	11/7/2016	0.196 J	209	4190	0.71	6.88	0.031 U	18400	0.0003 J	0.0479	4.23365	0.00285 J	0.00027 J	0.05267	0.05011 J	0.06279	0.07398 J	0.00004 U	0.01899	0.01161	0.00031 J	7.18	5.59
2	MW-23	1/11/2017	0.214	298	5700	0.025 U	6.9	3.17	18900	0.00055 J	0.04366	4.01205	0.00022 U	0.000175 U	0.01383	0.00182 J	0.0006 J	0.01191 J	0.00004 U	0.04611	0.00238 J	0.000175 U	5.44	9.52
3	MW-23	3/8/2017	0.668 J	470	9640	0.025 U	6.83	0.33	24400	0.00049 J	0.04935	6.49077	0.00049 J	0.000035 UJ	0.00234 J	0.00162 J	0.00759	0.02597	0.00004 U	0.07489	0.00359 J	0.000175 U	11.8	23
4	MW-23	4/13/2017	0.49 J	576	8550	0.025 U	6.79	0.031 U	16940	0.0018 U	0.04495 J+	8.18547	0.00044 U	0.00035 U	0.005 U	0.00205 J	0.0006 J	0.04514	0.00004 U	0.04588	0.00232 J	0.0009 U	14.4	37
5	MW-23	5/18/2017	0.147 J	163	3280	0.067 J	7.24	26.2	10800	0.0013	0.02725	1.80338	0.00022 U	0.00017 U	0.005 U	0.00096 J	0.00052 U	0.02026 J	0.00006 J	0.07691	0.00139 J	0.00017 U	3.39	9.36
6	MW-23	6/22/2017	0.176 J	399	6850	0.025 U	6.97	2.83	38400	0.00057 J	0.03159	4.0236	0.00022 U	0.00017 U	0.005 U	0.0013 J	0.00052 U	0.05348	0.00004 U	0.01294	0.0022 U	0.00017 U	7.99	20.5
7	MW-23	7/20/2017	0.197 J	541	7900	0.025 U	6.68	1.8	28200	0.00064 J	0.02792	4.67341	0.00022 U	0.00017 U	0.00165 J	0.00181 J	0.00053 J	0.05581	0.00004 U	0.00702	0.0011 UJ	0.00017 U	10.7	22.1
8	MW-23	8/22/2017	0.183 J	487	7870	0.025 U	6.76	0.778	29800	0.00078 J	0.03474	4.22522	0.00022 U	0.00017 U	0.00153 J	0.00343 J	0.00052 U	0.0321	0.00004 U	0.01048	0.0011 UJ	0.00017 UJ	14.2 J	34.5 J
9 (DM-1)	MW-23	10/2/2017	0.178 J	620	11600	0.025 U	6.84	0.079 J	46100	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1	MW-24	11/3/2016	0.239	127	3730	0.167	7.05	26.3	6876	0.00096	0.02203	1.84204	0.00022 U	0.00024 J	0.01213	0.00247 J	0.00174 J	0.01035 J	0.00004 U	0.12692	0.00266 J	0.000175 U	3.55	4.02
2	MW-24	1/12/2017	0.276	221	5350	4.47	6.99	2.96	18900	0.00033 J	0.02513	4.24308	0.00088 U	0.000175 U	0.01132 J	0.00953 J	0.01226	0.02816 J	0.00004 U	0.05288	0.00483 J	0.000175 U	7.4	14.3
5	MW-24	5/24/2017	0.255	119	1930	0.365	7.13	86.9	4320	0.00141 U	0.00833	1.11262	0.00022 UJ	0.00017 U	0.00255 J	0.00195 J	0.00139 J	0.01144 J	0.00004 U	0.13815	0.00209 J	0.00017 U	1.67	5.53
6	MW-24	6/27/2017	0.254	131	3150	0.066 J	7.12	95.4	17200	0.00098 U	0.02036	1.47904	0.00022 U	0.00017 U	0.00256 J	0.00143 J	0.00124 J	0.01518 J	0.00004 U	0.1046	0.0011 U	0.00017 U	2.36	4.31
7	MW-24	7/20/2017	0.27	161	3820	0.03 J	6.84	78.7	13000	0.00143	0.01874	1.81523	0.00022 U	0.00017 U	0.00171 J	0.00139 J	0.00052 U	0.0183 J	0.00004 U	0.07314	0.0011 UJ	0.00017 U	2.94	7.83
8	MW-24	8/22/2017	0.28	182	4670	0.025 U	6.79	28	16300	0.0009 U	0.01524	2.46586	0.00022 U	0.00017 U	0.00103 J	0.00097 J	0.00052 U	0.02754	0.00004 U	0.02503	0.0011 UJ	0.00017 UJ	3.28	7.52
9 (DM-1)	MW-24	10/2/2017	0.292	270	5520	0.025 U	6.95	7.24 J-	19400	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2	MW-25	1/12/2017	0.185 J	139	3500	0.051 J	7.19	0.429	6780	0.000175 U	0.03542	3.68888	0.00024 J	0.000175 U	0.00414 J	0.00291 J	0.00424	0.00899 J	0.00004 U	0.04373	0.00392 J	0.000175 U	4.57	4.52
3	MW-25	3/9/2017	0.464 J	193	4380	0.025 U	7.06	0.447	7500	0.0009 U	0.04394	4.84205	0.00022 U	0.000175 U	0.005 U	0.00155 J	0.00129 J	0.00823 J	0.00004 U	0.03903	0.0014 J	0.000175 U	4.11	4.2
4	MW-25	4/12/2017	0.2 J	229	4800	0.025 U	7.21	0.305	18500	0.0002 J	0.04645	6.01031	0.00022 U	0.000175 U	0.00692	0.00384 J	0.00389	0.01394 J	0.00004 U	0.02901	0.0011 U	0.000175 U	4.35	4.59
5	MW-25	5/18/2017	0.271 J	154	2040	0.412 J-	7.9	25.7	5800	0.00087 U	0.02014	1.98736	0.0011 U	0.00087 U	0.025 U	0.00441 J	0.00506 J	0.025 U	0.00005 J	0.01963 J	0.0055 U	0.00087 U	2.89	3.84
6	MW-25	6/21/2017	0.167 J	200	2940	0.122	7.43	0.483	17400	0.0009 U	0.03563	3.42806	0.0022 U	0.00017 U	0.0045 U	0.01462 J	0.01485	0.05 U	0.00004 U	0.01403	0.00272 J	0.00017 U	3.5	3.13

TABLE 3-1
CCR RULE GROUNDWATER MONITORING ANALYTICAL RESULTS SUMMARY
McELROY's RUN CCB DISPOSAL FACILITY - 2017 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

SAMPLING EVENT NO.[2]	WELL ID[3]	SAMPLE DATE	APPENDIX III (all Chemical Constituents sampled as TOTAL RECOVERABLE)[1]							APPENDIX IV (all Chemical Constituents sampled as TOTAL RECOVERABLE)[1]														
			BORON	CALCIUM	CHLORIDE	FLUORIDE	PH	SULFATE	TDS	ANTIMONY	ARSENIC	BARIUM	BERYLLIUM	CADMIUM	CHROMIUM	COBALT	LEAD	LITHIUM	MERCURY	MOLYBDENUM	SELENIUM	THALLIUM	RADIUM-226	RADIUM-228
			METALS	METALS	MISC	MISC	MISC	MISC	MISC	METALS	METALS	METALS	METALS	METALS	METALS	METALS	METALS	METALS	METALS	METALS	METALS	METALS	RADIOCHEM	RADIOCHEM
			MG/L	MG/L	MG/L	MG/L	S.U.	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	PCI/L	PCI/L
1	MW-26	11/1/2016	0.138 J	7.56	61.7	1.17	8.33	95.7 J-	968	0.00048 J	0.01198	0.13885 J+	0.00023 J	0.000175 U	0.00187 J	0.00071 J	0.00163 J	0.005 U	0.00004 U	0.06427	0.0011 U	0.000175 U	0.838	1.25
2	MW-26	1/11/2017	0.176 J	5.33	103	1.26	8.21	78.3	935	0.000175 U	0.0136	0.08979	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00068 J	0.005 U	0.00004 U	0.06759	0.0011 U	0.000175 U	0.63 U	1.82 U
3	MW-26 (D)	3/9/2017	0.162 J	4.88	103	1.41	8.23	80.2	868	0.00038 J	0.01318	0.08281	0.00022 UJ	0.000175 UJ	0.00322 J	0.00057 J	0.0006 J	0.005 U	0.00004 U	0.06452	0.0021 J	0.000175 U	0.227	0.598
3	MW-26	3/9/2017	0.194 J	4.81	108	1.5	7.85	77.1	880	0.00049 J	0.01372	0.08166	0.00022 UJ	0.000175 UJ	0.00111 J	0.00051 J	0.00088 J	0.005 U	0.00004 U	0.06391	0.00214 J	0.000175 U	0.161 U	0.183 U
4	MW-26	4/17/2017	0.168 J	3.61	135	1.48 J-	8.21	74.6	924	0.000175 U	0.01416	0.06079	0.00022 U	0.000175 U	0.005 U	0.000475 U	0.00052 U	0.005 U	0.00004 U	0.0594	0.0011 UJ	0.000175 U	0.0481 U	0.169 U
5	MW-26	5/17/2017	0.153 J	6.55	91.1	1.41	8.08	88.2	804	0.00031 J	0.01117	0.07164	0.00022 U	0.00017 U	0.005 U	0.00047 U	0.00052 U	0.005 U	0.00006 J	0.05368	0.0011 U	0.00017 U	0.0833 U	0.0608 U
6	MW-26	6/21/2017	0.172 J	6.21	132	1.48 J-	8.34	76.7	968	0.0009 U	0.01156	0.08412	0.00022 U	0.00017 U	0.0003 U	0.00047 U	0.00052 U	0.005 U	0.00004 U	0.04957	0.0011 U	0.00017 U	0.104	0.236 U
7	MW-26	7/25/2017	0.18 J	11.2	180	1.52 J	8.39	59.6	1384	0.00017 U	0.01481	0.18151	0.00028 J	0.00017 U	0.00368 J	0.00095 U	0.00259 J	0.005 U	0.00004 U	0.05345	0.0011 UJ	0.00017 U	0.537	1 U
1	MW-27 (D)	10/26/2016	0.0997 J	45.7	134	0.255 J-	7.43	10	560	0.000175 U	0.00069 J	0.79513 J+	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.01517 J	0.00004 U	0.01077	0.0011 U	0.000175 U	0.53 U	0.716
1	MW-27	10/26/2016	0.1 J	45.5	133	0.26 J-	7.47	10.6	560	0.000175 U	0.00068 J	0.77494 J+	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.01429 J	0.00004 U	0.01072	0.0011 U	0.000175 U	0.456 U	0.71 U
2	MW-27	1/10/2017	0.13 J	39	114	0.319	7.13	19.5	500	0.000175 U	0.00016 J	0.6402	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.01072 J	0.00007 J	0.0094	0.0011 U	0.000175 U	0.566	0.618
3	MW-27	2/28/2017	0.125 J	51.9	104	0.292	7.38	18.9	512	0.0009 U	0.00066 J	0.70772	0.00022 U	0.0009 U	0.0003 U	0.000475 U	0.00052 U	0.0121 J	0.00004 U	0.00713	0.0011 U	0.000175 U	0.377	0.0977 U
4	MW-27	4/6/2017	0.129 J	48.5	107	0.303	7.53	16.4 J-	500	0.000175 U	0.001 U	0.71642	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.01337 J	0.00004 U	0.00617	0.0011 U	0.000175 U	0.367	0.462
5	MW-27	5/17/2017	0.113 J	43.9	107	0.267	7.52	14.7	476	0.00017 U	0.00053 J	0.71261	0.00022 U	0.00017 U	0.005 U	0.00047 U	0.00052 U	0.01344 J	0.00006 J	0.00534	0.0011 U	0.00017 U	0.274	0.29 U
6	MW-27 (D)	6/22/2017	0.108 J	46.5	108	0.264	7.52	13.2	505	0.00017 U	0.00047 J	0.72611	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01232 J	0.00004 U	0.00491 J	0.0011 U	0.00017 U	0.268	0.112 UJ
6	MW-27	6/22/2017	0.107 J	46.3	105	0.265	7.53	13.3	504	0.00017 U	0.00055 J	0.72679	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01196 J	0.00004 U	0.00486 J	0.0011 U	0.00017 U	0.365	0.836 J
7	MW-27	7/20/2017	0.0963 J	49.6	112	0.274	7.43	11.8	588	0.00017 U	0.00038 J	0.8187	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01175 J	0.00004 U	0.00384 J	0.0011 UJ	0.00017 U	0.405	0.489
8	MW-27	8/21/2017	0.0977 J	46.1	111	0.256	7.48	10.7	512	0.00017 U	0.00058 J	0.82439	0.00044 U	0.00017 U	0.00045 U	0.00095 U	0.00052 U	0.01186 J	0.00004 U	0.00478 J	0.0011 UJ	0.00017 UJ	1 U	0.697
9 (DM-1)	MW-27 (D)	9/28/2017	0.0871 J	46.3	106	0.265	7.46	8.61	516	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9 (DM-1)	MW-27	9/28/2017	0.0932 J	45.5	108	0.266	7.24	8.68	528	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1	MW-28	10/25/2016	0.237	7.92	791	1.79 J-	7.43	4.97	2116	0.00037 J	0.00518	0.2324	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.01508 J	0.00004 U	0.03307	0.0011 U	0.000175 U	0.732	0.615
2	MW-28 (D)	1/10/2017	0.25	7.64	748	1.84	7.74	4.6	2076	0.00039 J	0.00572	0.2363	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.01176 J	0.00004 U	0.0343	0.0011 U	0.000175 U	0.423 U	0.896
2	MW-28	1/10/2017	0.244	7.61	776	1.79	7.8	4.87	2120	0.00027 J	0.00596	0.22263	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.0111 J	0.00007 J	0.03477	0.0011 U	0.000175 U	0.449	1.25
3	MW-28	3/2/2017	0.267	7.21	697	1.87	7.97	3.03	1967	0.009 U	0.00572	0.23093	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.01277 J	0.00004 U	0.02938	0.0011 U	0.000175 U	0.282	0.0553 U
4	MW-28	4/11/2017	0.271	7.09	697	1.7	7.92	1.42	2100	0.000175 U	0.00512	0.2377	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.01532 J	0.00004 U	0.03303	0.0011 U	0.000175 U	0.25	0.723
5	MW-28 (D)	5/16/2017	0.245	6.2	677	1.77	8.09	0.797	2020	0.00017 U	0.00403	0.23879	0.00022 U	0.00017 U	0.005 U	0.00047 U	0.00052 U	0.01743 J	0.00006 J	0.03146	0.0011 U	0.00017 U	0.299	0.101 U
5	MW-28	5/16/2017	0.248	5.97	690	2.02	8.06	0.972	2060	0.00017 U	0.00406	0.24462	0.00022 U	0.00017 U	0.005 U	0.00047 U	0.00052 U	0.01793 J	0.00006 J	0.03237	0.0011 U	0.00017 U	0.257	0.18 U
6	MW-28	6/20/2017	0.254	6.51	724	1.6	8.1	0.441	2187	0.00017 U	0.0032	0.21356	0.00022 U	0.00017 U	0.00045 UJ	0.00047 U	0.00052 U	0.01624 J	0.00004 U	0.0295	0.0011 U	0.00017 U	0.351	0.313 U
7	MW-28	7/24/2017	0.253	6.31	677	2.04 J	8.06	0.563	2200	0.00017 U	0.0031	0.23466	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01751 J	0.00004 U	0.03071	0.0011 UJ	0.00017 U	0.226	0.654 U
8	MW-28	8/21/2017	0.242	6.15	680	1.94	7.88	0.443	2067	0.00017 U	0.00377	0.2038	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01669 J	0.00004 U	0.03071	0.0011 U	0.00017 U	1 U	0.0242 U
9 (DM-1)	MW-28	9/28/2017	0.215	5.91	631	1.95	7.66	0.263	2093	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1	MW-29	10/26/2016	0.339	12.2	715	1.09 J-	7.84	36.7	2364	0.00094	0.03028	0.5939 J+	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.02155 J	0.00004 U	0.03046	0.0011 U	0.000175 U	0.572	0.501 U
2	MW-29	1/4/2017	0.367	14.6	875	1.08	7.74	15.7 J+	2730	0.00027 J	0.02101	0.76854	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.02513	0.00012 J	0.01572	0.0011 U	0.000175 U	0.431 U	0.666 U
3	MW-29	2/28/2017	0.342	12.5	797	1.13	7.51	26	2587	0.0009 U	0.02743	0.75695	0.00022 U	0.000175 U	0.005 U	0.000475 U	0.00052 U	0.02235 J	0.00004 U	0.02284	0.0011 U	0.000175 U	0.336	0.281 U
4	MW-29	4/11/2017	0.372	13.2	967	1.08	7.76	3.36	2867	0.000175 U	0.01583	0.8608	0.00022 U	0.000175 U	0.0003 U	0.000475 U	0.00052 U	0.03438	0.00004 U	0.00645	0.0011 U	0.000175 U	0.588	0.821
5	MW-29	5/16/2017	0.336	11.6	952	1.14	7.82	3.85	2910	0.00017 U	0.01861	0.95472	0.00022 U	0.00017 U	0.005 U	0.00047 U	0.00052 U	0.03051	0.00006 J	0.00675	0.0011 U	0.00017 U	0.455	0.548 U
6	MW-29	6/20/2017	0.348	12.3	967	0.749	7.85	0.998	3120	0.00017 U	0.01186	0.83503	0.00022 U	0.00017 U	0.00045 UJ	0.00047 U	0.00052 U	0.03204	0.00004 U	0.00388 J	0.0011 U	0.00017 U	0.503	0.286 U
7	MW-29	7/24/2017	0.323	12.3	936	1.15 J	7.78	1.11	3160	0.00017 U	0.01357	0.95024	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.03061	0.00004 U	0.00352 J	0.0011 UJ	0.00017 U	0.429	0.885
8	MW-29	8/21/2017	0.355	11.9	959	1.11	7.76	0.926	2930	0.0009 U	0.01646	0.86084	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.03182	0.00004 U	0.00432 J	0.0011 U	0.00026 J	1 U	0.421 U
9 (DM-1)	MW-29	9/27/2017	0.301	11.5	910	1.14	7.66	0.654	2980	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

NOTES:

[1] Lab analyses were completed by Beta Lab and TestAmerica Laboratories, Inc., both of which are accredited/certified laboratories: Beta Lab ISO/IEC 17025 Cert No. 2490.01 (Exp. 11-30-18) and ISO/IEC 9001 Cert. No. 83761-IS7 (Exp. 01-16-21) and TestAmerica NELAP Identification Number: 02-00416, EPA Region: 3, Expiration Date: 04-30-18.

[2] Event Nos. 1 through 8 were background/baseline sampling events. Event No. 9 was the initial Detection Monitoring (DM-1) sampling event.

[3] Field duplicate samples that were taken for Quality Control purposes are noted with a (D).

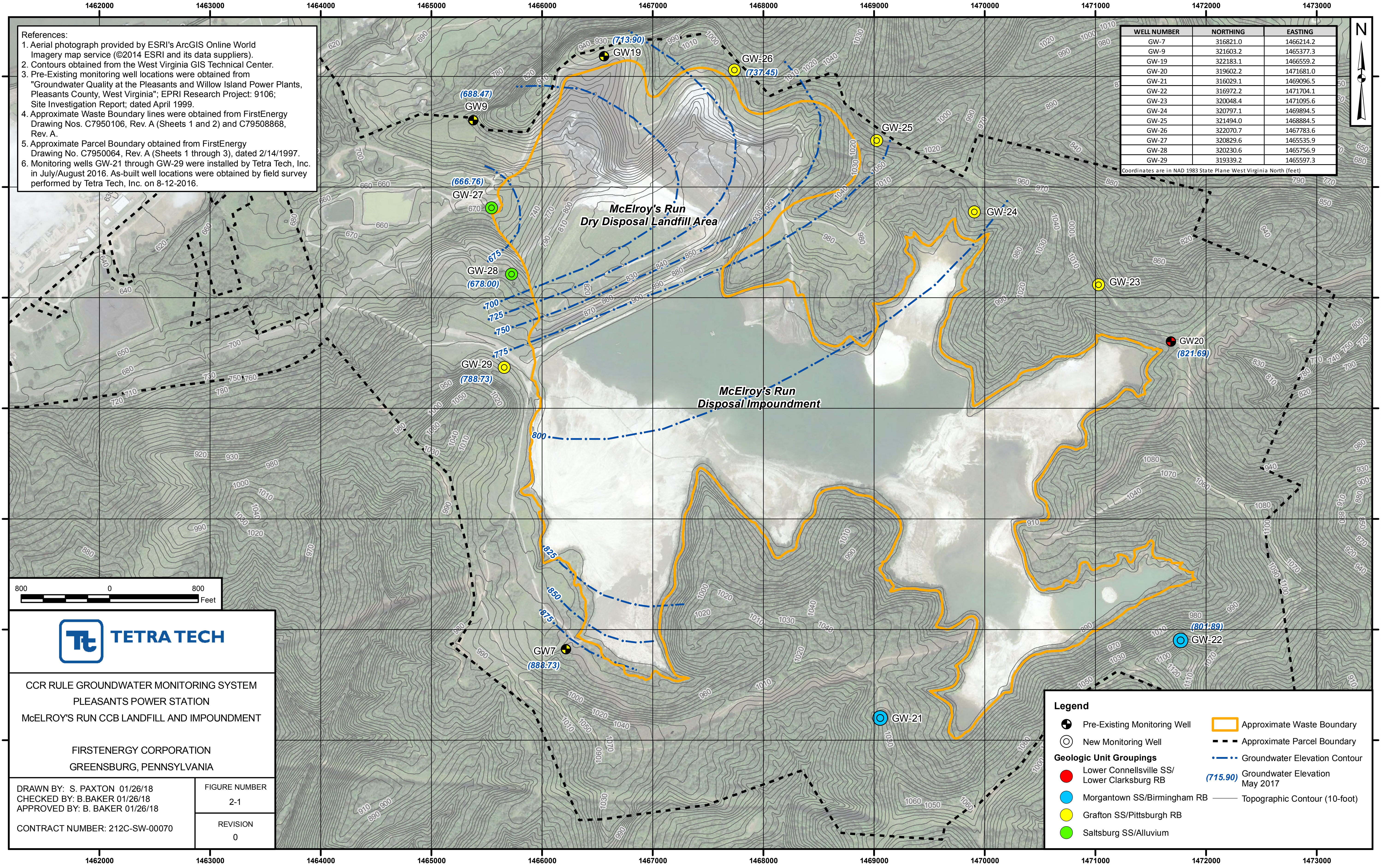
DATA QUALIFER DEFINITIONS:

The following definitions provide brief explanations of the validation qualifiers assigned to results in the data review process.

U	The analyte was analyzed for, but was not detected at a level greater than or equal to the level of the adjusted method detection limit for sample and method.
J	The analyte was positively identified and the associated numerical value is the approximate concentration of the analyte in the sample (due either to the quality of the data generated because certain quality control criteria were not met, or the concentration of the analyte was below the reporting limit).
J+	The result is an estimated quantity, but the result may be biased high.
J-	The result is an estimated quantity, but the result may be biased low.
UJ	The analyte was analyzed for, but was not detected. The reported detection limit is approximate and may be inaccurate or imprecise.
R	The sample result (detected) is unusable due to the quality of the data generated because certain criteria were not met. The analyte may or may not be present in sample
UR	The sample result (nondetected) is unusable due to the quality of the data generated because certain criteria were not met. The analyte may or may not be present in sample.

FIGURES

PGH P:\GIS\FIRST_ENERGY\MAPDOCS\PLEASANTSCO_EUREKA_PROPOSED_CCR_MAY2017_CCR.MXD 01/26/18 SP



References:
1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (©2014 ESRI and its data suppliers).
2. Contours obtained from the West Virginia GIS Technical Center.
3. Pre-Existing monitoring well locations were obtained from "Groundwater Quality at the Pleasants and Willow Island Power Plants, Pleasants County, West Virginia"; EPRI Research Project: 9106; Site Investigation Report; dated April 1999.
4. Approximate Waste Boundary lines were obtained from FirstEnergy Drawing Nos. C7950106, Rev. A (Sheets 1 and 2) and C79508868, Rev. A.
5. Approximate Parcel Boundary obtained from FirstEnergy Drawing No. C7950064, Rev. A (Sheets 1 through 3), dated 2/14/1997.
6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

WELL NUMBER	NORTHING	EASTING
GW-7	316821.0	1466214.2
GW-9	321603.2	1465377.3
GW-19	322183.1	1466559.2
GW-20	319602.2	1471681.0
GW-21	316029.1	1469096.5
GW-22	316972.2	1471704.1
GW-23	320048.4	1471095.6
GW-24	320797.1	1469894.5
GW-25	321494.0	1468884.5
GW-26	322070.7	1467783.6
GW-27	320829.6	1465535.9
GW-28	320230.6	1465756.9
GW-29	319339.2	1465597.3

Coordinates are in NAD 1983 State Plane West Virginia North (feet)

TETRA TECH

CCR RULE GROUNDWATER MONITORING SYSTEM
PLEASANTS POWER STATION
McELROY'S RUN CCB LANDFILL AND IMPOUNDMENT

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: S. PAXTON 01/26/18
CHECKED BY: B.BAKER 01/26/18
APPROVED BY: B. BAKER 01/26/18

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
2-1

REVISION
0

2018 ANNUAL CCR GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

McELROY's RUN COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY

Pleasants Power Station
Pleasants County, West Virginia

Prepared for:

FirstEnergy

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Greensburg, PA 15601

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Tetra Tech Project No. 212C-SW-00070

January 2019

2018 ANNUAL CCR GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

McELROY's RUN COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY

PLEASANTS POWER STATION
PLEASANTS COUNTY, WEST VIRGINIA

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Tetra Tech Project No. 212C-SW-00070

January 2019

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ATTACHMENT

1.0 INTRODUCTION

This 2018 Annual Coal Combustion Residuals (CCR) Groundwater Monitoring and Corrective Action Report was prepared by Tetra Tech, Inc. (Tetra Tech) on behalf of FirstEnergy (FE), for the McElroy's Run Coal Combustion Byproduct Disposal Facility (CCBDF or "CCR units") at the Pleasants Power Station (hereinafter referred to as the "Station"). The Station is located in Pleasants County, West Virginia. The report was developed to comply with requirements of 40 CFR § 257.90(e).

1.1 BACKGROUND AND SITE CHARACTERISTICS

CCRs produced at the Station are placed in the facility's captive CCBDF, which is located approximately one mile east-southeast of the Station. The facility consists of both a wet disposal area (impoundment) and dry disposal area (landfill) developed in the McElroy's Run watershed. Taken together, the landfill and impoundment are regulated under West Virginia Department of Environmental Protection (WVDEP) Solid Waste/National Pollutant Discharge Elimination System (NPDES) Water Pollution Control Permit No. WV0079171. A WVDEP groundwater monitoring program for the facility has been in effect since 1994 and a separate CCR Rule groundwater monitoring program has been in effect since 2017. As per the CCR Rule, the landfill and impoundment are considered two separate, existing CCR units that share a common boundary (i.e., the impoundment dam). As provided by the CCR Rule, a multiunit groundwater monitoring system has been established for the CCBDF.

The impoundment is situated in the upper portion of the watershed, is unlined, and has been in continuous use since the late 1970s. The landfill is situated in the lower portion of the watershed (adjacent to, and overlying, the impoundment dam), is lined, and has been in continuous use since the early 1990s. At the current water level, the surface impoundment area is about 250 acres. The impoundment dam was constructed with a clay-filled cutoff trench at the upstream toe and with a clay blanket on the upstream slope for a low permeability seepage barrier. The downstream portion of the dam was constructed using compacted fly ash and periodic layers of bottom ash for blanket drains connected to sloping chimney drains that collect and convey seepage to discharge pipes for monitoring. The downstream face of the dam is covered by the landfill facility which WVDEP considers to be a buttress for the dam.

The landfill consists of three primary development stages (I, II, and III in the original WVDEP permit drawings and now referred to as 1, 2, and 3) which are further subdivided into construction subareas (e.g., Stage 1G, 2A, etc.). At this time, development and disposal operations have only been performed in the Stage 1 and 2 areas while the Stage 3 area remains undeveloped. Up until 2009, all of the landfill subareas were constructed with a compacted clay liner system that included an underlying combined groundwater underdrain/leak detection system and overlying leachate collection system. However, since 2009 (in subareas 1G and 2B), a composite geosynthetic liner system (geosynthetic clay liner and geomembrane) has been utilized that also includes an underlying combined groundwater underdrain/leak detection system and overlying leachate collection system. For all portions of the landfill that overlie the downstream face of the impoundment dam, a bottom ash blanket drain layer has also been installed. Leachate and contact stormwater runoff from the Stage 1 and 2 disposal areas are managed in Sedimentation Pond Nos. 1 and 2, which are lined impoundments located immediately down-valley of the future Stage 3 landfill development area.

Groundwater in the CCBDF area occurs primarily within fractured bedrock, principally in the following sandstone units (in descending order): the Morgantown sandstone, Grafton sandstone, Jane Lew sandstone, and the Saltsburg sandstone. Groundwater has also been identified in the Ames limestone and Harlem Coal (in association with the Jane Lew sandstone), and, to a lesser extent, the redbed units at the site. Generally, the fine-grained rock units (e.g., redbeds) typically serve as aquitards to limit vertical groundwater migration, while the coarser grained rock units (e.g., sandstones) typically have more well-developed and open fracture systems and are the primary conduits for groundwater migration. The fractured bedrock of multiple sandstone units, including the Morgantown sandstone, Grafton sandstone, Jane Lew sandstone, and Saltsburg sandstone, has been collectively identified as the uppermost aquifer for CCR Rule groundwater monitoring for the combined landfill and impoundment units.

Historic and recent groundwater level data indicate groundwater flow at the CCBDF as being primarily controlled by topography (more important for vertical migration across groundwater flow units along the valley margins near where the units outcrop) with limited, secondary control by orientation (strike and dip) of the rock units (i.e. migration down-dip within a groundwater flow unit). Groundwater is interpreted to flow north from the topographically higher areas located to the south and southeast of the impoundments. West and northwest of the impoundment dam, topography may be the dominant influence on groundwater flow, as the multiple sandstone units underlying the site are eroded and discontinuous across the valley. Groundwater flow northwest of the dam and under the landfill is in the downstream direction of McElroy's Run toward the west. Flow in all of the rock units exhibit very little seasonal and temporal fluctuations. A representative set of water level data from the current reporting period (2018) were used for contouring groundwater flow patterns at the site as shown on Figure 2-1. A more detailed discussion of the site's geologic and hydrogeologic characteristics is provided in Section 2.0 of this report.

1.2 REGULATORY BASIS

As required by § 257.90(e), of the CCR Rule, Owners or Operators of existing CCR landfills and surface impoundments must prepare an Annual Groundwater Monitoring and Corrective Action Report no later than January 31, 2018 and annually thereafter. According to the subject section, "For the preceding calendar year, the annual report must document the status of the groundwater monitoring and corrective action program for the CCR unit, summarize key actions completed, describe any problems encountered, discuss actions to resolve the problems, and project key activities for the upcoming year."

This report has been developed to meet the general requirements above and the specific requirements of § 257.90(e)(1) through (5), which include:

> "(1) A map, aerial image, or diagram showing the CCR unit and all background (or upgradient) and downgradient monitoring wells, to include the well identification numbers, that are part of the groundwater monitoring program for the CCR unit (see Figure 2-1);
>
> (2) Identification of any monitoring wells that were installed or decommissioned during the preceding year, along with a narrative description of why those actions were taken (see Section 2.1.1);
>
> (3) In addition to all the monitoring data obtained under §§ 257.90 through 257.98, a summary including the number of groundwater samples that were collected for analysis for each background and downgradient well, the dates the samples were collected, and whether the sample was required by the detection monitoring or assessment monitoring programs (see Sections 3.0 and 4.0 and Tables 3-2a and 3-2b);
>
> (4) A narrative discussion of any transition between monitoring programs (e.g., the date and circumstances for transitioning from detection monitoring to assessment monitoring in addition to identifying the constituent(s) detected at a statistically significant increase over background levels) (see Section 2.3); and
>
> (5) Other information required to be included in the annual report as specified in §§ 257.90 through 257.98."

In addition, the Owner and Operator must place the report in the facility's operating record as required by § 257.105(h)(1), provide notification of the report's availability to the appropriate State Director within 30 days of placement in operating record as required by § 257.106(h)(1), and place the report on the facility's publically accessible website, also within 30 days of placing the report in the operating record.

1.3 OVERVIEW OF REPORT CONTENTS

Section 1.0 of this report provided an overview of the CCR unit characteristics, regulatory basis, and a summary of the requirements for CCR Annual Groundwater Monitoring and Corrective Action Reports. Section 2.0 summarizes the status of key actions pertaining to CCR groundwater monitoring completed during 2018 for the CCBDF and plans for the upcoming year. Section 3.0 presents Detection Monitoring (DM) statistical evaluations completed in 2018 from groundwater sampling events completed in 2017 and presents DM results from groundwater sampling events completed in 2018. Section 4.0 presents Assessment Monitoring (AM) results from groundwater sampling events completed in 2018.

2.0 GENERAL INFORMATION

This section provides an overview of the status of the CCR groundwater monitoring program through 2018 and key activities planned for 2019.

2.1 STATUS OF THE CCR GROUNDWATER MONITORING AND CORRECTIVE ACTION PROGRAM

During calendar year 2018, the following key actions were completed with regard to the CCR groundwater monitoring program for the CCBDF.

2.1.1 Groundwater Monitoring Well System

As detailed in the facility's 2017 Annual CCR Groundwater Monitoring and Corrective Action Report ("2017 AGWMCA Report", accessible at http://ccrdocs.firstenergycorp.com/), the certified CCR monitoring well network consists of three upgradient (background) wells (GW-7, -21, and -22), seven downgradient wells to monitor the northern side of the combined CCR units (GW-9, -19, -20, -23, -24, -25, and -26), and three downgradient wells to monitor the western side of the combined CCR units (GW-27, -28, and -29), as summarized in attached Table 2-1 and shown on attached Figure 2-1.

It was originally intended that upgradient wells GW-21 and GW-22, which are both screened in the Morgantown sandstone, would be grouped for statistical evaluation purposes. However, after both the background and the initial detection monitoring sampling events were completed, it was determined that the two wells did not have the level of statistical similarity needed for grouping and that the availability of sufficient volumes of recoverable water was a recurring problem for GW-21. As such, it was decided that only GW-22 would be used to establish background chemistry for the northern side of the CCR units since it exhibited lower concentrations of all the Appendix III parameters than those measured in GW-21 and it also provided a reliable water yield while GW-21 did not. GW-21 was left in place (i.e., it was not abandoned) and it has been sampled when sufficient volumes of recoverable water were available. GW-21's water levels have also continued to be used to verify groundwater flow patterns at the site. The current intent is to keep GW-21 as a part of the CCR monitoring network until a sufficiently-sized data set can be compiled and used to determine whether or not it's statistically appropriate to group its results with the data set for GW-22. No other changes to the monitoring well network (i.e., new wells added or existing wells abandoned) occurred during 2018.

2.1.2 Groundwater Monitoring Plan

Consistent with the work performed and summarized in the 2017 AGWMCA Report, the CCR units' Groundwater Monitoring Plan (GWMP) was followed during all 2018 field sampling and laboratory analysis activities and for statistically evaluating groundwater monitoring data developed from the CCR sampling and analysis program. No changes to the facility's GWMP occurred during 2018.

2.1.3 Background Groundwater Sampling

As discussed in the 2017 AGWMCA Report, eight independent rounds of background groundwater samples for analyzing all Appendix III and IV parameters from each of the CCR monitoring wells were collected prior to initiating the facility's CCR Detection Monitoring program in October 2017. No modifications to this background data set occurred during 2018.

2.1.4 Statistical Methods

As presented in the 2017 AGWMCA Report, the background data set discussed in Section 2.1.3 was used to select the appropriate statistical evaluation method for each CCR groundwater monitoring parameter to identify any Statistically Significant Increases (SSIs) over background concentrations. These statistical methods are available on the facility's publicly accessible website and no changes were made to them during 2018.

2.2 PROBLEMS ENCOUNTERED/RESOLVED

As discussed in the 2017 AGWMCA Report, having sufficient recoverable volumes of groundwater from one of the CCR monitoring network's upgradient wells (GW-21) and four of its downgradient wells (GW-23, -24, -25, and -26) were found to be problematic during both the background and initial DM sampling events that occurred in 2016 and 2017. This low yield issue was anticipated given that historical well borings drilled at the site under the WVDEP groundwater monitoring program were abandoned over time due to a lack of water in the same rock units. The lack of sufficient recoverable water in these low-yield wells was believed to be from overstressing them due to the large number of samples that had to be obtained prior to the required CCR groundwater detection monitoring startup date of October 2017. Since the remaining CCR monitoring network still met the minimum required number of downgradient wells, one of the key activities listed in the 2017 AGWMCA Report was to obtain quarterly water levels in GW-21, -23, -24, -25 and -26 to determine if one or more of them would be viable for use in the CCR groundwater monitoring network, and if they would require a sampling frequency of between six months and one year, as allowed for in 40 CFR § 257.94(d). Water levels were measured during the first three quarters of 2018 and are presented below:

Well	Date	Depth to Water (ft)	Total Well Depth (ft)	Total Standing Water Depth (ft)
GW-21	2/5/2018	NM	236.40	NM
	5/15/2018	228.35	236.40	8.05
	8/6/2018	229.06	236.40	7.34
GW-23	2/5/2018	376.62	395.20	18.58
	5/15/2018	371.48	395.20	23.72
	8/6/2018	368.15	395.20	27.05
GW-24	2/5/2018	262.84	273.50	10.66
	5/15/2018	261.25	273.50	12.25
	8/6/2018	260.57	273.50	12.93
GW-25	2/5/2018	300.56	306.00	5.44
	5/15/2018	299.23	306.00	6.77
	8/6/2018	300.15	306.00	5.85
GW-26	2/5/2018	275.57	290.50	14.93
	5/15/2018	275.43	290.50	15.07
	5/22/2018	276.89	290.50	13.61
	8/6/2018	276.55	290.50	13.95

Note: “NM” indicates not measured due to impassibility of the well access road during the sampling event.

The February, May, and August dates listed above correspond to the DM-2, AM-1, and AM-2 sampling events that are discussed in Sections 3.0 and 4.0 of this report. During those events, there were a total of five instances where samples could not be recovered:

- Sampling Event DM-2: Wells GW-21, GW-25, and -26. The inability to recover a sample in GW-21 was due to the impassibility of the monitoring well access road at the site, not insufficient available water. However, for GW-25 and -26, the inability to recover a sample was attributed to insufficient available water.

- Sampling Event AM-1: Well GW-26. The inability to recover a sample was attributed to insufficient available water.

- Sampling Event AM-2: Well GW-26. The inability to recover a sample was attributed to insufficient available water.

Based on the water level measurements presented above and the ability to successfully obtain a combined total of ten samples from GW-21, -23, -24, and -25 (out of a total of eleven possible samples), it was determined that using an alternative sampling frequency in accordance with 40 CFR § 257.94(d) should not be necessary for these wells and they should remain a part of the CCR monitoring network. However, upgradient well GW-21 was still not used for any of the statistical evaluation work performed in 2018 as its background data set is still not complete – it currently has only six rounds of data available and not the eight rounds needed to provide sufficient statistical power for use. With respect to GW-26, the water level data indicates that sample recovery should be feasible but, in the field, this well consistently exhibits low flow return even though its pump has been checked and cleared of potential mechanical problems. Due to its favorable positioning along the northern end of the site it's preferable to keep it as part of the CCR groundwater monitoring network. As such, GW-26 will be re-examined for potential mechanical or structural issues in early 2019. Should this examination fail to provide resolution to the on-going sampling issues, FirstEnergy will make a determination as to the viability of relocating GW-26 to a location as close as practical to its existing position or the need to eliminate it from the CCR monitoring network.

Other than the issues noted above, there were no other significant problems (e.g., quality control issues) encountered during 2018 with regard to the CCR groundwater monitoring program.

2.3 TRANSITION BETWEEN MONITORING PROGRAMS

As discussed in the 2017 AGWMCA Report, the CCR Detection Monitoring program was initiated with the collection of the first DM samples in September and October of 2017 (referred to hereafter as sampling event DM-1). Laboratory analysis and validation of the DM-1 sample data were completed in October of 2017 and the data were included in the 2017 AGWMCA Report. Statistical evaluation of the DM-1 data was subsequently completed in January of 2018 within the 90-day period allowed by the CCR Rule, and it was determined that SSIs existed as detailed in Section 3.1 of this Report. Based on the parameters for which SSIs were identified, an Appendix III Alternative Source Demonstration (ASD) was undertaken as discussed in Section 3.2 of this Report. However, all of the Appendix III SSIs that were identified for DM-1 could not be attributed to alternative sources. As such, a transition to the applicable requirements of Assessment Monitoring per § 257.95 of the CCR Rule occurred and are discussed in Section 4.0 of this report. Pursuant to §§ 257.94(e)(3), 257.105(h)(5), and 257.106(h)(4), a notice was prepared and posted to the facility's Operating Record and issued to the relevant State Director on August 15, 2018, to provide notification that a groundwater Assessment Monitoring program for the CCR unit had been established. Pursuant to § 257.107(h)(4) the subject notice was posted to the facility's publicly accessible website on September 7, 2018.

2.4 KEY ACTIVITIES PLANNED FOR THE UPCOMING YEAR

The following are the key CCR groundwater compliance activities planned for 2019:

- Complete the statistical evaluation of the two AM sampling events that occurred in 2018 to determine if there are any Appendix IV constituent concentrations in the downgradient wells that are at Statistically Significant Levels (SSLs) above applicable Groundwater Protection Standards (GWPS).

- If there are no SSLs, then continue with Assessment Monitoring by conducting the annual and semi-annual rounds of sampling and analysis for applicable Appendix III and Appendix IV constituents [per § 257.95(f)].

- If any SSLs are identified, provide appropriate notification [per § 257.95(g)] then potentially conduct an Appendix IV ASD [per § 257.95(g)(3)(ii)] to determine if a source other than the CCR unit may be causing the SSLs. Concurrent with undertaking an Appendix IV ASD, characterize the Nature and Extent (N&E) of the Appendix IV release and provide appropriate notification depending on the findings [per § 257.95(g)(1) and (2), respectively].

- If any SSL's are identified and an ASD is either not undertaken, indicates that an alternative source is not responsible for all the SSL's identified, or is not completed within 90 days of identifying there are SSL's, then initiate and perform an Assessment of Corrective Measures (ACM) in accordance with § 257.96.

- Re-examine GW-26 for potential mechanical or structural issues in early 2019. Should this examination fail to provide resolution to the on-going sampling issues, FirstEnergy will make a determination as to the viability of relocating GW-26 to a location as close as practical to its existing position or the need to eliminate it from the CCR monitoring network.

3.0 DETECTION MONITORING INFORMATION

3.1 GROUNDWATER ANALYTICAL RESULTS SUMMARY

As previously noted in Section 2.3, laboratory analysis and validation of the DM-1 sample data were completed in October of 2017 and the data were included in the 2017 AGWMCA Report. A statistical evaluation of the data set was performed using the approach and methods referenced in Section 2.1.4. The evaluation for DM-1 used nine rounds of data for the Appendix III parameters in the upgradient (background) wells and the September/October 2017 Appendix III data for the downgradient wells. These results are summarized in Table 3-1 and indicate that the following Appendix III parameters were identified as exhibiting SSIs in the downgradient monitoring wells (labeled "GW-#") as summarized below:

	Northern Boundary (Upgradient Well GW-22)					Western Boundary (Upgradient Well GW-7)		
Appendix III Parameters	**GW-9**	**GW-19**	**GW-20**	**GW-23**	**GW-24**	**GW-27**	**GW-28**	**GW-29**
Boron (B)		SSI	SSI		SSI			
Calcium (Ca)				SSI	SSI	SSI	SSI	SSI
Chloride (Cl)		SSI	SSI	SSI	SSI	SSI	SSI	SSI
Fluoride (F)			SSI					
pH				SSI	SSI	SSI	SSI	SSI
Sulfate (SO_4)	SSI					SSI		SSI
TDS		SSI	SSI	SSI	SSI		SSI	SSI

Note: Northern Boundary wells GW-25 and -26 were not sampled during the initial Detection Monitoring event due to insufficient water.

Based on the various parameters for which SSIs were identified, an Appendix III ASD was undertaken as discussed in Section 3.2 of this Report.

During the transition period between completing the statistical evaluation of the DM-1 data and performing the Appendix III ASD, FirstEnergy performed another round of DM sampling (event DM-2) in order to have data available should the ASD prove to be successful and the facility remained in the DM program. DM-2 sampling occurred between February 5 and 15, 2018, with laboratory analysis and data validation completed by April 24, 2018. However, before statistical evaluation of the DM-2 data commenced, it was determined that a transition to Assessment Monitoring was required which precluded the need to statistically evaluate the DM-2 data. This data has been retained and is presented in Table 3-2a with the intent to add to the background data set, thereby increasing the statistical power of future statistical analysis.

3.2 APPENDIX III ALTERNATIVE SOURCE DEMONSTRATION

40 CFR § 257.94(e)(2) allows the owner or operator of a CCR unit 90 days from the date of determining that an SSI has occurred to demonstrate that a source other than the CCR unit caused the SSI or that the apparent SSI was from a source other than the CCR unit or resulted from errors in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. Pursuant to § 257.94(e)(2), an ASD was undertaken to assess if the Appendix III SSIs determined for DM-1 were attributable to a release from the CCR unit or from a demonstrable alternative source(s). A copy of the report that documents the Appendix III ASD activities and findings is included as Attachment A of this Report.

For the Appendix III ASD a multiple Line of Evidence (LOE) approach was followed. This approach divides LOEs into five separate categories (types): Sampling causes (ASD Type I); Laboratory causes (ASD Type II); Statistical evaluation causes (ASD Type III); Natural variation not accounted for in the basic DM statistics (ASD Type IV); and Potential natural or anthropogenic sources (ASD Type V). As detailed in Attachment A, LOE Types I through IV were assessed along with the following site-specific Type V LOEs: Regional groundwater chemistry studies/reports; Potential existing and historic oil and/or gas extraction well effects; and Potential off-site sources.

Based on the information and data included in Attachment A, it was determined that there may be natural levels of Chloride and TDS in the site area that could have resulted in some, but not all, of the SSIs identified for those constituents. It was also determined that potential impacts to groundwater by the numerous historical and existing oil and gas wells on the site and in nearby upgradient areas appears to be significant, with the most likely Appendix III parameters to reflect these impacts also being Chloride and TDS. However, the other Appendix III SSIs determined at the site (Boron, Calcium, Fluoride, pH, and Sulfate) have a moderate to low probability of being related to oil and gas impacts. Therefore, since all of the Appendix III SSIs that were identified for DM-1 could not be attributed to sources other than the CCR unit, to errors in sampling, analysis, or statistical evaluation, or to natural variation in groundwater quality, a transition to the applicable requirements of Assessment Monitoring per § 257.95 of the CCR Rule occurred and are discussed in Section 4.0 of this report.

4.0 ASSESSMENT MONITORING INFORMATION

4.1 GROUNDWATER ANALYTICAL RESULTS SUMMARY

In accordance with 40 CFR § 257.95(b) and (d)(1), the CCR groundwater sampling and analysis program implemented during 2018 consisted of two AM sampling events (AM-1 and AM-2) performed between May 15 and 24, 2018 and between August 6 and 16, 2018, respectively. For AM-1, all Appendix IV constituents were analyzed while, for AM-2, analyses included all Appendix III parameters and only those Appendix IV constituents that were detected during AM-1. Laboratory analysis and validation of the sample data were completed on July 11, 2018 and October 12, 2018 for AM-1 and AM-2, respectively. Table 3-2b presents the validated analytical results for these events.

Statistical evaluation of the AM data in Table 3-2b remains in-progress as of the end of the 2018 reporting period since receipt of validated AM-2 data occurred in the fourth quarter of 2018 and a 90-day period is allowed by the CCR Rule for statistical evaluation, which falls in the first quarter of 2019. If any Appendix IV SSLs are identified, ASD, N&E, and/or ACM activities will be undertaken as outlined in Section 2.4 of this Report, and the associated recordkeeping, notification, and reporting will be performed in accordance with the applicable requirements of 40 CFR §§ 257.95, 96, 105, 106, and 10.

4.2 GROUNDWATER PROTECTION STANDARDS

In accordance with 40 CFR § 257.95(h), as amended by the United States Environmental Protection Agency (USEPA) in July of 2018, GWPS for Appendix IV constituents at the site were established based on either the prescribed limits in the CCR Rule or on the Upper Prediction Limits (UPLs) determined for the two upgradient (background) monitoring wells at the site (GW-7 and GW-22) during the eight background sampling rounds conducted between September 2016 and August 2017. In accordance with the CCR Rule requirements, GWPSs are set at the higher of the federal Maximum Contaminant Level (MCL) or UPL. For those constituents that don't have MCLs, the GWPSs are set at the higher of the EPA Risk Screening Level (RSL) or the UPL. The site-specific Appendix IV GWPSs are as follows:

			Northern Boundary (GW-22)		Western Boundary (GW-7)	
Appendix IV Constituents	**Units**	**CCR Rule Limit**	**UPL**	**GWPS**	**UPL**	**GWPS**
Antimony	mg/L	0.006	0.00241	0.006	0.00133	0.006
Arsenic	mg/L	0.01	0.300239	0.300239	0.00682	0.01
Barium	mg/L	2	0.093799	2	0.0934	2
Beryllium	mg/L	0.004	0.00157	0.004	NA	0.004
Cadmium	mg/L	0.005	0.00139	0.005	NA	0.005
T. Chromium	mg/L	0.1	0.00825	0.1	NA	0.1
Cobalt	mg/L	0.006	0.0076	0.0076	NA	0.006
Fluoride	mg/L	4	3.108	4	9.291	9.291
Lead	mg/L	0.015	0.00391	0.015	NA	0.015
Lithium	mg/L	0.04	0.016562	0.04	0.023374	0.04
Mercury	mg/L	0.002	0.00032	0.002	0.00031	0.002
Molybdenum	mg/L	0.1	0.125025	0.125025	0.006805	0.1
Selenium	mg/L	0.5	NA	0.5	NA	0.5
Thallium	mg/L	0.002	NA	0.002	NA	0.002
Ra226+Ra228	pCi/L	5	1.38	5	0.58	5

Note: “NA” indicates not applicable because constituent was not detected during the eight rounds of background sampling and analysis.

The GWPS listed above will be used to evaluate potential Appendix IV SSLs for the AM-1 and AM-2 data sets as noted in Section 4.1 of this Report.

4.3 APPENDIX IV ALTERNATIVE SOURCE DEMONSTRATION

FirstEnergy will determine whether it may be appropriate to perform an ASD for any Appendix IV constituents that may be identified as being at SSLs above applicable GWPS. As per the CCR Rule timeframe allowance (90-days), this determination will be made during the first quarter of 2019. Whatever determination is made, the associated recordkeeping, notification, and reporting will be performed in accordance with the applicable requirements of 40 CFR §§ 257.95, 96, 105, 106, and 107.

TABLES

TABLE 2-1
CCR RULE GROUNDWATER MONITORING SYSTEM WELL SUMMARY
McELROY's RUN CCB DISPOSAL FACILITY – 2018 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

Well	Year Installed	Formation Monitored	Ground Surface Elevation (ft MSL)	Total Well Depth (ft bgs)	Monitored Interval (ft bgs)	Monitored Interval (ft MSL)	Casing ID and Material
Upgradient (Background)							
GW-7	1994	Grafton SS, Ames LS	918.40	101.2	75.7 – 100.7	817.70 – 842.70	4" - Sch. 40 PVC
GW-21*	2016	Morgantown SS	1033.01	234.2	214.2 – 234.2	798.77 – 818.77	2" - Sch. 40 PVC
GW-22	2016	Morgantown SS	1045.18	370.2	350.2 – 370.2	675.02 – 695.02	2.5" - Sch. 80 PVC
Downgradient							
GW-9	1994	Ames LS, Jane Lew SS, Pittsburgh RB	797.42	177.7	137.2 – 177.2	620.22 – 660.22	4" - Sch. 40 PVC
GW-19	1995	Birmingham RB, Grafton SS, Ames LS	920.64	238.9	198.9 – 238.9	681.74 – 721.74	2" - Sch. 40 PVC
GW-20	1995	Lower Clarksburg RB	923.00	150.5	100.5 – 150.5	772.50 – 822.50	2" - Sch. 40 PVC
GW-23	2016	Grafton SS	974.40	392.9	372.9 – 392.9	581.53 – 601.53	2.5" - Sch. 80 PVC
GW-24	2016	Grafton SS	941.55	271.1	251.1 – 271.1	670.50 – 690.50	2" - Sch. 40 PVC
GW-25	2016	Grafton SS	1006.22	303.7	283.7 – 303.7	702.53 – 722.53	2" - Sch. 40 PVC
GW-26*	2016	Grafton SS	984.16	288.2	268.2 – 288.2	695.95 – 715.95	2" - Sch. 40 PVC
GW-27	2016	Saltsburg SS	675.30	48.3	38.3 – 48.3	626.96 – 636.96	2" - Sch. 40 PVC
GW-28	2016	Saltsburg SS	801.95	175.6	165.6 – 175.6	626.38 – 636.38	2" - Sch. 40 PVC
GW-29	2016	Grafton SS	928.49	166.0	156.0 – 166.0	762.45 – 772.45	2" - Sch. 40 PVC

Notes: SS = sandstone LS = limestone RB = red beds MSL = mean sea level bgs = below ground surface ID = inside diameter
PVC = polyvinyl chloride * = currently used only for water level measurements

TABLE 3-1
CCR RULE GROUNDWATER DETECTION MONITORING STATISTICAL EVALUATION SUMMARY
McELROY'S RUN CCB DISPOSAL FACILITY - CCR SAMPLING EVENT DM-1

Northern Boundary				Downgradient Wells						
Parameter	**Units**	**Data Distribution for Upgradient Well GW-22**	**UPL[a]**	**GW-9**	**GW-19**	**GW-20**	**GW-23**	**GW-24**	**GW-25[c]**	**GW-26[c]**
🟩 Boron	mg/L	Normal	0.222	0.0945	🟩 0.226	🟩 0.229	0.178	🟩 0.292		
🟩 Calcium	mg/L	Normal	16.832	15.3	10.1	5.38	🟩 620	🟩 270		
🟩 Chloride	mg/L	Normal	380.891	7.54	🟩 571	🟩 490	🟩 11600	🟩 5520		
🟩 Fluoride	mg/L	Normal	3.108	0.221	1.47	🟩 4.8	0.0125	0.0125		
🟩 pH	S.U.	Normal	8.965 (7.400)[b]	7.68	7.63	8.11	🟩 6.84 (< LPL)	🟩 6.95 (< LPL)		
🟩 Sulfate	mg/L	Normal	85.395	🟩 119	0.14	28.6	0.079	7.24		
🟩 TDS	mg/L	Normal	1404.824	744	🟩 2320	🟩 1785	🟩 46100	🟩 19400		

Western Boundary				Downgradient Wells		
Parameter	**Units**	**Data Distribution for Upgradient Well GW-7**	**UPL[a]**	**GW-27**	**GW-28**	**GW-29**
Boron	mg/L	Normal	0.387	0.09015	0.215	0.301
🟩 Calcium	mg/L	Non-Parametric	3.08	🟩 45.9	🟩 5.91	🟩 11.5
🟩 Chloride	mg/L	Non-Parametric	104	🟩 107	🟩 631	🟩 910
Fluoride	mg/L	Normal	9.291	0.2655	1.95	1.14
🟩 pH	S.U.	Normal	8.451 (7.844)[b]	🟩 7.336 (< LPL)	🟩 7.66 (< LPL)	🟩 7.66 (< LPL)
🟩 Sulfate	mg/L	Log-Normal	0.537	🟩 8.645	0.263	🟩 0.654
🟩 TDS	mg/L	Non-Parametric	1260	522	🟩 2093.33333	🟩 2980

[a] Prediction Limits calculated using 5% alpha; Upper Prediction Limit used for all parameters, except pH where both upper and lower prediction limits were calculated.

[b] For pH, lower prediction limit shown in parantheses, both used for comparison.

[c] Downgradient wells GW-25 and -26 had insufficent recoverable volumes of water for sampling.

🟩 = Appendix III Parameter SSI

TABLE 3-2a
CCR RULE GROUNDWATER DETECTION MONITORING ANALYTICAL RESULTS SUMMARY
McELROY'S RUN CCB DISPOSAL FACILITY - 2018 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

			APPENDIX III (all Chemical Constituents reported as TOTAL RECOVERABLE)[1]							APPENDIX IV (all Chemical Constituents reported as TOTAL RECOVERABLE)[1]														
SAMPLING EVENT NO.[2]	WELL ID[3]	SAMPLE DATE	BORON METALS MG/L	CALCIUM METALS MG/L	CHLORIDE MISC MG/L	FLUORIDE MISC MG/L	PH MISC S.U.	SULFATE MISC MG/L	TDS MISC MG/L	ANTIMONY METALS MG/L	ARSENIC METALS MG/L	BARIUM METALS MG/L	BERYLLIUM METALS MG/L	CADMIUM METALS MG/L	CHROMIUM METALS MG/L	COBALT METALS MG/L	LEAD METALS MG/L	LITHIUM METALS MG/L	MERCURY METALS MG/L	MOLYBDENUM METALS MG/L	SELENIUM METALS MG/L	THALLIUM METALS MG/L	RADIUM-226 RADIOCHEM PCI/L	RADIUM-228 RADIOCHEM PCI/L
10 (DM-2)	GW-7	2/6/2018	0.284	2.68	101	7.67	8.28	0.083 J	1555	0.00017 U	0.0006 J	0.07751 J-	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01983 J	0.00004 U	0.00041 J	0.0011 U	0.00017 U	0.0665 U	0.609
10 (DM-2)	GW-9 (D)	2/15/2018	0.0909 J	16.4	7.78	0.177	7.83	127	764	0.00017 U	0.00039 J	0.05788	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01492 J	0.00004 U	0.00028 U	0.0011 UJ	0.00017 U	0.139	-0.0488 U
10 (DM-2)	GW-9	2/15/2018	0.0948 J	16.7	7.78	0.186	7.81	126	764	0.00017 U	0.00071 J	0.06033	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01526 J	0.00004 U	0.00042 J	0.0011 UJ	0.00017 U	0.149	0.322 U
10 (DM-2)	GW-19	2/13/2018	0.231	9.62	609	1.65	7.64	0.049 J	2320	0.00017 U	0.15238	1.07665	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01277 J	0.00004 U	0.00028 U	0.0022 UJ	0.00017 U	1.03	0.665
10 (DM-2)	GW-20	2/14/2018	0.238	5.22	472	5.67	8.05	29.7	1620	0.0004 J	0.00202	0.20765	0.00022 U	0.0003 J	0.00073 J	0.00047 U	0.00054 J	0.01283 J	0.00004 U	0.09339	0.01775 J-	0.00017 U	0.293	0.205 U
10 (DM-2)	GW-21	NS[4]																						
10 (DM-2)	GW-22	2/15/2018	0.185 J	3.61	297	2.08	8.58	43	1180	0.00026 J	0.09507	0.03502	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00084 J	0.005 U	0.00004 U	0.09406	0.0011 UJ	0.00017 U	0.219	0.262 U
10 (DM-2)	GW-23	2/8/2018	0.178 J	912	12300	0.422 J	6.88	0.031 UJ	24510	0.00044 J	0.02801	10.48185 J-	0.00044 U	0.00035 U	0.0009 U	0.00257 J	0.00104 U	0.13749	0.00004 U	0.00748 J	0.00733 J	0.00035 U	22.6 J	49.8 J
10 (DM-2)	GW-24	2/8/2018	0.331 J	357	6770	2.9 J	6.94	0.031 UJ	12500	0.00053 J	0.03176	8.13099 J-	0.00044 U	0.00017 U	0.0009 U	0.00214 J	0.00052 U	0.0399 J	0.00004 U	0.01169	0.00264 J	0.00017 U	9.71	22.9
10 (DM-2)	GW-25	NS[4]																						
10 (DM-2)	GW-26	NS[4]																						
10 (DM-2)	GW-27	2/12/2018	0.0857 J	50.7	113	0.26	7.61	5.76	520	0.00017 U	0.00027 J	0.81089 J-	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01435 J	0.00004 U	0.00407 J	0.0011 U	0.00017 U	0.467	0.377 U
10 (DM-2)	GW-28	2/6/2018	0.216	7.64	639	0.025 U	7.75	0.122 J	2100	0.00017 U	0.00587	0.24682 J-	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01639 J	0.00004 U	0.03295	0.0011 U	0.00017 U	0.297	0.888
10 (DM-2)	GW-29	2/12/2018	0.319	14	841	1.09	7.87	0.158 J	2870	0.00017 U	0.02115	1.04374 J-	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.03238	0.00004 U	0.00541	0.0011 U	0.00017 U	0.568	0.513

NOTES:

[1] Lab analyses were completed by Beta Lab and TestAmerica Laboratories, Inc., both of which are accredited/certified laboratories: Beta Lab ISO/IEC 17025 Cert No. 2489.01 (Exp. 11-30-20) and ISO/IEC 9001 Cert. No. 83761-IS7 (Exp. 01-16-21) and TestAmerica NELAP Identification Number: 02-00416, EPA Region: 3, Expiration Date: 04-30-19.

[2] Event No. 10 corresponds to Detection Monitoring (DM) sampling event DM-2.

[3] Field duplicate samples that were taken for Quality Control purposes are noted with a (D).

[4] NS = not sampled. For GW-21 this occurred due to impassibility of the well access road. For GW-25 and -26 this occurred due to an insufficient volume of recoverable water in each well.

DATA QUALIFER DEFINITIONS:

The following definitions provide brief explanations of the validation qualifiers assigned to results in the data review process.

U	The analyte was analyzed for, but was not detected at a level greater than or equal to the level of the adjusted method detection limit for sample and method.
J	The analyte was positively identified and the associated numerical value is the approximate concentration of the analyte in the sample (due either to the quality of the data generated because certain quality control criteria were not met, or the concentration of the analyte was below the reporting limit).
J+	The result is an estimated quantity, but the result may be biased high.
J-	The result is an estimated quantity, but the result may be biased low.
UJ	The analyte was analyzed for, but was not detected. The reported detection limit is approximate and may be inaccurate or imprecise.
R	The sample result (detected) is unusable due to the quality of the data generated because certain criteria were not met. The analyte may or may not be present in sample
UR	The sample result (nondetected) is unusable due to the quality of the data generated because certain criteria were not met. The analyte may or may not be present in sample.

TABLE 3-2b
CCR RULE GROUNDWATER ASSESSMENT MONITORING ANALYTICAL RESULTS SUMMARY
McELROY'S RUN CCB DISPOSAL FACILITY - 2018 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

			APPENDIX III (all Chemical Constituents reported as TOTAL RECOVERABLE)[1]							APPENDIX IV (all Chemical Constituents reported as TOTAL RECOVERABLE)[1]														
SAMPLING EVENT NO.[2]	WELL ID[3]	SAMPLE DATE	BORON	CALCIUM	CHLORIDE	FLUORIDE	PH	SULFATE	TDS	ANTIMONY	ARSENIC	BARIUM	BERYLLIUM	CADMIUM	CHROMIUM	COBALT	LEAD	LITHIUM	MERCURY	MOLYBDENUM	SELENIUM	THALLIUM	RADIUM-226	RADIUM-228
			METALS	METALS	MISC	MISC	MISC	MISC	MISC	METALS	METALS	METALS	METALS	METALS	METALS	METALS	METALS	METALS	METALS	METALS	METALS	METALS	RADIOCHEM	RADIOCHEM
			MG/L	MG/L	MG/L	MG/L	S.U.	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	PCI/L	PCI/L
11 (AM-1)	GW-7	5/22/2018	0.2872	2.62	105	7.89 J-	8.33	0.093 J	1300	0.00017 U	0.00075 U	0.0811	0.00022 UJ	0.00017 UJ	0.00045 U	0.00047 UJ	0.00052 UJ	0.02062 J	0.00004 UJ	0.00028 U	0.0055 UJ	0.00017 UJ	0.232 U	0.0518 U
12 (AM-2)	GW-7	8/6/2018	0.306	2.48	107	7.61 J-	8.22	0.132 J	1340	0.00017 U	0.0006 U	0.07365	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01916 J	0.00004 U	0.00028 U	0.0044 U	0.00017 U	1 U	-0.0483 U
11 (AM-1)	GW-9	5/17/2018	0.0865 J	15.582	7.94	0.224	7.76	127	752	0.00017 U	0.00033 J	0.05607	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01629 J	0.00004 U	0.00033 J	0.0011 U	0.00017 U	0.147	0.0343 U
12 (AM-2)	GW-9	8/16/2018	0.0862 J	15.506	7.98	0.139	7.79	117	812	0.00017 U	0.00068 J	0.05274	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01462 J	0.00004 U	0.00028 U	0.0011 U	0.00017 U	1 U	0.616 J+
11 (AM-1)	GW-19	5/17/2018	0.2257	10.117	594	1.59	7.54	0.031 U	2246.667	0.00017 U	0.12848 J-	1.11921	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01403 J	0.00004 U	0.00028 U	0.0044 U	0.00017 U	1.11	0.447
12 (AM-2)	GW-19	8/14/2018	0.2183	9.57	546	1.71	7.59	0.031 U	2353.333	0.00017 U	0.08846	1.08458	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01314 J	0.00004 U	0.00028 U	0.0011 U	0.00017 U	1.6	0.486 U
11 (AM-1)	GW-20	5/24/2018	0.2162	5.31	475	5.58 J-	8.1	29.1 J-	1860	0.00022 U	0.00208	0.18475	0.00022 UJ	0.00017 UJ	0.00188 J	0.00047 UJ	0.00052 UJ	0.01344 J	0.00004 UJ	0.09681	0.01997 J-	0.00017 UJ	0.0617 U	1.542 U
12 (AM-2)	GW-20	8/14/2018	0.2181	9.73	484	5.61	8.1	28.8	1826.667	0.00024 U	0.00235	0.18929	0.00022 U	0.00021 J	0.00138 J	0.00047 U	0.00052 U	0.01361 J	0.00004 U	0.09825	0.01718	0.00017 U	1 U	0.345 U
11 (AM-1)	GW-21	5/21/2018	0.1144 J	10.365	523	2.91 J-	8.42	263	2053.333	0.00107	0.0189 J-	0.09837	0.00022 U	0.00017 U	0.00092 J	0.00067 J	0.00058 J	0.00554 J	0.00004 U	0.25122	0.11488 J-	0.00017 U	0.354	1.542 U
12 (AM-2)	GW-21	8/13/2018	0.1322 J	8.61	579	2.86	8.38	264	2140	0.00117 U	0.01932	0.09648	0.00022 U	0.00033 J	0.00097 J	0.00063 J	0.00052 U	0.00569 J	0.00004 U	0.25685	0.11687	0.00017 U	1 U	1 U
11 (AM-1)	GW-22	5/24/2018	0.1768 J	3.83	365	2.32 J-	8.08	41.1 J-	1365	0.00017 U	0.10861	0.03841	0.00022 UJ	0.00017 UJ	0.00045 U	0.00047 UJ	0.00052 UJ	0.005 UJ	0.00004 UJ	0.10859	0.0011 UJ	0.00017 UJ	0.554	0.557 U
12 (AM-2)	GW-22	8/15/2018	0.1848 J	4.07	467	2.2	8.39	37.7	1415	0.00039 U	0.12013	0.03547	0.00022 U	0.00017 U	0.00049 J	0.00047 U	0.00168 J	0.005 U	0.00004 U	0.11226	0.0011 U	0.00017 U	1 U	0.163 UJ
11 (AM-1)	GW-23	5/22/2018	0.2351 J	925	12600	0.025 UJ	6.88	0.079 J	46300	0.00089 U	0.02904	10.40809	0.00022 UJ	0.00017 UJ	0.0009 U	0.00217 J	0.00052 UJ	0.1054 J-	0.00004 UJ	0.00568	0.00279 J	0.00017 UJ	31.7 J	54.9 J
12 (AM-2)	GW-23	8/8/2018	0.2177	709	13000	0.062 J	6.86	0.399 J-	49700	0.00068 J	0.02875	10.51039	0.00022 U	0.00017 U	0.00045 U	0.00211 J	0.00052 U	0.11306	0.00004 U	0.00481 J	0.0022 U	0.00017 U	27.3 J	58.3 J
11 (AM-1)	GW-24	5/21/2018	0.3097	306	7590	0.025 UJ	6.87	0.031 U	25300	0.00045 J	0.02311 J	8.53453	0.00022 U	0.00017 U	0.0005 J	0.00184 J	0.00052 U	0.03662	0.00004 U	0.00711	0.0011 U	0.00017 U	17.2 J	32 J
12 (AM-2)	GW-24	8/8/2018	0.3303	310	9490	0.25 U	6.9	0.089 J	26400	0.00045 J	0.02401	10.27638	0.00022 U	0.00017 U	0.00045 U	0.00162 J	0.00052 U	0.03499	0.00004 U	0.00658	0.0011 U	0.00017 U	13.4	25.5
11 (AM-1)	GW-25	5/22/2018	0.1522 J	304	6220	0.025 UJ	7.45	0.091 J	23800	0.00025 U	0.04674	6.69065	0.00024 J	0.00017 UJ	0.00947	0.00213 J	0.00599 J-	0.02067 J	0.00004 UJ	0.01146	0.0011 UJ	0.00017 UJ	10.9	13.3 J
12 (AM-2)	GW-25	8/9/2018	0.1519 J	277	6880	0.536 J	7.34	0.361 J-	24300	0.00041 J	0.04887	7.03146	0.00022 U	0.00017 U	0.00464 J	0.00143 J	0.00306	0.02258 J	0.00004 U	0.01186	0.0011 U	0.00017 U	11.5	16.9
11 (AM-1)	GW-26	NS[4]																						
12 (AM-2)	GW-26	NS[4]																						
11 (AM-1)	GW-27 (D)	5/21/2018	0.0679 J	49.197	123	0.26 J-	7.57	6.63	540	0.00017 U	0.00042 J	0.83016	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01333 J	0.00004 U	0.00457 J	0.0011 U	0.00017 U	0.448	0.207 U
11 (AM-1)	GW-27	5/21/2018	0.0716 J	50.052	123	0.281 J-	7.58	6.87	532	0.00017 U	0.0003 J	0.80552	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01288 J	0.00004 U	0.00472 J	0.0011 U	0.00017 U	0.599	1.542 U
12 (AM-2)	GW-27 (D)	8/13/2018	0.0855 J	51.093	122	0.251	7.51	6.99	540	0.00017 U	0.00048 J	0.84273	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01274 J	0.00013 J	0.00376 J	0.0011 U	0.00017 U	1 U	1 U
12 (AM-2)	GW-27	8/13/2018	0.0812 J	48.141	122	0.296	7.5	7.15	552	0.00017 U	0.00046 J	0.85732	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01264 J	0.00004 U	0.00546	0.0011 U	0.00017 U	1 U	1 U
11 (AM-1)	GW-28	5/16/2018	0.2103	6.89	680	1.91	7.71	0.079 J	2093.333	0.00017 U	0.00494 J-	0.23483	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01558 J	0.00004 U	0.03037	0.0011 U	0.00017 U	0.304	1 U
12 (AM-2)	GW-28	8/7/2018	0.2362	6.57	756	2.06	7.66	0.065 J	2220	0.00017 U	0.00512	0.2713	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.01811 J	0.00004 U	0.03482	0.0011 U	0.00017 U	1 U	0.0411 U
11 (AM-1)	GW-29	5/16/2018	0.3126	13.881	964	1.1	7.79	1.06	3000	0.00017 U	0.01792 J-	1.01725	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.03304	0.00004 U	0.00421 J	0.0011 U	0.00017 U	0.631	0.35 U
12 (AM-2)	GW-29	8/7/2018	0.3122	10.999	1060	1.23	7.62	0.402	3170	0.00017 U	0.01337	0.94805	0.00022 U	0.00017 U	0.00045 U	0.00047 U	0.00052 U	0.03224	0.00004 U	0.0039 J	0.0011 U	0.00017 U	1 U	0.393 U

NOTES:

[1] Lab analyses were completed by Beta Lab and TestAmerica Laboratories, Inc., both of which are accredited/certified laboratories: Beta Lab ISO/IEC 17025 Cert No. 2489.01 (Exp. 11-30-20) and ISO/IEC 9001 Cert. No. 83761-IS7 (Exp. 01-16-21) and TestAmerica NELAP Identification Number: 02-00416, EPA Region: 3, Expiration Date: 04-30-19.

[2] Event Nos. 11 and 12 correspond to Assessment Monitoring (AM) sampling events AM-1 and AM-2, respectively.

[3] Field duplicate samples that were taken for Quality Control purposes are noted with a (D).

[4] NS = not sampled. For GW-26 this occurred due to an insufficient volume of recoverable water in well.

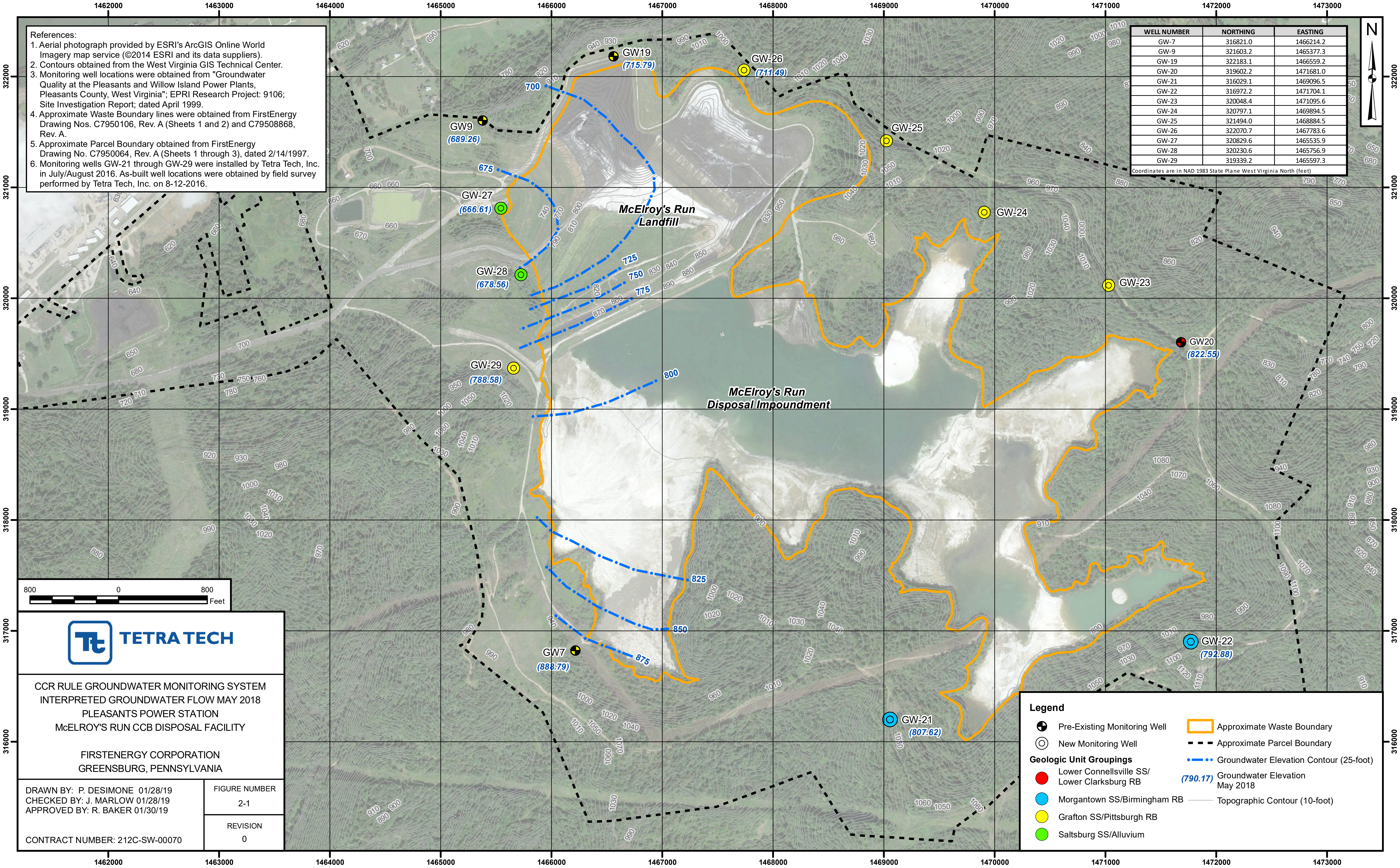
DATA QUALIFER DEFINITIONS:

The following definitions provide brief explanations of the validation qualifiers assigned to results in the data review process.

U	The analyte was analyzed for, but was not detected at a level greater than or equal to the level of the adjusted method detection limit for sample and method.
J	The analyte was positively identified and the associated numerical value is the approximate concentration of the analyte in the sample (due either to the quality of the data generated because certain quality control criteria were not met, or the concentration of the analyte was below the reporting limit).
J+	The result is an estimated quantity, but the result may be biased high.
J-	The result is an estimated quantity, but the result may be biased low.
UJ	The analyte was analyzed for, but was not detected. The reported detection limit is approximate and may be inaccurate or imprecise.
R	The sample result (detected) is unusable due to the quality of the data generated because certain criteria were not met. The analyte may or may not be present in sample
UR	The sample result (nondetected) is unusable due to the quality of the data generated because certain criteria were not met. The analyte may or may not be present in sample.

FIGURES

PGH P:\GIS\FIRST_ENERGY\MAPDOCS\PLEASANTS_POWERSTATION_PROPOSED_MAY2018_CCR.MXD 01/30/19 PD



References:
1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (©2014 ESRI and its data suppliers).
2. Contours obtained from the West Virginia GIS Technical Center.
3. Monitoring well locations were obtained from "Groundwater Quality at the Pleasants and Willow Island Power Plants, Pleasants County, West Virginia"; EPRI Research Project: 9106; Site Investigation Report; dated April 1999.
4. Approximate Waste Boundary lines were obtained from FirstEnergy Drawing Nos. C7950106, Rev. A (Sheets 1 and 2) and C79508868, Rev. A.
5. Approximate Parcel Boundary obtained from FirstEnergy Drawing No. C7950064, Rev. A (Sheets 1 through 3), dated 2/14/1997.
6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

WELL NUMBER	NORTHING	EASTING
GW-7	316821.0	1466214.2
GW-9	321603.2	1465377.3
GW-19	322183.1	1466559.2
GW-20	319602.2	1471681.0
GW-21	316029.1	1469096.5
GW-22	316972.2	1471704.1
GW-23	320048.4	1471095.6
GW-24	320797.1	1469894.5
GW-25	321494.0	1468884.5
GW-26	322070.7	1467783.6
GW-27	320829.6	1465535.9
GW-28	320230.6	1465756.9
GW-29	319339.2	1465597.3

Coordinates are in NAD 1983 State Plane West Virginia North (feet)

Legend

◒	Pre-Existing Monitoring Well
◎	New Monitoring Well
▭	Approximate Waste Boundary
- - -	Approximate Parcel Boundary
•—•	Groundwater Elevation Contour (25-foot)
(790.17)	Groundwater Elevation May 2018
—	Topographic Contour (10-foot)

Geologic Unit Groupings

🔴	Lower Connellsville SS/ Lower Clarksburg RB
🔵	Morgantown SS/Birmingham RB
🟡	Grafton SS/Pittsburgh RB
🟢	Saltsburg SS/Alluvium

TETRA TECH

CCR RULE GROUNDWATER MONITORING SYSTEM
INTERPRETED GROUNDWATER FLOW MAY 2018
PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 01/28/19
CHECKED BY: J. MARLOW 01/28/19
APPROVED BY: R. BAKER 01/30/19

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
2-1

REVISION
0

ATTACHMENT A

CCR Appendix III Alternative Source Demonstration Report – 2017 Detection Monitoring

McElroy's Run Coal Combustion Byproduct Disposal Facility

Pleasants Power Station
Pleasants County, West Virginia

Prepared for:

FirstEnergy

800 Cabin Hill Drive
Greensburg, PA 15601

Prepared by:

Tetra Tech, Inc.

400 Penn Center Boulevard, Suite 200
Pittsburgh, PA 15235
Phone: (412) 829-3600
Fax: (412) 829-3260

Tetra Tech Project No. 212C-SW-00070

April 16, 2018

CCR APPENDIX III ALTERNATIVE SOURCE DEMONSTRATION REPORT
2017 DETECTION MONITORING

McELROY'S RUN COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY

PLEASANTS POWER STATION
PLEASANTS COUNTY, WEST VIRGINIA

Prepared for:

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Prepared by:

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Tetra Tech Project No. 212C-SW-00070

April 16, 2018

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1.0 INTRODUCTION/BACKGROUND

FirstEnergy (FE) owns and operates the coal-fired Pleasants Power Station (hereinafter referred to as the "Station") located in Pleasants County, West Virginia. Coal Combustion Residuals (CCRs) produced at the Station are placed in the facility's Coal Combustion Byproduct Disposal Facility (CCBDF or "CCR unit"), which is located approximately one mile east-southeast of the Station. The facility consists of both a wet disposal area (impoundment) and dry disposal area (landfill) developed in the McElroy's Run watershed. Taken together, the landfill and impoundment are regulated under West Virginia Department of Environmental Protection (WVDEP) Solid Waste/National Pollutant Discharge Elimination System (NPDES) Water Pollution Control Permit No. WV0079171, and the United States Environmental Protection Agency (USEPA) Disposal of Coal Combustion Residuals from Electric Utilities rule (40 CFR Part 257, hereinafter referred to as the "CCR Rule" or "Rule"). As per the CCR Rule, the landfill and impoundment are considered two separate, existing CCR units that share a common boundary (the impoundment dam). As provided by the CCR Rule, a multiunit groundwater monitoring system has been established for the CCBDF.

In accordance with § 257.94 of the Rule, the initial Detection Monitoring (DM) sampling and analysis event for the CCR unit was completed in October 2017, and the statistical evaluation of the resulting data was completed in January 2018. As required by § 257.90(e), results and findings from the 2017 groundwater monitoring program were documented in an Annual Groundwater Monitoring and Corrective Action Report that was posted in both the CCR unit's operating record and on its publicly accessible website in January 2018 (Tetra Tech, 2018). Subsequent to the monitoring period documented in that report, Statistically Significant Increases (SSIs) for the following CCR Rule Appendix III parameters were determined in the downgradient monitoring wells (labeled "GW-#") as summarized in the following table:

	Northern Boundary (Upgradient Well GW-22)					Western Boundary (Upgradient Well GW-7)		
Appendix III Parameters	**GW-9**	**GW-19**	**GW-20**	**GW-23**	**GW-24**	**GW-27**	**GW-28**	**GW-29**
Boron (B)		SSI	SSI		SSI			
Calcium (Ca)				SSI	SSI	SSI	SSI	SSI
Chloride (Cl)		SSI	SSI	SSI	SSI	SSI	SSI	SSI
Fluoride (F)			SSI					
pH				SSI	SSI	SSI	SSI	SSI
Sulfate (SO_4)	SSI					SSI		SSI
TDS		SSI	SSI	SSI	SSI		SSI	SSI

Note: Northern Boundary wells GW-25 and -26 were not sampled during the initial Detection Monitoring event due to insufficient water.

40 CFR § 257.94(e)(2) allows the owner or operator of a CCR unit 90 days from the date of determining that an SSI has occurred to demonstrate that a source other than the CCR unit caused the SSI or that the apparent SSI was from a source other than the CCR unit or resulted from errors in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. Pursuant to § 257.94(e)(2), this Alternative Source Demonstration (ASD) report has been prepared to assess if the Appendix III SSIs determined for the October 2017 DM event are attributable to a release from the CCR unit or from a demonstrable alternative source(s).

2.0 APPROACH

For this ASD, a multiple Line of Evidence (LOE) approach as presented in *Guidance for Development of Alternative Source Demonstrations at Coal Combustion Residual Sites* (EPRI, 2017) was followed. This approach divides LOEs into five separate ASD categories (types):

- Sampling causes (ASD Type I);
- Laboratory causes (ASD Type II);
- Statistical evaluation causes (ASD Type III);
- Natural variation not accounted for in the basic DM statistics (ASD Type IV); and
- Potential natural or anthropogenic sources (ASD Type V).

EPRI (2017) includes detailed checklists that provide a standardized, incremental approach that is followed to determine whether additional LOE evaluations are warranted or not. These checklists include:

- Checklist 1: Sampling, Laboratory, or Statistical Causes (ASD Types I, II, and III);
- Checklist 2: LOEs Associated with the CCR Unit (ASD Type IV); and
- Checklist 3: LOEs Associated with Alternative Natural or Anthropogenic Sources (ASD Type V).

For this ASD only Checklists 1 and 2 were completed. Based on indications from these checklists as well as the CCR unit's topographic and geologic setting, development and operational history, and currently available information and data, it was determined that most of the LOEs in Checklist 3 were either not applicable, indeterminate, or that defensible demonstrations could not be made. However, additional evaluations of the following site-specific LOEs were performed:

- Regional groundwater chemistry studies/reports;
- Potential existing and historic oil and/or gas extraction well effects; and
- Potential off-site sources.

The findings from the checklist completion activities and site-specific LOE evaluations are summarized in Section 3.0.

3.0 SUMMARY OF FINDINGS

3.1 ASD CHECKLIST 1

ASD Checklist 1 is attached as Table 1 of this report. The checklist evaluations were performed by re-reviewing the CCR groundwater monitoring program's field sampling notes and chain-of-custody forms, laboratory data validation (Level 2) reports, statistical evaluation spreadsheets, and results from field-filtered duplicate samples that were obtained during events where turbid unfiltered samples had been obtained. Referring to Table 1 it's seen that for many potential sampling, laboratory, or statistical evaluation causes, no instances/issues/indications were identified. Turbidity may be a contributing factor for all the Appendix III SSIs (especially Chloride) in GW-20 since turbidity was elevated (>10 NTU) in Event 9, and potential petroleum and/or brine contamination from on-site oil and gas production activities could be a contributing factor to the SSIs for Calcium, Chloride, and TDS in GW-23 -24, and -25. For other potential causes where some issues were identified, it was determined that they most likely did not contribute to the Appendix III SSIs. Based on these LOE findings, sampling, laboratory analysis, and statistical evaluations are not demonstrable alternative sources of all the Appendix III SSIs determined for the October 2017 DM event.

3.2 ASD CHECKLIST 2

ASD Checklist 2 is attached as Table 2 of this report. The checklist evaluations were performed by re-reviewing the groundwater analytical results (background and DM) for both Appendix III and IV parameters provided in Tetra Tech (2018), leachate data for the CCR unit provided by FE (summarized in attached Table 3), and hydrogeologic and design information and data included in *CCR Rule Groundwater Monitoring System Evaluation Report for the Pleasants Power Station* (Tetra Tech, 2017). For the LOEs in Checklist 2, the following evaluation criteria were used:

- Primary Indicators – As per Table A-1 in EPRI (2017), primary indicator constituents for CCRs include the CCR Rule parameters Boron (Appendix III), Calcium (Appendix III), Chloride (Appendix III), Fluoride (Appendix III and IV), Lithium (Appendix IV), Molybdenum (Appendix IV), and Sulfate (Appendix III), as well as Bromide, Potassium, and Sodium, which are parameters that are not listed in the CCR Rule.
- Secondary Indicators – For this ASD, secondary indicator constituents for CCRs include those Appendix III and IV constituents that are not considered primary indicators.

- Leachate Data – Analytical results from the October 2017 sampling event at the CCR unit (three locations – LM1, LM5, and LM7) were used for comparison to the October 2017 DM results. These results and associated comparisons are attached as Table 3 of this report.
- Site Hydrogeology - As discussed in in the *CCR Rule Groundwater Monitoring System Evaluation Report* (Tetra Tech, 2017), groundwater in the CCBDF area occurs primarily within the fractured bedrock of multiple Conemaugh Group sandstone units including the Morgantown, Grafton, Jane Lew, and Saltsburg, which have been collectively identified as the uppermost aquifer for CCR Rule groundwater monitoring for the combined landfill and impoundment units. Historic and recent groundwater level data indicate groundwater flow at the site as flowing north from the topographically higher areas located to the south and southeast of the impoundment. Groundwater flow northwest of the dam and under the landfill is in the downstream direction of McElroy's Run toward the west. Flow in all of the rock units exhibit very little seasonal and temporal fluctuations. The CCR groundwater monitoring well network at the site is shown on Figure 1 and consists of three upgradient (background) wells (GW-7, -21, and -22), six downgradient wells to monitor the northern side of the combined CCR units (GW-19, -20, -23, -24, -25, and -26), and four downgradient wells to monitor the western side of the combined CCR units (GW-9, -27, -28, and -29).

  Having sufficient recoverable volumes of groundwater from one of the new upgradient (GW-21) and three of the new downgradient (GW-23, -24, and -25) wells was found to be problematic during both the background and initial Detection Monitoring sampling events. These four wells were noted to have low to very low yields during their installation and development which was anticipated given that historical well borings drilled at the site under the WVDEP groundwater monitoring program were abandoned over time due to a lack of water in the same rock units. During the initial Detection Monitoring sampling event, sufficient recoverable groundwater volumes were found to be available in GW-23 and -24 but not in GW-21, -25, or in an additional downgradient well, GW-26. Geologic and hydrogeologic characteristics of the site, the monitoring well network, and the initial Detection Monitoring results are discussed in greater detail in both Tetra Tech 2017 and 2018.
- CCR Unit Design - As shown on Figure 1, the CCR unit consists of two conterminous disposal areas, an impoundment and a landfill, that share a common boundary (i.e., the impoundment dam). The majority of the CCR material that has been disposed of at the

site is managed in an unlined impoundment created by a dam constructed across McElroy’s Run. The dam was constructed with a clay-filled cutoff trench at the upstream toe and a clay blanket on the upstream face to function as a low permeability barrier. The downstream portion of the dam was constructed using compacted fly ash and periodic layers of bottom ash for blanket drains connected to sloping chimney drains that collect seepage to discharge pipes for monitoring. The downstream face of the dam is covered by the landfill facility which WVDEP considers to be a buttress to the dam.

The landfill consists of three primary development stages which are further subdivided into construction subareas. At this time, development and disposal operations have only been performed in Stages 1 and 2 and the Stage 3 area remains undeveloped. Up until 2009 all of the landfill subareas were constructed with a compacted clay liner system that included an underlying combined groundwater underdrain/leak detection system and an overlying leachate collection system. Since 2009 a composite geosynthetic liner system (geosynthetic clay liner and geomembrane) has been utilized that also includes an underlying combined groundwater underdrain/leak detection system and an overlying leachate collection system. For all portions of the landfill that overlie the downstream face of the impoundment dam, a bottom ash blanket drain layer has also been utilized. Leachate and contact stormwater runoff from the landfill disposal areas are managed in Sedimentation Pond Nos. 1 and 2, which are lined impoundments located immediately down-valley of the future Stage 3 landfill development area. These impoundments also accept flows from the groundwater underdrain/leak detection zones and stormwater runoff from portions of the landfill’s South Haul Road. Discharges from Sedimentation Pond Nos. 1 and 2 are pumped up to the CCR disposal impoundment and, ultimately, routed through the impoundment’s dewatering system.

Based on the various LOE findings presented in Table 2, at least one or more of the Appendix III SSIs determined for the October 2017 DM event can most likely be attributed to a release from the CCR unit.

3.3 REGIONAL GROUNDWATER STUDY

In an effort to evaluate the natural variation in groundwater quality in the various water producing units of the Conemaugh Group (e.g., Morgantown, Grafton, Jane Lew, and Saltsburg sandstones) which comprise the CCR Rule uppermost aquifer, *Ground-Water Hydrology of the Minor Tributary Basins of the Ohio River, West Virginia* (USGS, 1984) was reviewed. Table 1 of the subject report includes concentration data for three Appendix III constituents for which there were SSIs at the site: Chloride, Sulfate and TDS. It is noted that the study results were reported as dissolved concentrations while the CCR analytical results are reported as total (unfiltered) concentrations. In general, total (unfiltered) concentrations for the same sample would be expected to be higher than dissolved concentrations. The following table presents the range and mean concentrations reported for these constituents in Conemaugh Group wells:

	Dissolved Chloride (mg/L)	Dissolved Sulfate (mg/L)	TDS (mg/L)
No. of Wells	6	6	6
Range	2.6 - 130	10 - 88	241 - 589
Mean	31	37	371

Based on these reported values, the following observations were made:

- **Chloride -** The reported mean concentration of 31 mg/L is below the upper prediction limits (UPLs) for both upgradient wells GW-22 (381 mg/L) and GW-7 (104 mg/L). The reported maximum concentration of 130 mg/L is also below the GW-22 UPL and slightly higher than the GW-7 UPL. With respect to downgradient wells with SSIs, the reported maximum concentration of 130 mg/L is slightly higher than the concentration for GW-27 (107 mg/L) and well below the concentrations for GW-19 (571 mg/L), GW-20 (490 mg/L), GW-23 (11,600 mg/L), GW-24 (5,520 mg/L), GW-28 (631 mg/L), and GW-29 (910 mg/L).
- **Sulfate** – The reported mean concentration of 37 mg/L is below the GW-22 UPL of 85 mg/L and significantly higher than the GW-7 UPL of 0.5 mg/L. The reported maximum sulfate concentration of 88 mg/L is essentially equal to the GW-22 UPL and much higher than the GW-7 UPL. With respect to downgradient wells with SSIs, the reported maximum concentration of 88 mg/L is higher than the concentrations for GW-27 (8.6 mg/L) and GW-28 (0.7 mg/7) and below the concentration for GW-9 (119 mg/L).
- **TDS** – The reported mean concentration of 371 mg/L is well below the UPLs for both GW-22 (1,481 mg/L) and GW-7 (1,260 mg/L). The reported maximum TDS concentration of 589 mg/L is also well below both the GW-22 and GW-7 UPLs. With respect to downgradient wells with SSIs, the reported maximum concentration of 589 mg/L is well below the concentrations for GW-19 (2,320 mg/L), GW-20 (1,785 mg/L), GW-23 (46,100 mg/L), GW-24 (19,400 mg/L), GW-9 (744 mg/L), GW-28 (2,093 mg/L), and GW-29 (2,980 mg/L).

The comparisons noted above indicate that upgradient Chloride and TDS concentrations at the site appear to be higher than the concentrations measured in regional Conemaugh Group groundwater during the USGS study period, while upgradient Sulfate concentrations appear to be within the range of or below the concentrations measured in the study. However, comparing the maximum reported study results to the corresponding downgradient SSI concentrations indicates that almost all of the SSI concentrations are higher to much higher than those for regional groundwater. Taken together and given the limited information on the natural variation of the SSI constituents that was identified under the scope of this ASD, there may be natural levels of Chloride and TDS in the site area that could have resulted in some, but not all, of the SSIs identified for those constituents.

3.4 POTENTIAL FOR OIL AND GAS WELL IMPACTS

In an effort to evaluate the potential for oil and gas well development on and near the site to impact groundwater quality for the SSI constituents, particularly chloride and TDS, the locations of oil and gas wells and basic information on the wells (e.g., total depth, date drilled, status, etc.) were obtained from the West Virginia Geologic and Economic Survey (WVGES) online oil and gas well database (http://ims.wvgs.wvnet.edu/WVOG/viewer.htm). Figure 2 presents the locations of these wells relative to the CCR monitoring well network. A total of more than 100 existing or plugged/abandoned oil and gas wells were identified as shown on Figure 2. The table below summarizes key information for these wells obtained from the database records:

API #	Completion Year	Well Type	Operator	Total Depth (ft)	Deepest Formation
4707300005		Oil	Oper in Min.owner fld,no code assgn(Orphan well proj)	1052	Undiff Price below Big Injun
4707300008		Oil	Oper in Min.owner fld,no code assgn(Orphan well proj)	512	Undetermined unit
4707300043	1935	Dry w/ Oil Show	All In One Producing & Refining Co., The	71	Big Injun (Price & equivs)
4707300069	1936	Oil w/ Gas Show	Feeney Oil & Gas	1600	Squaw
4707300069	1941	Dry w/ O&G Show	Feeney Oil & Gas	3379	Berea Sandstone
4707300073		Dry	Love, C. E.	1903	
4707300124	1939	Oil w/ Gas Show	Columbian Carbon Co.	5311	Oriskany Sandstone
4707300170	1940	Oil w/ Gas Show	Columbian Carbon Co.	2280	Up Devonian undiff:Berea to Lo Huron
4707300179	1940	Dry w/ Gas Show	Columbian Carbon Co.	2930	Berea Sandstone
4707300183	1940	Dry	Columbian Carbon Co.	2930	Berea Sandstone
4707300192	1941	Dry w/ Oil Show	Faith Oil Co.	430	Buffalo Ss (Lit Dunkard)/1st Cow Run
4707300578	1959	Dry w/ O&G Show	Smellie & Myers	2527	Up Devonian undiff:Berea to Lo Huron

API #	Completion Year	Well Type	Operator	Total Depth (ft)	Deepest Formation
4707300588	1960	Dry	Daugherty, John	1217	Maxton
4707300611	1962	Dry w/ O&G Show	Quaker State Oil Refining Co.	1727	Berea Sandstone
4707300646	1968	Dry	Holton, Harry A.	5684	Salina
4707300682	1974	Gas	McDuff, Inc.	3297	Up Devonian undiff:Berea to Lo Huron
4707300684	1974	Gas	McDuff, Inc.	3179	Up Devonian undiff:Berea to Lo Huron
4707300913	1980	Oil and Gas	Haught, Inc.	3911	Lower Huron (undifferentiated)
4707300914	1980	Oil and Gas	Haught, Inc.	4011	Lower Huron (undifferentiated)
4707300915	1980	Oil and Gas	Haught, Inc.	4286	Lower Huron (undifferentiated)
4707300975	1980	Oil and Gas	Prior, Ferrell L.	3906	Java Formation
4707300976	1980	Oil and Gas	Prior, Ferrell L.	3646	Java Formation
4707300976	1989	Gas w/ Oil Show	Dupke, Roger	3646	Lower Huron (undifferentiated)
4707300996	1980	Oil and Gas	Prior, Ferrell L.	4129	Java Formation
4707301025	1980	Oil and Gas	Prior, Ferrell L.	3100	Lower Huron (undifferentiated)
4707301026	1981	Oil and Gas	Prior, Ferrell L.	3557	Lower Huron (undifferentiated)
4707301033	1980	Oil and Gas	Haught, Inc.	3990	Angola Formation
4707301087	1981	Oil and Gas	Prior, Ferrell L.	4050	Java Formation
4707301368	1981	Gas	Shafer Oil & Gas Corp.	4350	Rhinestreet Shale
4707301594	1983	Gas w/ Oil Show	Jenkins Energy Corp. & H. Davis Jenkins	4761	Rhinestreet Shale
4707301595	1983	Gas w/ Oil Show	Jenkins Energy Corp. & H. Davis Jenkins	4940	Rhinestreet Shale
4707301595	2011	not available	Ritchie Petroleum Corp., Inc.		
4707301596	1983	Gas w/ Oil Show	Jenkins Energy Corp. & H. Davis Jenkins	4769	Rhinestreet Shale
4707301597	1984	Dry w/ O&G Show	Stalnaker, Gene, Inc.	5059	Angola Formation
4707301604	1983	Oil and Gas	Jenkins Energy Corp. & H. Davis Jenkins	2038	Up Devonian undiff:Berea to Lo Huron
4707301630	1983	Dry w/ O&G Show	Stalnaker, Gene, Inc.	5050	Rhinestreet Shale
4707301635	1983	Dry w/ O&G Show	Stalnaker, Gene, Inc.	5060	Middlesex Shale
4707302514	2009	Gas w/ Oil Show	Patchwork Oil & Gas, LLC	2514	Up Devonian undiff:Berea to Lo Huron
4707302514	2009	Dry w/ Oil Show	Patchwork Oil & Gas, LLC	2125	Up Devonian undiff:Berea to Lo Huron
4707330089		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330090		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330113		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330115		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330127		not available	Faith Oil Co.		

API #	Completion Year	Well Type	Operator	Total Depth (ft)	Deepest Formation
4707330196		not available	Delong, J. R.		
4707330250		Oil and Gas	Oper in Min.owner fld,no code assgn(Orphan well proj)	884	Big Injun (undifferentiated)
4707330251		Oil and Gas	Oper in Min.owner fld,no code assgn(Orphan well proj)	820	Maxton
4707330258		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330270		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330271		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330593		not available	Dinsmoor & Co.		
4707330596		not available	Dinsmoor & Co.		
4707330597		not available	Dinsmoor & Co.		
4707330831		not available	Daugherty, John		
4707330885		not available	Daugherty, John		
4707331095		not available	WV Department of Mines, Oil & Gas Division		
4707331114		not available	Monongahela Power Company		
4707331115		not available	Monongahela Power Company		
4707331116		not available	Monongahela Power Company		
4707331117		not available	Monongahela Power Company		
4707331118		not available	Monongahela Power Company		
4707331119		not available	Monongahela Power Company		
4707331120		not available	Monongahela Power Company		
4707331121		not available	Monongahela Power Company		
4707331122		not available	Monongahela Power Company		
4707331123		not available	Monongahela Power Company		
4707331124		not available	Monongahela Power Company		
4707331125		not available	Monongahela Power Company		
4707331126		not available	Monongahela Power Company		
4707331127		not available	Monongahela Power Company		
4707331128		not available	Monongahela Power Company		
4707331129		not available	Monongahela Power Company		
4707331130		not available	Monongahela Power Company		
4707331131		not available	Monongahela Power Company		
4707331132		not available	Monongahela Power Company		
4707331133		not available	Monongahela Power Company		
4707331135		not available	Monongahela Power Company		
4707331136		not available	Monongahela Power Company		
4707331137		not available	Monongahela Power Company		
4707331138		not available	Monongahela Power Company		
4707331139		not available	Monongahela Power Company		
4707331141		not available	Lauderman Oil & Gas Drilling		

API #	Completion Year	Well Type	Operator	Total Depth (ft)	Deepest Formation
4707370016		not available	---------- unknown ----------		
4707370048		not available	Jennings Brothers, E. H., Company		
4707301119	1981	Dry w/ Gas Show	Vessel Resources Corp.	4000	Lower Huron (undifferentiated)
4707301606	1983	Gas w/ Oil Show	Beacon Resources Corp.	4110	Lower Huron (undifferentiated)
4707302524	2010		WVDEP Office Of Oil & Gas		
4707390126					
4707391316					

Note: Wells having API #s from 4707390041 through 4707390140 are also listed but have no associated information.

The completion dates for most of the wells are unknown, implying they were drilled as part of historic oil and gas well exploration in the area and potentially could have been drilled in the early 1900s or possibly in the late 1800s. A review of data for the other wells indicates they were drilled between 1935 and 2011. The total depths of the wells range from 71 ft to 5,684 ft and they've produced from formations including undifferentiated Upper Devonian Sandstone units. Many of the wells are reported as orphan wells and some have little or no information provided. As indicated on Figure 2, the wells are distributed throughout much of the site. Considering the age of the wells there would seem to be potential for groundwater impacts from corroded/damaged well casing, degrading seals, etc. which could result in out-of-interval migration of oil and gas and formation brine. Any leaking oil and gas gathering lines/pipelines and well head brine storage tanks at currently producing locations could be another potential source of releases. Potential constituents known to be associated with oil and gas wells include Barium, Chloride, Sodium and elevated TDS levels. At this point in time, insufficient information is available to specifically link the petroleum sheens/odors observed in MW-23, MW-24, and MW-25 to specific oil/gas wells or pipelines.

In March 2004, Hydrosystems Management, Inc. prepared a report for Allegheny Power Supply Company (a predecessor company of FirstEnergy) which evaluated increased Barium concentrations in groundwater samples from monitoring well GW-4. GW-4 is part of the state Solid Waste/NPDES groundwater monitoring system, is located in the northeastern portion of the site (as shown on Figure 2), is 255 feet deep and has a screen that's 55 feet long. Barium concentrations in in the well consistently exceeded the Ground-Water Quality Standard (GWQS) established in the facility's Solid Waste/NPDES permit. The HMI report concluded that leakage of brine from surrounding oil and gas wells was the most probable cause of the Barium GWQS exceedances. GW-4 also showed increases in sodium and chloride levels. The HMI report indicated two known oil and gas wells were within 1,000 feet of GW-4 and referenced the existence of numerous orphaned wells in the area. The boring log for GW-4 indicated oil and gas odors, some oil associated with groundwater, and oil sheen were all present during well installation and development.

In summary, the potential for impacts to groundwater by oil and gas wells on the site and in nearby upgradient areas appears to be significant, particularly in light of the well-documented oil and gas well impacts at GW-4. The most likely Appendix III parameters to reflect these impacts are Chloride and TDS. However, the other Appendix III SSIs determined at the site (Boron, Calcium, Fluoride, pH, and Sulfate) have a moderate to very low probability of being related to oil and gas impacts. It should also be noted that the potential exists for significant impacts to groundwater by Barium, Sodium and other constituents associated with the historical and ongoing oil and gas well operations.

3.5 SURROUNDING LAND USE REVIEW

To identify potential offsite anthropologic source areas, currently available GoogleEarth aerial photo imagery for the site area was reviewed. This review found that most of the land use in the upgradient site area appears to be forested with some farming. Two buildings of unknown use were identified along a road near the southeastern edge of the site as shown on Figure 3. The buildings appear to have flat roofs and be of similar design. Lumber or some other material can be seen laying on the ground surface near one of the buildings. It also appears that a cell tower is located in the southern upgradient area along with power transmission lines. However, other than these features, it does not appear there are any readily identifiable upgradient source areas (e.g., coal refuse disposal sites) that could contribute to Appendix III SSIs.

4.0 CERTIFICATION STATEMENT

In accordance with § 257.94(e)(2) of the CCR Rule, an ASD for Appendix IIII constituents was undertaken for the CCR unit identified herein. Based on the information and data that were available for review, all of the Appendix III SSIs that were identified for the October 2017 Detection Monitoring event could not be attributed to sources other than the CCR unit, to errors in sampling, analysis, or statistical evaluation, or from natural variation in groundwater quality. As such, a transition to the applicable requirements of Assessment Monitoring per § 257.95 of the CCR Rule appears to be warranted.

5.0 REFERENCES

USGS, 1984. *Ward, P.E., and Wilmoth, B.M., Ground-Water Hydrology of the Minor Tributary Basins of the Ohio River, West Virginia. West Virginia Geological and Economic Survey Basic Data Report 1.*

EPRI, 2017. *Guidelines for Development of Alternative Source Demonstrations at Coal Combustion Residual Sites*. EPRI, Palo Alto, CA: 2017. 3002010920.

Tetra Tech, 2017. *Coal Combustion Residuals (CCR) Rule Groundwater Monitoring System Evaluation Report, Pleasants Power Station, Coal Combustion Byproduct Landfill and Impoundment*. Tetra Tech, Inc., Pittsburgh, PA, October 2017.

Tetra Tech, 2018. *2017 Annual CCR Groundwater Monitoring and Corrective Action Report, McElroy's Run Coal Combustion Byproduct Disposal Facility, Pleasants Power Station*. Tetra Tech, Inc., Pittsburgh, PA, January 2018. http://ccrdocs.firstenergycorp.com/

TABLES

Table 1 - ASD Checklist 1: Sampling, Laboratory, or Statistical Causes

ASD Type	Potential Cause	Evaluation Summary
Sampling Causes (ASD Type I)	Sample mislabeling	No mislabeling found by comparing all COCs and lab data identifiers.
	Contamination	Field notes identified sheens and petroleum odors in GW-23 for Events 4 through 9, GW-24 for Events 6 through 9, and GW-25 for Events 4 through 6 (well was dry and not sampled in Events 7 through 9). Petroleum contamination could be contributing factor for SSIs in these wells for Ca, Cl, and TDS.
	Sampling technique	HydraSleeves™ used instead of bladder pumps on some dates in wells GW-21 (upgradient), -23, -24, and -25 due to limited available water.
	Turbidity	High turbidity (> 10 NTU) in GW-19 (Events 1 and 2), GW-20 (Events 1 and 4 through 9), GW-22 (Events 1 and 8 through 9), GW-26 (Events 1 through 7), GW-28 (Event 1), and GW-29 (Event 1); When HydraSleeves™ used, turbidity not reported. Turbidity may be contributing factor to SSIs in GW-20, especially Cl.
	Sampling anomalies	Insufficient water for sampling in GW-21 (upgradient) for Events 5 through 9, GW-24 for Events 3 and 4, GW-25 for Events 1 and 7 through 9, and GW-26 for Events 8 through 9.
Laboratory Causes (ASD Type II)	Calibration	No comments on lab calibration in Data Validation Reports for Appendix III parameters.
	Contamination	No Appendix III parameters in lab blanks.
	Digestion methods	No differences for Appendix III parameters.
	Dilution corrections	Dilution factors in some events different for Ca, Cl, and F between wells in same event and for Cl for same well in different events. Dilution factors high for Cl in some events in wells GW-23, -24, and -25. All Appendix III parameters detected in upgradient wells and in downgradient wells for Event 9, except GW-23 and -24 for F, but dilution factor was 1 for F in both wells, so no errors in detection limit calculations.
	Interference	No concerns mentioned in Data Validation Reports, unlikely for Appendix III parameters.
	Analytical methods	Methods same as in CCR GW Monitoring Plan.
	Laboratory technique / qualifier flags	Had low recovery for MS/MSD for F in Event 1 (GW-27, -28, -29 and duplicate), Event 4 (GW-9, -19, -26), Event 5 (GW-9, -19, -25), Event 6 (GW-26), and Event 7 (GW-22, -26, -28 and -29). Had low recovery for MS/MSD for SO_4 in Event 1 (GW-20 and -26), Event 4 (GW-27), and Event 9 (GW-22 and -24). Had high recovery for SO_4 in Event 2 (GW-29). Qualifier flags added appropriately. Had SSI for SO_4 in GW-9, where all values greater than for upgradient well GW-22 and Event 9 value in GW-22 not lowest, so not contributing reason for SSI. Other SSIs for SO_4 were in GW-27 and -29 where GW-7 is upgradient well, no issues in GW-7 or Event 9 for GW-29, so not contributing reasons for SSI. Only SSI for F was in GW-20 where all values higher than in upgradient well GW-22 and Event 9 value in GW-22 not lowest, so not contributing reason for SSI.
	Transcription error(s)	None identified.
Statistical Evaluation Causes (ASD Type III)	Lack of statistical independence	Sampling interval was at least 4-5 weeks in upgradient wells GW-22 and GW-7 which are 2.5-inch and 4-inch diameter, respectively, wells in fractured bedrock, so not likely to be a concern.
	Outliers	Outlier identified for SO_4 in GW-25 in Event 5. Downward trend for SO_4 in GW-29 and Event 9 value was slightly above UPL. Possible outlier for Cl in GW-23 in Event 9, although other Cl values higher than upgradient well GW-7.
	False positives	In general, for the case of small sample sizes (e.g., n < 10-20), there is no mathematical algorithm to statistically prove a false positive result without resampling.
	Non-detect processing	Appendix III parameters had all detected values in upgradient wells GW-22 and GW-7, and in all 8 downgradient wells for Event 9 used for Detection Monitoring 1, except for GW-23 and -24 which had non-detect values for F.
	Background data / change in normality	No new background data used for Detection Monitoring 1.

Table 2 - ASD Checklist 2: Lines of Evidence Associated with the CCR Unit

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Primary CCR Indicators						
1a	If the CCR unit contains fly ash, is there an SSI/SSL for boron and sulfate?	Yes	CCR Release	Key	Monitoring Point	Northern Boundary: Boron SSIs in GW-19, -20, and -24; No Sulfate SSIs. Western Boundary: No Boron SSIs; Sulfate SSIs in GW-9, -27, and -29.
1b	If the CCR unit contains FGD gypsum (only) is there an SSI/SSL for sulfate?	Yes	CCR Release	Key	Monitoring Point	Northern Boundary: No. Western Boundary: Sulfate SSIs in GW-9, -27, and -29.
1c	Are there other constituents in the groundwater that represent primary indicators? List the applicable constituents.	Yes	CCR Release	Supporting	Monitoring Point	Northern Boundary: Calcium, Chloride, Fluoride, Lithium, and Molybdenum are all found at detectible levels in multiple downgradient monitoring wells. Western Boundary: Calcium, Chloride, Fluoride, Lithium, and Molybdenum are all found at detectible levels in multiple downgradient monitoring wells.
1d	Is there an SSI/SSL for any of the other primary indicators?	Yes	CCR Release	Key if No	Monitoring Point	Northern Boundary: Calcium (GW-23 and -24), Chloride (GW-19, -20, -23, and -24), and Fluoride (GW-20) have exhibited SSIs. Lithium (GW-23 and -24) has exhibited elevated downgradient concentrations as compared to upgradient concentrations. No statistical evaluations of Lithium data have been performed as no assessment monitoring sampling has been required to date. Western Boundary: Calcium (GW-27, -28, and -29) and Chloride (GW-27, -28, and -29) have exhibited SSIs. Lithium (GW-29) and Molybdenum (GW-28) have exhibited elevated downgradient concentrations as compared to upgradient concentrations. No statistical evaluations of Lithium or Molybdenum data have been performed as no assessment monitoring sampling has been required to date.
1e	Is the leachate concentration for any of the primary indicators (including boron and sulfate) with an SSI/SSL statistically higher than background? List the applicable constituents.	Yes	CCR Release	Key if No	Constituent	Northern Boundary: Boron, Calcium, and Chloride – Yes; Fluoride - No. It is noted that statistical analysis has not been performed on leachate results -- evaluation based on the October 2017 leachate sampling event. Western Boundary: Calcium, Chloride, and Sulfate – Yes. It is noted that statistical analysis has not been performed on leachate results; evaluation based on the October 2017 leachate sampling event.
1f	Are concentrations for the primary indicators increasing?	No	Uncertain	Supporting	Monitoring Point	Northern Boundary: No. It should be noted that the CCR dataset covers a very limited time range (~1 year) for trend analysis. Western Boundary: No. It should be noted that the CCR dataset covers a very limited time range (~1 year) for trend analysis.
Secondary Indicators						
2a	Are there other SSI(s) or SSL(s) of Appendix III or IV parameters?	Yes	CCR Release	Supporting	Monitoring Point	Northern Boundary: SSIs for pH (GW-23 and -24) and TDS (GW-19, -20, -23, and -24). Barium (GW-19, -20, -23, and -24) and Radium 226+228 (GW-19, -23, and -24) have exhibited elevated downgradient concentrations as compared to upgradient concentrations. No statistical evaluations of these Appendix IV constituents have been performed as no assessment monitoring sampling has been required to date.

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Secondary Indicators (Continued)						
2a (con't)	(These are potential secondary indicators. List the applicable constituents.)					Western Boundary: SSIs for pH (GW-27, -28, and -29) and TDS (GW-28 and -29). Arsenic (GW-29), Barium (GW-27, -28, and -29) and Radium 226+228 (GW-27 and -29) have exhibited elevated downgradient concentrations as compared to upgradient concentrations. No statistical evaluations of these Appendix IV constituents have been performed as no assessment monitoring sampling has been required to date.
2b	Are the constituents identified in 2a present in leachate in concentrations statistically higher than background?	Yes / No	Uncertain	Key if No	Constituent	Northern Boundary: TDS – Yes; pH and Barium – No; Radium 226+228 not analyzed in leachate sampling program. It is noted that statistical analysis has not been performed on leachate results; evaluation based on the October 2017 leachate sampling event. Western Boundary: TDS and Arsenic – Yes; pH and Barium – No; Radium 226+228 not analyzed in leachate sampling program. It is noted that statistical analysis has not been performed on leachate results; evaluation based on the October 2017 leachate sampling event.
2c	Are concentrations for any of the secondary indicators increasing? List the applicable constituents.	No	Uncertain	Supporting	Monitoring Point	Northern Boundary: No. It should be noted that the CCR dataset covers a very limited time range (~1 year) for trend analysis. Western Boundary: No. It should be noted that the CCR dataset covers a very limited time range (~1 year) for trend analysis.
Other Chemistry						
3a	Are organic constituents present in concentrations statistically higher than background?	N/A	-----	Supporting	Monitoring Point	Organics not analyzed as part of groundwater testing program at site.
3b	Is major ion chemistry similar to leachate?	ND	-----	Key	Monitoring Point	Based on primary and secondary indicator LOE's listed above, major chemistry analysis was not performed as part of Appendix III ASD.
3c	Does major ion chemistry suggest a mixture of leachate and background groundwater?	ND	-----			Based on primary and secondary indicator LOE's listed above, major chemistry analysis was not performed as part of Appendix III ASD.
3d	Does tritium age dating indicate that the groundwater was recharged after the facility was first used?	N/A	-----	Key if No	Monitoring Point	Disposal site development initiated in the late 1970's.
3e	Does isotopic analysis show evidence of mixing with CCR leachate?	ND	-----	Key	Monitoring Point	Based on primary and secondary indicator LOE's listed above, isotopic analysis was not performed as part of Appendix III ASD.
Hydrogeology						
4a	Is the monitoring well with an SSI/SSL downgradient from CCR unit at any point during year?	Yes	CCR Release	Key if No	Monitoring Point	Multiple SSIs were identified in the downgradient wells, all of which are positioned downgradient of the disposal site during all times of the year.

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Hydrogeology (Continued)						
4b	Review the Hydrogeological vs Leachate Scenario Table (EPRI, Table A-2) and identify the most representative scenario for each SSI or SSL case. List cases and scenario numbers.	-----	-----	Key	Monitoring Point	**Northern Boundary** Boron - CCR Leachate Release (Row c) Calcium - CCR Leachate Release + Possible Alternative Source (Row b) Chloride - CCR Leachate Release + Possible Alternative Source (Row c) Fluoride – Alternative Source Release (Row b) pH – Alternative Source Release (Row a) TDS - CCR Leachate Release + Possible Alternative Source (Row b) **Western Boundary** Calcium - CCR Leachate Release (Row a) Chloride - CCR Leachate Release + Possible Alternative Source (Row b) pH – CCR Leachate Release (Row a) Sulfate - CCR Leachate Release (Row a) TDS - CCR Leachate Release (Row a)
4c	Is the CCR unit immediately underlain by clay, shale, or other geologic media with low hydraulic conductivity?	Varies	Uncertain	Supporting	Unit	Some areas of site are underlain by clayey colluvial soils, mostly along what were the lower portions of tributary valleys.
4d	Is the monitoring point distant from the facility AND does the constituent with an SSI/SSL have low mobility in groundwater given the hydrogeologic environment at the monitoring location (EPRI, Table A-3)?	No	CCR Release	Supporting	Case	All downgradient monitoring wells are located at the waste boundary except for GW-23 (Northern Boundary) and GW-9 (Western Boundary).
4e	Are the background monitoring wells screened in the same hydrostratigraphic unit, and along the same groundwater flow path, as the monitoring location with the SSI?	No / Yes	CCR Release	Supporting	Monitoring Point	The CCR Rule-defined uppermost aquifer at the site is comprised of multiple water-bearing strata that are hydraulically connected. Both of the site's upgradient wells (GW-7 and GW-22) are located along the appropriate groundwater flow paths to their corresponding downgradient wells, however, they are also positioned stratigraphically higher than the downgradient wells.

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
CCR Unit Design						
5a	Does the entire footprint of the monitored CCR unit have a liner?	Yes / No	Potential Alternate Source / CCR Release	Supporting	Unit	The landfill area does have a liner system while the impoundment area (including the dam) does not.
5b	If the facility is lined, is it a composite liner?	Yes / No	Potential Alternate Source / CCR Release	Supporting	Unit	A portion of the landfill area is lined with only 24-inches of compacted clay, while the remainder utilizes a composite system comprised of a geosynthetic clay liner (GCL) overlain by a high density polyethylene (HDPE) geomembrane.
5c	Does the entire footprint of the CCR unit have a leachate collection system?	Yes / No	Potential Alternate Source / CCR Release	Supporting	Unit	The entire footprint of the landfill area does have a leachate collection system. The impoundment area does not have a leachate collection system.
5d	If the CCR unit is unlined, is it known to have or is it likely to have groundwater intersecting the CCR?	Yes	CCR Release	Supporting	Unit	Both the landfill and impoundment areas are situated within a valley (the impoundment at the head and the landfill at the mouth) and the CCR Rule-defined uppermost aquifer at the site is comprised of multiple water-bearing strata that are hydraulically connected. The uppermost aquifer rock strata all outcropped within the valley before the disposal site was developed so it is very likely that groundwater intersects the CCR, particularly in the impoundment area.

Table Notes:

[1] ND (not determined) indicates that this line of evidence was not tested or there are insufficient data to make a determination; N/A means lines of evidence not applicable to the CCR unit.

[2] Line of Evidence (LOE) Types:
Key lines of evidence are based on relationships that must be observed in order for an SSI/SSL to be due to a release from a CCR unit. If these relationships are not observed, then they are critical to establishing an ASD. It is difficult to build a strong ASD without any key lines of evidence. It may be possible to build an ASD with a single key line of evidence, but the ASD will be stronger with additional key or supporting lines of evidence.
Supporting lines of evidence provide additional information that supports the ASD. Supporting lines of evidence are generally not sufficient to build an ASD unless there is at least one key line of evidence, although it may be possible if there are many supporting lines of evidence.

[3] This LOE applies to:
Constituent: An SSI/SSL for that constituent at any monitoring point
Monitoring Point: All SSIs/SSLs at a specific monitoring point
Case: An SSI/SSL for a specific constituent at a specific monitoring point
Unit: All SSIs/SSLs at the monitored unit

Table 3 - Leachate Data Summary

	Leachate Concentrations (mg/L)								GW Concentrations (mg/L) Northern Boundary											
Parameters	**LM1**	**LM2**	**LM3**	**LM4**	**LM5**	**LM6**	**LM7**	**Leachate Avg.**	**UG UPL (GW-22)**	**GW-19**	**GW-20**	**GW-23**	**GW-24**	**DG Avg.**	**Leachate Avg. > UG UPL?**	**DG Avg. > UG UPL?**	**GW-19 < Leachate Avg.?**	**GW-20 < Leachate Avg.?**	**GW-23 < Leachate Avg.?**	**GW-24 < Leachate Avg.?**
Boron	56.8	0.207	3.62	0.327	188	0.16	86.7	47.97	0.222	0.226	0.229	0.178	0.292	0.231	Yes	Yes	Yes	Yes	Yes	Yes
Calcium	515	243	220	2.58	574	105	244	272	16.832	10.1	5.38	620	270	226.37	Yes	Yes	Yes	Yes	No	Yes
Chloride	356	26	78.5	18.4	2,220	49.5	1,040	541	380.89	571	490	11,600	5,520	4,545.3	Yes	Yes	No	Yes	No	No
Fluoride	0.313	0.159	0.18	0.299	2.57	0.213	5.42	1.308	3.108	1.47	4.8	0.0125	0.0125	1.57	No	No	No	No	Yes	Yes
pH	8.09	7.43	6.96	7.8	8.67	7.25	8.36	7.79	8.965 (7.40)	7.63	8.11	6.84	6.95	7.38	In Range	< LPL	In Range	In Range	< LPL	< LPL
Sulfate	4,950	495	587	324	26,800	203	14,000	6,766	85.395	0.14	28.6	0.079	7.24	9.01	Yes	No	Yes	Yes	Yes	Yes
TDS	11,200	1,426.7	1,440	980	88,500	716	47,300	21,652	1,404.82	2,320	1,785	46,100	19,400	17,401	Yes	Yes	Yes	Yes	No	Yes
Barium	0.014952	0.033836	0.03367	0.033595	0.014577	0.045466	0.02769	0.029112	0.093799	1.24456	0.21416	4.22522	2.46586	2.03745	No	Yes	No	No	No	No
Lithium	----	----	----	----	----	----	----	----	0.016562	0.01397	0.01417	0.0321	0.02754	0.02195	----	Yes	----	----	----	----
Radium (226+228)	----	----	----	----	----	----	----	----	1.38	3.48	0.816	48.7	10.8	15.949	----	----	----	----	----	----

	Leachate Concentrations (mg/L)								GW Concentrations (mg/L) Western Boundary											
Parameters	**LM1**	**LM2**	**LM3**	**LM4**	**LM5**	**LM6**	**LM7**	**Leachate Avg.**	**UG UPL (GW-7)**	**GW-9**	**GW-27**	**GW-28**	**GW-29**	**DG Avg.**	**Leachate Avg. > UG UPL?**	**DG Avg. > UG UPL?**	**GW-9 < Leachate Avg.?**	**GW-27 < Leachate Avg.?**	**GW-28 < Leachate Avg.?**	**GW-29 < Leachate Avg.?**
Calcium	515	243	220	2.58	574	105	244	272	3.08	0.0945	45.9	5.91	11.5	15.85	Yes	Yes	Yes	Yes	Yes	Yes
Chloride	356	26	78.5	18.4	2220	49.5	1040	541	104	15.3	107	631	910	416	Yes	Yes	Yes	Yes	No	No
pH	8.09	7.43	6.96	7.8	8.67	7.25	8.36	7.79	8.451 (7.844)	7.54	7.34	7.66	7.66	7.55	< LPL	< LPL	< LPL	< LPL	< LPL	< LPL
Sulfate	4,950	495	587	324	26,800	203	14,000	6,766	0.537	0.221	8.645	0.263	0.654	2.446	Yes	Yes	Yes	Yes	Yes	Yes
TDS	11,200	1,426.7	1,440	980	88,500	716	47,300	21,652	1,260	7.68	522	2,093	2,980	1,401	Yes	Yes	Yes	Yes	Yes	Yes
Arsenic	0.056298	0.000282	0.000713	0.001005	0.076662	0.000434	0.399924	0.076474	0.00682	119	0.00058	0.00377	0.01646	29.75520	Yes	Yes	No	Yes	Yes	Yes
Barium	0.014952	0.033836	0.033670	0.033595	0.014577	0.045466	0.027690	0.029112	0.0934	744	0.82439	0.2038	0.86084	186.47226	No	Yes	No	No	No	No
Lithium	----	----	----	----	----	----	----	----	0.023374	0.06068	0.01186	0.01669	0.03182	0.03026	----	----	----	----	----	----
Molybdenum	10.75847	0.010788	0.14269	0.148449	15.6257	0.000898	4.72505	4.48744	0.006805	0.01523	0.00478	0.03071	0.00432	0.01376	Yes	Yes	Yes	Yes	Yes	Yes
Radium (226+228)	----	----	----	----	----	----	----	----	0.58	0.3455	1.197	0.5242	0.921	0.747	----	----	----	----	----	----

Notes: DG -Downgradient; GW - Groundwater; UG - Upgradient; UPL - Upper Prediction Limit
Leachate Concentrations from sampling performed in October 2017.
GW Concentrations of App. III parameters from sampling and analysis completed in October 2017.
GW Concentrations of App. IV parameters from sampling and analysis completed in August 2017.
UG UPL's based on 8 baseline sampling events.
Two-sided comparison (upper and lower) performed for pH. Comparisons to the UG UPL must fall within the PL range to be considered "No".

LM1 - Leachate collection from dam underdrain
LM2 - Landfill leachate detection system
LM3 - Surface Impoundment No. 1 underdrain effluent
LM4 - Surface Impoundment No. 2 underdrain effluent
LM5 - Stage 1G LCS
LM6 - Stage 2B LDS
LM7 - Stage 2B LCS

FIGURES

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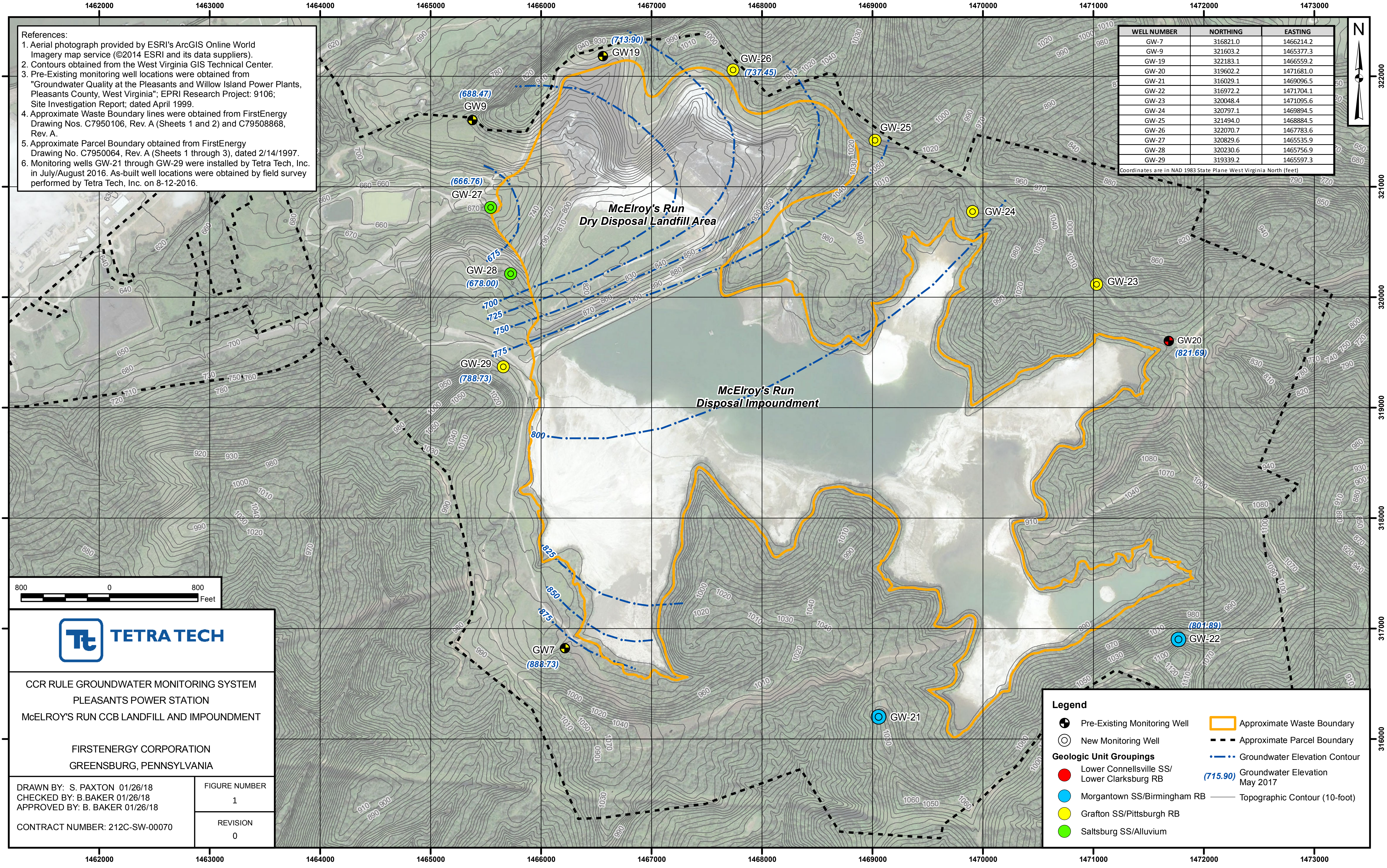

References:
1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (©2014 ESRI and its data suppliers).
2. Contours obtained from the West Virginia GIS Technical Center.
3. Pre-Existing monitoring well locations were obtained from "Groundwater Quality at the Pleasants and Willow Island Power Plants, Pleasants County, West Virginia"; EPRI Research Project: 9106; Site Investigation Report; dated April 1999.
4. Approximate Waste Boundary lines were obtained from FirstEnergy Drawing Nos. C7950106, Rev. A (Sheets 1 and 2) and C79508868, Rev. A.
5. Approximate Parcel Boundary obtained from FirstEnergy Drawing No. C7950064, Rev. A (Sheets 1 through 3), dated 2/14/1997.
6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

WELL NUMBER	NORTHING	EASTING
GW-7	316821.0	1466214.2
GW-9	321603.2	1465377.3
GW-19	322183.1	1466559.2
GW-20	319602.2	1471681.0
GW-21	316029.1	1469096.5
GW-22	316972.2	1471704.1
GW-23	320048.4	1471095.6
GW-24	320797.1	1469894.5
GW-25	321494.0	1468884.5
GW-26	322070.7	1467783.6
GW-27	320829.6	1465535.9
GW-28	320230.6	1465756.9
GW-29	319339.2	1465597.3

Coordinates are in NAD 1983 State Plane West Virginia North (feet)

Legend

Pre-Existing Monitoring Well	Approximate Waste Boundary
New Monitoring Well	Approximate Parcel Boundary
	Groundwater Elevation Contour

Geologic Unit Groupings

- 🟥 Lower Connellsville SS/ Lower Clarksburg RB
- ● Morgantown SS/Birmingham RB
- 🟨 Grafton SS/Pittsburgh RB
- 🟩 Saltsburg SS/Alluvium

(715.90) Groundwater Elevation May 2017

Topographic Contour (10-foot)

TETRA TECH

CCR RULE GROUNDWATER MONITORING SYSTEM
PLEASANTS POWER STATION
McELROY'S RUN CCB LANDFILL AND IMPOUNDMENT

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: S. PAXTON 01/26/18
CHECKED BY: B.BAKER 01/26/18
APPROVED BY: B. BAKER 01/26/18

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
1

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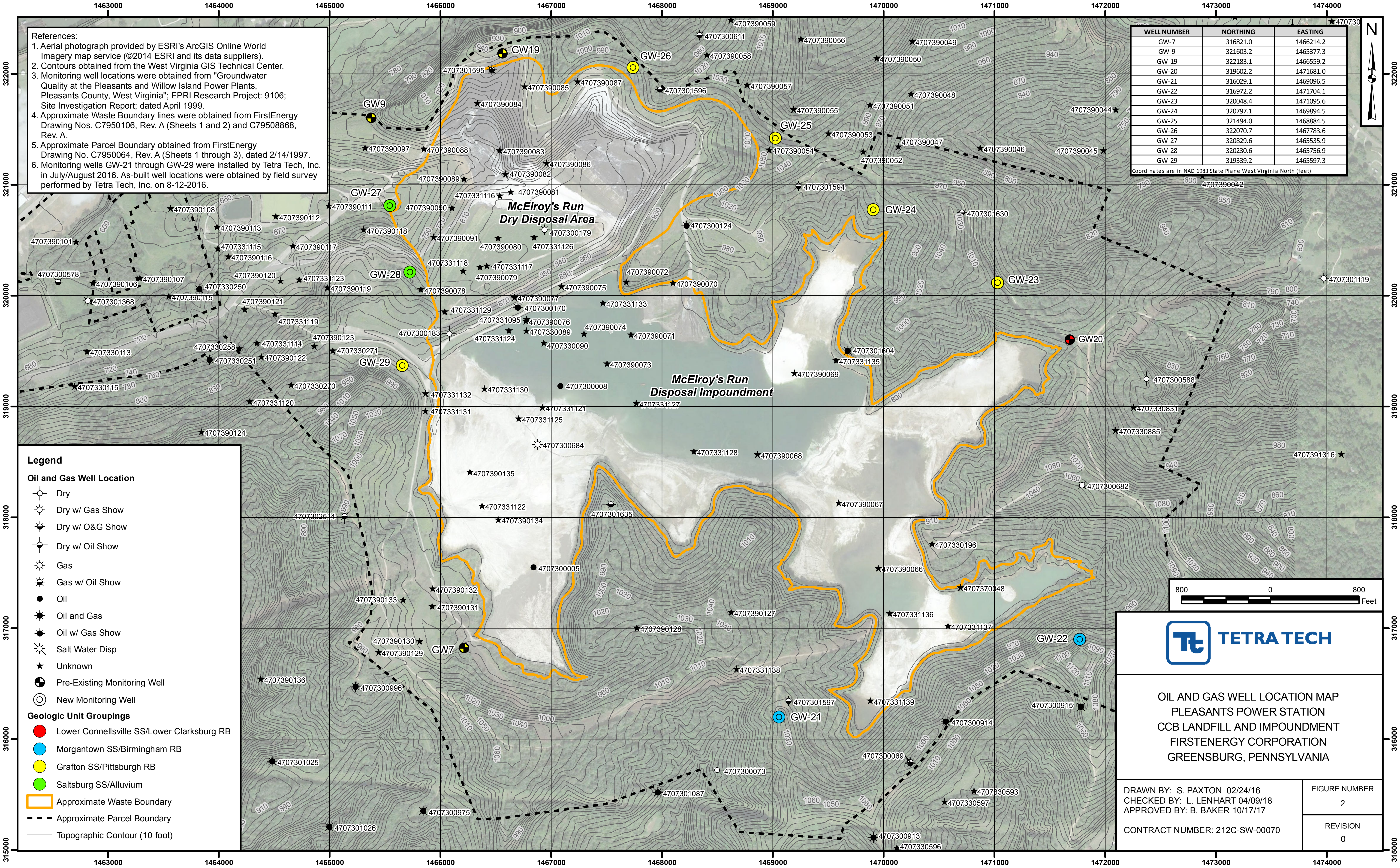

References:

1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (©2014 ESRI and its data suppliers).
2. Contours obtained from the West Virginia GIS Technical Center.
3. Monitoring well locations were obtained from "Groundwater Quality at the Pleasants and Willow Island Power Plants, Pleasants County, West Virginia"; EPRI Research Project: 9106; Site Investigation Report; dated April 1999.
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GW-26	322070.7	1467783.6
GW-27	320829.6	1465535.9
GW-28	320230.6	1465756.9
GW-29	319339.2	1465597.3

Coordinates are in NAD 1983 State Plane West Virginia North (feet)

Legend

Oil and Gas Well Location

- Dry
- Dry w/ Gas Show
- Dry w/ O&G Show
- Dry w/ Oil Show
- Gas
- Gas w/ Oil Show
- ● Oil
- Oil and Gas
- Oil w/ Gas Show
- Salt Water Disp
- ★ Unknown
- Pre-Existing Monitoring Well
- ◎ New Monitoring Well

Geologic Unit Groupings

- 🟥 Lower Connellsville SS/Lower Clarksburg RB
- 🟦 Morgantown SS/Birmingham RB
- 🟨 Grafton SS/Pittsburgh RB
- 🟩 Saltsburg SS/Alluvium
- ▭ Approximate Waste Boundary
- - - Approximate Parcel Boundary
- — Topographic Contour (10-foot)

TETRA TECH

OIL AND GAS WELL LOCATION MAP
PLEASANTS POWER STATION
CCB LANDFILL AND IMPOUNDMENT
FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: S. PAXTON 02/24/16
CHECKED BY: L. LENHART 04/09/18
APPROVED BY: B. BAKER 10/17/17

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
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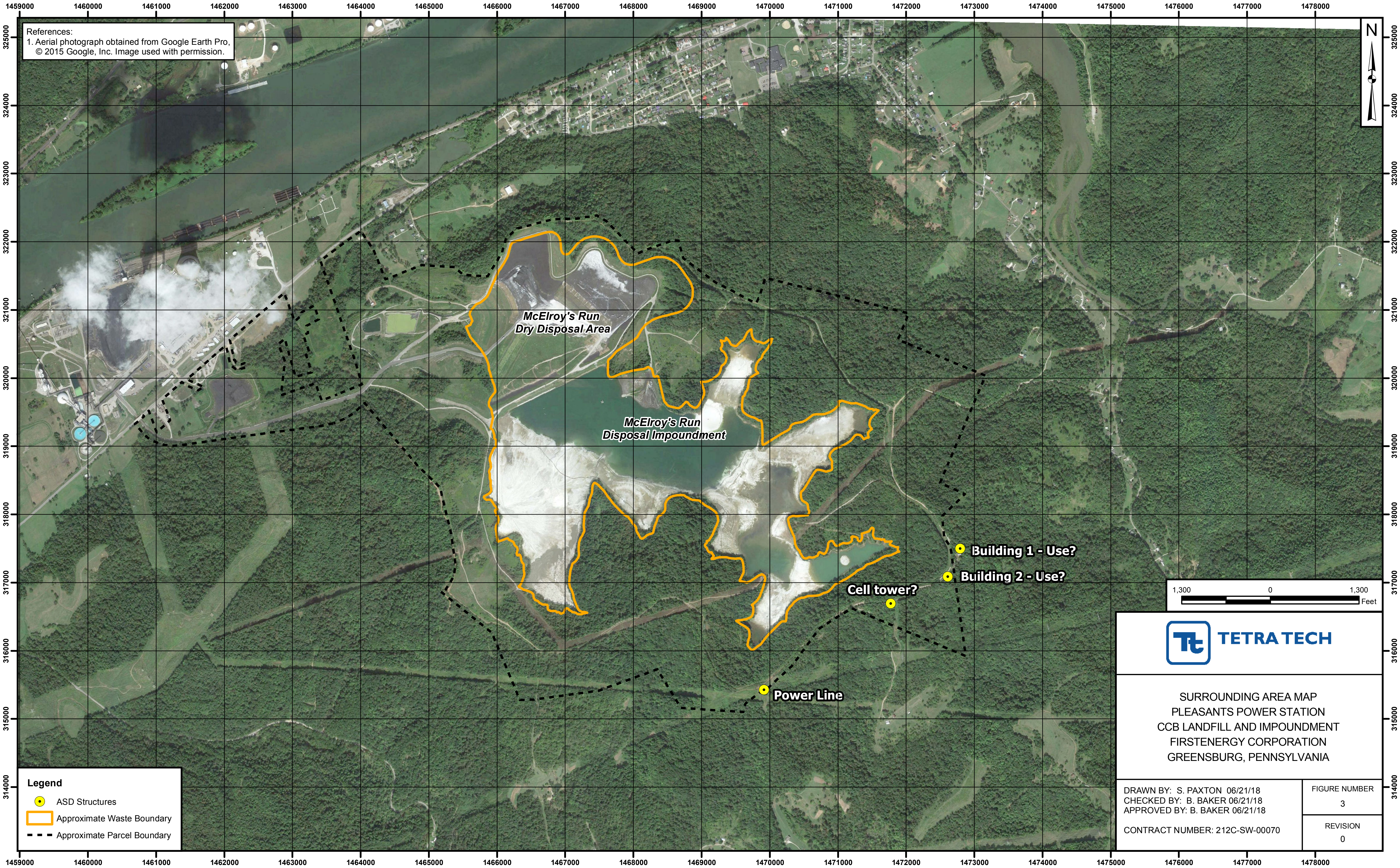

References:
1. Aerial photograph obtained from Google Earth Pro, © 2015 Google, Inc. Image used with permission.

TETRA TECH

SURROUNDING AREA MAP
PLEASANTS POWER STATION
CCB LANDFILL AND IMPOUNDMENT
FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: S. PAXTON 06/21/18
CHECKED BY: B. BAKER 06/21/18
APPROVED BY: B. BAKER 06/21/18

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
3

REVISION
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2019 ANNUAL CCR RULE GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

McELROY'S RUN COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY

Pleasants Power Station
Pleasants County, West Virginia

Prepared for:

FirstEnergy

800 Cabin Hill Drive
Greensburg, PA 15601

Prepared by:

Tetra Tech, Inc.

400 Penn Center Boulevard, Suite 200
Pittsburgh, PA 15235
Phone: (412) 829-3600
Fax: (412) 829-3260

Tetra Tech Project No. 212C-SW-00070

January 2020

2019 ANNUAL CCR RULE GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

McELROY'S RUN COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY

PLEASANTS POWER STATION
PLEASANTS COUNTY, WEST VIRGINIA

Prepared for:

FirstEnergy

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Tetra Tech Project No. 212C-SW-00070

January 2020

TABLE OF CONTENTS

TABLES

FIGURES

ATTACHMENTS

1.0 INTRODUCTION

This 2019 Annual Coal Combustion Residuals (CCR) Groundwater Monitoring and Corrective Action Report was prepared by Tetra Tech, Inc. (Tetra Tech) on behalf of FirstEnergy (FE), for the McElroy's Run Coal Combustion Byproduct Disposal Facility (CCBDF or "CCR units") at the Pleasants Power Station (hereinafter referred to as the "Station"). The Station is located in Pleasants County, West Virginia. This report was developed to comply with the requirements of § 257.90(e) of the federal CCR Rule (40 CFR, Part 257, Subpart D).

1.1 BACKGROUND AND SITE CHARACTERISTICS

CCRs produced at the Station are placed in the facility's captive CCBDF, which is located approximately one mile east-southeast of the Station. The facility consists of both a wet disposal area (impoundment) and dry disposal area (landfill) developed in the McElroy's Run watershed. Taken together, the landfill and impoundment are regulated under West Virginia Department of Environmental Protection (WVDEP) Solid Waste/National Pollutant Discharge Elimination System (NPDES) Water Pollution Control Permit No. WV0079171 and the CCR Rule. A WVDEP groundwater monitoring program for the facility has been in effect since 1994 and a separate CCR Rule groundwater monitoring program has been in effect since 2017. As per the CCR Rule, the landfill and impoundment are considered two separate, existing CCR units that share a common boundary (the impoundment dam). As provided by the CCR Rule, a multiunit groundwater monitoring system has been established for the CCBDF.

The impoundment is situated in the upper portion of the watershed, is unlined, and has been in continuous use since the late 1970s. The landfill is situated in the lower portion of the watershed (adjacent to and overlying the impoundment dam), is lined, and has been in continuous use since the early 1990s. At the current water level, the surface impoundment area is approximately 250 acres. The impoundment dam was constructed with a clay-filled cutoff trench at the upstream toe and with a clay blanket on the upstream face for a low permeability seepage barrier. The downstream portion of the dam was constructed using compacted fly ash and intermittent layers of bottom ash for blanket drains connected to sloping chimney drains that collect and convey seepage to discharge pipes for monitoring. The downstream face of the dam is covered by the landfill facility which WVDEP considers to be a buttress for the dam.

The landfill consists of three primary development stages (I, II, and III in the original WVDEP permit drawings and now referred to as 1, 2, and 3) which are further subdivided into construction subareas (e.g., Stage 1G, 2A, etc.). At this time, development and disposal operations have only been performed in the Stage 1 and 2 areas while the Stage 3 area remains undeveloped. Up until 2009, all the landfill subareas were constructed with a compacted clay liner system that included an underlying combined groundwater underdrain/leak detection system and overlying leachate collection system. However, since 2009 (in subareas 1G and 2B), a composite geosynthetic liner system (geosynthetic clay liner and geomembrane) has been utilized that also includes an underlying combined groundwater underdrain/leak detection system and overlying leachate collection system. For all portions of the landfill that overlie the downstream face of the impoundment dam, a bottom ash blanket drain layer has also been installed beneath the liner system. Leachate and contact stormwater runoff from the Stage 1 and 2 disposal areas are managed in Sedimentation Pond Nos. 1 and 2, which are lined impoundments located immediately down-valley of the future Stage 3 landfill development area.

Groundwater in the CCBDF area occurs primarily within fractured bedrock, principally in the following sandstone units (listed in descending order): the Morgantown sandstone, Grafton sandstone, Jane Lew sandstone, and the Saltsburg sandstone. Groundwater has also been identified in the Ames limestone and Harlem Coal (in association with the Jane Lew sandstone), and, to a lesser extent, the redbed units at the site. Generally, the fine-grained rock units (e.g., redbeds) typically serve as aquitards to limit vertical groundwater migration, while the coarser grained rock units (e.g., sandstones) typically have more well-developed and open fracture systems and are the primary conduits for groundwater migration. The fractured bedrock of multiple sandstone units, including the Morgantown sandstone, Grafton sandstone, Jane Lew sandstone, and Saltsburg sandstone, has been collectively identified as the uppermost aquifer for CCR Rule groundwater monitoring for the combined landfill and impoundment CCR units.

Historic and recent groundwater level data indicate groundwater flow at the CCBDF as being primarily controlled by topography (more important for vertical migration across groundwater flow units along the valley margins near where the units outcrop) with limited, secondary control by orientation (strike and dip) of the rock units (i.e. migration down-dip within a groundwater flow unit). Groundwater has previously been interpreted to flow north from the topographically higher areas located to the south and southeast of the impoundments. However, as additional rounds of site-wide groundwater level data have been collected and evaluated, a modified interpretation of current groundwater flow patterns along the northern boundary of the site has been made and included herein. West and northwest of the impoundment dam, topography may be the dominant influence on groundwater flow, as the multiple sandstone units underlying the site are eroded and discontinuous across the valley. Groundwater flow northwest of the dam and under the landfill is in the downstream direction of McElroy's Run toward the west. Flow in all of the rock units exhibit very little seasonal and temporal fluctuations. A representative set of water level data from the current reporting period (2019) were used for contouring groundwater flow patterns at the site. A more detailed discussion of the site's geologic and hydrogeologic characteristics, including the modified interpretation along the northern site boundary, is provided in Section 2.0 of this report.

1.2 REGULATORY BASIS

As required by § 257.90(e), of the CCR Rule, Owners or Operators of existing CCR landfills and surface impoundments must prepare an Annual Groundwater Monitoring and Corrective Action Report ("AGWMCA Report") no later than January 31, 2018 and annually thereafter. According to the subject section, "For the preceding calendar year, the annual report must document the status of the groundwater monitoring and corrective action program for the CCR unit, summarize key actions completed, describe any problems encountered, discuss actions to resolve the problems, and project key activities for the upcoming year."

This report has been developed to meet the general requirements above and the specific requirements of § 257.90(e)(1) through (5), which include:

"(1) A map, aerial image, or diagram showing the CCR unit and all background (or upgradient) and downgradient monitoring wells, to include the well identification numbers, that are part of the groundwater monitoring program for the CCR unit (see Figure 2-1);

(2) Identification of any monitoring wells that were installed or decommissioned during the preceding year, along with a narrative description of why those actions were taken (see Section 2.1.1);

(3) In addition to all the monitoring data obtained under §§ 257.90 through 257.98, a summary including the number of groundwater samples that were collected for analysis for each background and downgradient well, the dates the samples were collected, and whether the sample was required by the detection monitoring or assessment monitoring programs (see Sections 3.0 and 4.0 and Table 3-1);

(4) A narrative discussion of any transition between monitoring programs (e.g., the date and circumstances for transitioning from detection monitoring to assessment monitoring in addition to identifying the constituent(s) detected at a statistically significant increase over background levels) (see Section 2.3); and

(5) Other information required to be included in the annual report as specified in §§ 257.90 through 257.98 (see Sections 4.2, 4.3, and 5.0)."

In addition, the Owner or Operator must place the report in the facility's operating record as required by § 257.105(h)(1), provide notification of the report's availability to the appropriate State Director within 30 days of placement in the operating record as required by § 257.106(h)(1), and place the report on the facility's publicly accessible website, also within 30 days of placing the report in the operating record.

1.3 OVERVIEW OF REPORT CONTENTS

Section 1.0 of this report provided an overview of the CCR unit characteristics, regulatory basis, and a summary of the requirements for CCR Annual Groundwater Monitoring and Corrective Action Reports. Section 2.0 summarizes the status of key actions pertaining to CCR groundwater monitoring completed during 2019 for the CCBDF and plans for the upcoming year. Section 3.0 presents Detection Monitoring (DM) results from groundwater sampling events completed in 2019. Section 4.0 presents Assessment Monitoring (AM) results from groundwater sampling events completed in 2019 and discusses both Appendix IV Alternative Source Demonstration (ASD) activities and Nature and Extent of Release Characterization ("N&E Characterization") results from groundwater sampling events completed in 2019. Finally, Section 5.0 presents a summary of the Assessment of Corrective Measures (ACM) activities that were performed for the CCR units during 2019.

2.0 GENERAL INFORMATION

This section provides an overview of the status of the CCR groundwater monitoring program through 2019 and key activities planned for 2020.

2.1 STATUS OF THE CCR GROUNDWATER MONITORING AND CORRECTIVE ACTION PROGRAM

During calendar year 2019 (January 1st through December 31st), the following key actions were completed with regard to the CCR groundwater monitoring program for the CCBDF.

2.1.1 Groundwater Monitoring Well System

As documented in the facility's 2017 and 2018 AGWMCA Reports (accessible at http://ccrdocs.firstenergycorp.com/), the certified CCR monitoring well network consists of three upgradient (background) wells (GW-7, -21, and -22), seven downgradient wells to monitor the northern side of the combined CCR units (GW-9, -19, -20, -23, -24, -25, and -26), and three downgradient wells to monitor the western side of the combined CCR units (GW-27, -28, and -29), as summarized in attached Table 2-1 and shown on attached Figure 2-1. However, at this time, only GW-7 is being used for upgradient/background interwell comparisons based on the following:

- It was originally intended that upgradient wells GW-21 and GW-22, which are both screened in the Morgantown sandstone, would be grouped for statistical evaluation purposes. However, after both the background and the initial detection monitoring sampling events were completed, it was determined that the two wells did not have the level of statistical similarity needed for grouping and that the availability of sufficient volumes of recoverable water was a recurring problem for GW-21. As such, it was decided that only GW-22 would be used to establish background chemistry for the northern side of the CCR units since it exhibited lower concentrations of all the Appendix III parameters than those measured in GW-21 and it also provided a reliable water yield while GW-21 did not. GW-21 was left in place (i.e., it was not abandoned) and it has been sampled when sufficient volumes of recoverable water were available. GW-21's water levels have also continued to be used to verify groundwater flow patterns at the site. The current intent is to keep GW-21 as a part of the CCR monitoring network until a sufficiently sized data set can be compiled and used to determine whether or not it's statistically appropriate to group its results with the data set for GW-22.

- The groundwater levels measured throughout 2019 indicated that the wells installed along the northern CCBDF boundary had continued a downward trend that began after they were first installed in 2016 and later redeveloped in 2017, but finally appeared to stabilize. It's believed that this slow drop and stabilization of groundwater levels is attributable to the low permeability of the monitored aquifer along that side of the site. An updated evaluation of the site-wide groundwater level data resulted in a modified interpretation of groundwater flow patterns along the northern boundary of the site than were described in the 2017 and 2018 AGWMCA Reports. As shown on Figure 2-1, the current understanding is that groundwater flow beneath the CCBDF still flows north, but primarily originates from the topographically higher areas located to the south of the impoundment, with a portion flowing to the northwest and a portion flowing to the northeast. This modification to the groundwater flow pattern is such that one upgradient well, GW-7, is now considered the appropriate upgradient/background well for both the western and northern boundaries of the CCR units based on its physical position and since it exhibited lower background concentrations of all the Appendix IV parameters than those measured in GW-22 except for fluoride and lithium. As such, the AM statistical evaluations that were performed in 2019 have incorporated Upper Prediction Limits (UPLs) associated with GW-7 for both boundaries.

Other than the discussions presented above, no other changes to the monitoring well network (i.e., new wells added, or existing wells abandoned) occurred during 2019.

2.1.2 Groundwater Monitoring Plan

Consistent with the work performed and summarized in the 2017 and 2018 AGWMCA Reports, the CCR unit's Groundwater Monitoring Plan (GWMP) was followed during all 2019 field sampling and laboratory analysis activities and for statistically evaluating groundwater monitoring data developed from the CCR sampling and analysis program. No changes to the facility's GWMP occurred during 2019.

2.1.3 Background Groundwater Sampling

As documented in the 2017 and 2018 AGWMCA Reports, eight independent rounds of background groundwater samples for analyzing all Appendix III and IV parameters from each of the CCR monitoring wells were collected prior to initiating the facility's CCR Detection Monitoring program in October 2017. No modifications to this background dataset occurred during 2019.

2.1.4 Statistical Methods

As documented in the 2017 and 2018 AGWMCA Reports, the background dataset discussed in Section 2.1.3 of this Report was used to select the appropriate statistical evaluation methods for each CCR groundwater monitoring parameter to identify any Statistically Significant Increases (SSIs) over background concentrations and determine whether any concentrations were at Statistically Significant Levels (SSLs) above their respective Groundwater Protection Standards (GWPS) established for the site. These statistical methods are available on the facility's publicly accessible website and no changes were made to them during 2019.

2.2 PROBLEMS ENCOUNTERED/RESOLVED

As noted in the 2018 AGWMCA Report, having a sufficient recoverable volume of groundwater from downgradient well GW-26 continued to be a problem during sampling events AM-1 and AM-2. However, once the groundwater levels along the northern CCBDF boundary, including GW-26, were determined to have stabilized (refer to Section 2.1.1 of this Report), it was decided that the dedicated pump should be pulled from the well and have its intake depth lowered to try and take advantage of what water was available for sampling. The pump was pulled in February 2019 during the AM-3 sampling event, inspected for any maintenance issues (none were found), and a new safety cable and tubing were installed which lowered the pump intake depth by seven feet from its original setting. The pump was re-installed in April 2019 and successfully used for the AM-4 sampling event in July.

Other than the intake adjustment for GW-26 noted above, there were no other significant problems (e.g., quality control issues) encountered during 2019 with regard to the CCR groundwater monitoring program.

2.3 TRANSITION BETWEEN MONITORING PROGRAMS

As documented in the 2018 AGWMCA Report, the CCR units transitioned from Detection Monitoring to Assessment Monitoring. As part of this transition, all required notifications were issued, appropriate GWPS for Appendix IV parameters were established, and the first two AM sampling events (AM-1 and AM-2) were completed. The CCR units remained in Assessment Monitoring throughout 2019, with two additional AM sampling events completed (AM-3 and AM-4) and statistical evaluations of the AM-1, -2, and -3 sampling events being performed. As discussed in Section 4.1 of this Report, statistical evaluations of the AM-1, -2, and -3 data indicated there were SSLs in one or more well comparisons. Based on the parameters for which SSLs were identified, an Appendix IV Alternative Source Demonstration was then undertaken as discussed in Section 4.2 of this Report. However, all of the Appendix IV SSLs that were identified could not be attributed to alternative sources. As such, Nature and Extent of Release Characterization activities and an Assessment of Corrective Measures occurred and are discussed in Sections 4.3 and 5.0 of this Report, respectively.

As of December 31, 2019, the CCR units remained in Assessment Monitoring with ongoing Nature and Extent of Release Characterization and Selection of Remedy activities being performed.

2.4 KEY ACTIVITIES PLANNED FOR THE UPCOMING YEAR

The following are the key CCR groundwater compliance activities planned for 2020:

- Continue with Assessment Monitoring by conducting the annual and semi-annual rounds of sampling and analysis for applicable Appendix III and Appendix IV constituents [per 40 CFR § 257.95(f)] and evaluate the need to update the background data sets and associated UPLs.
- Complete the statistical evaluation of the AM-4 sampling event that occurred in 2019 to determine if there are any other Appendix IV constituent concentrations in the downgradient wells that are at SSLs above applicable GWPS.
- If any new SSLs are identified, provide appropriate notification [per § 257.95(g)] then potentially conduct an Appendix IV ASD [per § 257.95(g)(3)(ii)] to determine if a source other than the CCR units may be causing the new SSLs. Concurrent with undertaking an Appendix IV ASD, characterize the Nature and Extent of the new Appendix IV release and provide appropriate notification depending on the findings [per 40 CFR §§ 257.95(g)(1) and (2), respectively].
- If any new SSLs are identified and an ASD is either not undertaken, indicates that an alternative source is not responsible for all the new SSLs identified, or is not completed within 90 days of identifying there are new SSLs, then initiate and perform an Assessment of Corrective Measures for the new SSLs in accordance with 40 CFR § 257.96.
- Conduct SoR activities in compliance with 40 CFR § 257.97(a), which states that as soon as feasible after completion of the ACM, select a remedy that, at a minimum, meets the performance standards listed in 40 CFR § 257.97(b) and the evaluation factors listed in 40 CFR § 257.97(c). These activities are currently in progress and include determining current ownership of potentially affected adjacent properties, providing landowner notifications of potential impacts as per 40 CFR § 257.95(g)(2), confirming the presence

of potential downgradient domestic groundwater well receptors, and installing additional monitoring wells downgradient of the facility boundary.

- As required by 40 CFR § 257.97(d), specify, as part of the selected remedy, a schedule(s) for implementing and completing remedial activities. The schedule will require the completion of remedial activities within a reasonable period of time taking into consideration the factors set forth in 40 CFR §§ 257.97(d)(1) through (d)(6).
- As required by 40 CFR § 257.97(a), prepare a semi-annual report describing the progress in selecting and designing the remedy. The first semi-annual report will be prepared in the Spring of 2020.
- Should all required SoR activities be completed in 2020, prepare a final report describing the selected remedy. The final report will include a certification from a qualified professional engineer that the remedy selected meets the requirements of the CCR Rule selection criteria and the final report will be placed in the facility's operating record as required by § 257.105(h)(12).
- As required by 40 CFR § 257.96(e), discuss the results of the ACM at least 30 days prior to the final SoR, in a public meeting with interested and affected parties.

3.0 DETECTION MONITORING INFORMATION

3.1 GROUNDWATER ANALYTICAL RESULTS SUMMARY

As noted in Section 2.3, site-wide Assessment Monitoring was performed throughout 2019. As part of the AM program, all DM (Appendix III) parameters were also analyzed during each AM sampling event. This exceeds the requirements of 40 CFR § 257.95(d)(1) which only stipulate analyzing Appendix III parameters during every other AM sampling event.

The need to statistically analyze the 2019 Appendix III data to identify SSIs and determine if AM was necessary was precluded by the CCR units already being in AM during all of 2019, so no statistical analysis of the data was necessary. The 2019 Appendix III data that was collected and validated is presented in Table 3-1 with the intent of using it during the next update of the background dataset and associated UPLs, which will help increase the statistical power of future analyses.

4.0 ASSESSMENT MONITORING INFORMATION

4.1 GROUNDWATER ANALYTICAL RESULTS SUMMARY

In accordance with 40 CFR §§ 257.95(b) and (d)(1), the CCR groundwater sampling and analysis program implemented during 2019 consisted of two AM sampling events (AM-3 and AM-4) performed between February 5 and 25, 2019 and between July 23 and 31, 2019, respectively. For AM-3, all Appendix III and all Appendix IV constituents were analyzed while, for AM-4, analyses included all Appendix III parameters and only those Appendix IV parameters that were detected during previous AM sampling events. Laboratory analysis and validation of the sample data were completed on July 22, 2019 and January 17, 2020 for AM-3 and AM-4, respectively. Table 3-1 presents the validated analytical results for these events.

Statistical evaluations of AM data performed in 2019 included sampling events AM-1, AM-2, and AM-3. As noted in the 2018 AGWMCA Report, evaluations of data from sampling events AM-1 and AM-2 ended up being completed in January 2019 since receipt of outstanding validated results occurred late in the fourth quarter of that year. Statistical evaluation of AM-3 data was completed in August 2019 while evaluation of AM-4 data remains in-progress as of the end of the 2019 reporting period since receipt of validated AM-4 data occurred late in the fourth quarter of 2019 and a 90-day period is allowed by the CCR Rule for statistical evaluation, which falls in the first quarter of 2020. All statistical evaluation work was performed in accordance with the certified methods included in both the facility's operating record and the publicly accessible website and the results were used to determine whether there were any detected Appendix IV parameters at SSLs above the CCR unit's established GWPS. As documented in the 2018 AGWMCA Report, site-specific Appendix IV GWPS were established for the CCR units using the higher of the federal Maximum Contaminant Level (MCL) or UPL for each parameter or, for those parameters that don't have MCLs, the higher of the EPA Risk Screening Level (RSL) or the UPL. The site-specific GWPS and the results of the statistical evaluations of AM-1, -2, and -3 are presented in Tables 4-1 (northern boundary) and 4-2 (western boundary) and discussed below.

Statistical evaluation of the AM-1 and AM-2 data initially identified arsenic, barium, fluoride, lithium, and radium along the CCBDF northern boundary and arsenic along the western boundary as the parameters detected at concentrations greater than their respective GWPS. In accordance with 40 CFR § 257.106(h)(6), a notice was prepared and posted to the facility's operating record in February 2019, issued to the WVDEP, and then posted on the facility's publicly accessible website in April 2019, to provide notification of these five Appendix IV parameter SSLs at the CCR units. However, subsequent to the AM-1 and -2 statistical evaluations and as previously discussed in Section 2.1.1 of this Report, groundwater level data collected at the site necessitated a modified interpretation of current groundwater flow patterns along the northern boundary and an associated revision to the upgradient well comparisons in that area. The revised statistical evaluations determined that arsenic SSLs occurred in more wells than previously indicated but that fluoride was no longer an SSL for the single well (GW-20) in which it had originally been identified. As such, fluoride was no longer identified as an SSL at the site. During the SSL notification period and in accordance with 40 CFR § 257.95(g)(3)(ii), an Appendix IV ASD was initiated to assess the AM-1 and -2 findings (and later incorporated the AM-3 findings) and is discussed in Section 4.2 of this Report.

Results from statistical analysis of the AM-3 data were consistent with the previous AM results with respect to having SSLs for arsenic, barium, lithium, and radium along the northern boundary and arsenic along the western boundary. However, there were also first-time SSLs identified for cobalt in GW-26 and molybdenum in GW-20. The validity of these individual SSLs was questioned as, for GW-26, this was the first time a sample was able to be recovered during Assessment Monitoring and cobalt was not detected in any of the well's background sampling events, and, for GW-20, all previous background and AM sampling results were below the molybdenum GWPS. A determination as to whether or not these SSLs are anomalies will be made as part of the AM-4 statistical evaluations. If they are determined to be actionable, they will be addressed by ASD, N&E Characterization, and ACM, as applicable, in 2020.

As shown in Tables 4-1 and 4-2, to date, no other Appendix IV constituents have been detected at SSLs above the their GWPS under the CCR units' AM program.

4.2 APPENDIX IV ALTERNATIVE SOURCE DEMONSTRATION

40 CFR § 257.95(g)(3)(ii) allows the owner or operator of a CCR unit 90 days from the date of determining that an SSL has occurred to demonstrate that a source other than the CCR unit caused the SSL or that the apparent SSL was from a source other than the CCR unit or that it had resulted from errors in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. Pursuant to § 257.94(g)(3)(ii), an ASD was undertaken to assess if the Appendix IV SSLs determined for AM-1, -2, and -3 were attributable to a release from the CCR units or from a demonstrable alternative source(s). A copy of the report that documents the Appendix IV ASD activities and findings is included as Attachment A of this Report and summarized below.

For the Appendix IV ASD a multiple Line of Evidence (LOE) approach was followed. This approach divides LOEs into five separate categories (types): Sampling causes (ASD Type I); Laboratory causes (ASD Type II); Statistical evaluation causes (ASD Type III); Natural variation not accounted for in the basic AM statistics (ASD Type IV); and Potential natural or anthropogenic sources (ASD Type V). As detailed in Attachment A, LOE Types I through V were assessed along with the following additional site-specific Type V LOEs: Regional groundwater chemistry studies/reports; and Potential effects of on-site and nearby oil and gas wells.

Based on the information and data included in Attachment A, the following conclusions were reached for the SSLs that were identified for the AM-1, -2, and -3 events:

- The barium and combined radium 226/228 SSLs could be attributed to historical and current oil and gas exploration and production activities that have occurred at the site and, as such, no corrective measures were required for those parameters and assessment monitoring for barium and radium should continue.
- The source of the lithium SSLs was indeterminate, but the available evidence indicates there is a high potential they are also attributable to oil and gas impacts at the site. To resolve this uncertainty, isotopic analysis and lithium sampling of well brine from on-site production equipment will be considered in 2020 and assessment monitoring of lithium should continue.
- The arsenic SSLs could not be solely attributed to sources other than the CCR units, to errors in sampling, analysis, or statistical evaluation, or from natural variation in groundwater quality.

Based on the Appendix IV ASD findings and recommendations, a transition to the applicable requirements of Assessment of Corrective Measures for arsenic per § 257.96 of the CCR Rule was determined to be warranted along with continued Assessment Monitoring of lithium to verify concentrations remain below its GWPS.

4.3 NATURE AND EXTENT OF RELEASE CHARACTERIZATION

Pursuant to 40 CFR § 257.95(g)(1), following identification of SSLs greater than their respective GWPS and concurrent with performing the Appendix IV ASD, a N&E Characterization was initiated at the site. The N&E Characterization program is discussed in detail in the ACM Report prepared for the CCR units and posted on the facility's publicly accessible website. The scope of the N&E Characterization program included the following:

- Reviewing background information on the occurrence of arsenic and fate and migration characteristics of arsenic in groundwater.

- Evaluating groundwater flow patterns at the site to establish that a combination of CCR and WVDEP groundwater monitoring program wells (GW-9, -19, -20, -23, -24, -25, and -26) fulfilled the requirement of 40 CFR § 257.95(g)(3)(iii) of having at least one monitoring well positioned at the facility boundary in the direction of contaminant migration and that installation of additional monitoring wells did not appear necessary for N&E Characterization.

- Establishing a N&E Characterization sampling and analysis program that consisted of the two regularly scheduled 2019 AM events (AM-3 and AM-4) for all of the CCR monitoring wells at the site and a third sampling event performed in July 2019 dedicated solely to N&E Characterization purposes using two WVDEP monitoring wells at the site.

- Delineating the extent of arsenic in site groundwater based on the N&E Characterization sampling and analysis program.

Final validated results for the dedicated July 2019 N&E Characterization sampling event were not available at the time the Appendix IV ASD and subsequent ACM were completed, so they are provided in Table 4-3 of this Report. The data presented in Table 4-3 indicate concentration trends similar to those found in previous sampling events and support the ASD, N&E Characterization, and ACM findings and recommendations summarized herein.

The N&E Characterization found that elevated arsenic concentrations are occurring through the impoundment and nearby adjacent areas, with the highest concentrations occurring at GW-19 (northwestern area) and GW-22 (southeastern area). Based on the interpreted distribution in groundwater, arsenic concentrations above the GWPS likely occur beyond the property boundaries to the north and southeast. In response to these findings, additional N&E Characterization work was determined to be necessary and is currently in progress. This additional work includes determining current ownership of potentially affected adjacent properties, providing landowner notifications of potential impacts as per 40 CFR § 257.95(g)(2), confirming the presence of potential downgradient domestic groundwater well receptors, and installing additional monitoring wells downgradient of the facility boundary.

Potentially impacted groundwater flows downgradient of the landfill (to the north and southeast) are expected to undergo additional attenuation based on a combination of advection, dispersion, and, potentially, natural dilution, resulting in concentrations that are anticipated to be below the arsenic GWPS before flow reaches any potential off-site groundwater receptor, with the nearest potential groundwater supply user in the downgradient flow paths being located approximately 1,500 feet from the facility boundary. However, since arsenic concentrations greater than the GWPS are likely occurring in the areas situated immediately downgradient of the facility boundary, an ACM was performed as discussed in Section 5.0 of this Report.

5.0 ASSESSMENT OF CORRECTIVE MEASURES

5.1 ACM NOTIFICATIONS

As discussed in Section 4.0, CCR Rule groundwater assessment monitoring conducted at the site identified arsenic concentrations in certain downgradient CCR monitoring wells which were at SSLs that exceeded the GWPS for arsenic, resulting in the need to conduct an Assessment of Corrective Measures per 40 CFR § 257.96. The following summarizes the notifications related to the ACM:

- On April 15, 2019, pursuant to 40 CFR §§ 257.95(g)(3)(i) and 257.105(h)(9), FE provided notification in the facility's operating record that an ACM had been initiated for arsenic in groundwater at the site. The notification was posted to the publicly accessible website on May 22, 2019.
- On July 15, 2019, pursuant to 40 CFR § 257.96(a), FE provided a demonstration in the facility's operating record that, based on hydraulic characteristics of the uppermost aquifer at the site, an additional 60 days was required to complete the ACM.
- Pursuant to 40 CFR § 257.96(d), the ACM Report was posted in the operating record and to the publicly accessible website by October 16, 2019.

5.2 ACM REPORT SUMMARY

As required by 40 CFR § 257.96(c), the ACM included an analysis of the effectiveness of potential corrective measures in meeting the remedy requirements and objectives as described under 40 CFR § 257.97. The ACM Report evaluated the following corrective measures against the referenced criteria: Source Control, Groundwater Extraction and Treatment, In-Situ Technologies and Monitored Natural Attenuation.

Based on the evaluation of viable remediation technologies, Monitored Natural Attenuation (MNA), combined with source control by the eventual installation of a final cover system, ranked highest among the evaluated options. Also, additional monitoring of the groundwater network was recommended to confirm there are not trend changes that could impact remedy effectiveness. The candidate corrective measures will be further evaluated in 2020 as part of the Selection of Remedy process discussed in Section 7.0 of the ACM Report.

TABLES

TABLE 2-1
CCR RULE GROUNDWATER MONITORING SYSTEM WELL SUMMARY
McELROY's RUN CCB DISPOSAL FACILITY – 2019 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

Well	Year Installed	Formation Monitored	Ground Surface Elevation (ft MSL)	Total Well Depth (ft bgs)	Monitored Interval (ft bgs)	Monitored Interval (ft MSL)	Casing ID and Material
Upgradient (Background)							
GW-7	1994	Grafton SS, Ames LS	918.40	101.2	75.7 – 100.7	817.70 – 842.70	4" - Sch. 40 PVC
GW-21*	2016	Morgantown SS	1033.01	234.2	214.2 – 234.2	798.77 – 818.77	2" - Sch. 40 PVC
GW-22*	2016	Morgantown SS	1045.18	370.2	350.2 – 370.2	675.02 – 695.02	2.5" - Sch. 80 PVC
Downgradient							
GW-9	1994	Ames LS, Jane Lew SS, Pittsburgh RB	797.42	177.7	137.2 – 177.2	620.22 – 660.22	4" - Sch. 40 PVC
GW-19	1995	Birmingham RB, Grafton SS, Ames LS	920.64	238.9	198.9 – 238.9	681.74 – 721.74	2" - Sch. 40 PVC
GW-20	1995	Lower Clarksburg RB	923.00	150.5	100.5 – 150.5	772.50 – 822.50	2" - Sch. 40 PVC
GW-23	2016	Grafton SS	974.40	392.9	372.9 – 392.9	581.53 – 601.53	2.5" - Sch. 80 PVC
GW-24	2016	Grafton SS	941.55	271.1	251.1 – 271.1	670.50 – 690.50	2" - Sch. 40 PVC
GW-25	2016	Grafton SS	1006.22	303.7	283.7 – 303.7	702.53 – 722.53	2" - Sch. 40 PVC
GW-26*	2016	Grafton SS	984.16	288.2	268.2 – 288.2	695.95 – 715.95	2" - Sch. 40 PVC
GW-27	2016	Saltsburg SS	675.30	48.3	38.3 – 48.3	626.96 – 636.96	2" - Sch. 40 PVC
GW-28	2016	Saltsburg SS	801.95	175.6	165.6 – 175.6	626.38 – 636.38	2" - Sch. 40 PVC
GW-29	2016	Grafton SS	928.49	166.0	156.0 – 166.0	762.45 – 772.45	2" - Sch. 40 PVC

Notes: SS = sandstone LS = limestone RB = red beds MSL = mean sea level bgs = below ground surface ID = inside diameter
PVC = polyvinyl chloride * = currently used only for water level measurements

TABLE 3-1
CCR RULE GROUNDWATER ASSESSMENT MONITORING ANALYTICAL RESULTS SUMMARY
McELROY'S RUN CCB DISPOSAL FACILITY - 2019 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

			APPENDIX III (all Chemical Constituents reported as TOTAL RECOVERABLE)[1]							APPENDIX IV (all Chemical Constituents reported as TOTAL RECOVERABLE)[1]														
SAMPLING EVENT NO.[2]	WELL ID[3]	SAMPLE DATE	BORON METALS MG/L	CALCIUM METALS MG/L	CHLORIDE MISC MG/L	FLUORIDE MISC MG/L	PH MISC S.U.	SULFATE MISC MG/L	TDS MISC MG/L	ANTIMONY METALS MG/L	ARSENIC METALS MG/L	BARIUM METALS MG/L	BERYLLIUM METALS MG/L	CADMIUM METALS MG/L	CHROMIUM METALS MG/L	COBALT METALS MG/L	LEAD METALS MG/L	LITHIUM METALS MG/L	MERCURY METALS MG/L	MOLYBDENUM METALS MG/L	SELENIUM METALS MG/L	THALLIUM METALS MG/L	RADIUM-226 RADIOCHEM PCI/L	RADIUM-228 RADIOCHEM PCI/L
13 (AM-3)	GW-7	2/19/2019	0.2946	2.54	112	8.07 J-	8.25	0.115 J	1310	0.00107 U	0.00042	0.07666	0.00022 U	0.00067 U	0.00145 U	0.00047 U	0.00052 U	0.01904	0.00016 U	0.00113 U	0.0034 U	0.00017 U	0.0695 U	0.438
14 (AM-4)	GW-7	7/23/2019	0.2817	2.94	117	8.38	8.43 J	0.121 J	1355	0.00107 U	0.0007 U	0.08553	0.00022 U	0.00067 U	0.00145 U	0.00047 U	0.00052 U	0.0216	0.00016 U	0.00113 U	0.0068 U	0.00017 U	--	--
13 (AM-3)	GW-9	2/21/2019	0.0913 J	15.875	8	0.203 J-	7.85	123	780	0.00107 U	0.0005	0.06275	0.00022 U	0.00067 U	0.00145 U	0.00047 U	0.00052 U	0.01743	0.00016 U	0.00113 U	0.0034 U	0.00017 U	0.118 U	0.0674 U
14 (AM-4)	GW-9 (D)	7/30/2019	0.1039 J	15.028	8 J-	0.198	7.79 J	123	796	0.00107 U	0.00039	0.06203	0.00022 U	0.00067 U	0.00145 U	0.00047 U	0.00052 U	0.01581	0.00016 UJ	0.00113 U	0.0034 U	0.00017 U	--	--
14 (AM-4)	GW-9	7/30/2019	0.093 J	14.318	7.98 J-	0.199	7.85 J	123	792	0.00107 U	0.00066	0.06104	0.00022 U	0.00067 U	0.00145 U	0.00047 U	0.00052 U	0.01575	0.00016 UJ	0.00113 U	0.0034 U	0.00017 U	--	--
13 (AM-3)	GW-19	2/14/2019	0.2405	9.85	600	1.63	7.74	0.223	2413.333	0.00107 U	0.09721	1.10111	0.00022 U	0.00067 U	0.00145 U	0.00047 U	0.00052 U	0.01414	0.00016 U	0.00113 U	0.0034 U	0.00017 U	1.3	1.14
14 (AM-4)	GW-19	7/25/2019	0.2328 J+	10.261	638	1.69	7.78 J	0.0386 UJ	2480	0.00107 U	0.11223	1.23469	0.00022 U	0.00067 U	0.00145 U	0.00047 U	0.00052 U	0.01601	0.00016 U	0.00113 U	0.0034 U	0.00017 U	--	--
13 (AM-3)	GW-20	2/11/2019	0.2442	5.29	559	5.66	7.92	27.1 J-	1840	0.00107 U	0.00249	0.24056	0.00022 U	0.00067 U	0.00354	0.00058 J	0.00099	0.01607	0.00016 U	0.10255	0.00991	0.00017 U	0.273	0.232 U
14 (AM-4)	GW-20	7/24/2019	0.2771 J+	6.73	580	5.57	8.26 J	30	2375	0.00107 U	0.00253	0.22915	0.00022 U	0.00067 U	0.00197	0.00047 U	0.00052 U	0.01625	0.00016 U	0.10137	0.01529	0.00017 U	--	--
13 (AM-3)	GW-21	2/19/2019	0.144 J	7.95	656	2.57 J-	8.32	225	2360	0.00107 U	0.0168	0.11947	0.00022 U	0.00067 U	0.00584	0.00076 J	0.00052 U	0.00769	0.00016 U	0.26165	0.10061	0.00017 U	0.0758 U	0.457
14 (AM-4)	GW-21	7/23/2019	0.1436 J	10.461	691	2.57	8.4 J	237	2460	0.00107 U	0.01449	0.12625	0.00022 U	0.00067 U	0.00259	0.00047 U	0.00052 U	0.00916	0.00016 U	0.23858	0.08281	0.00017 U	--	--
13 (AM-3)	GW-22	2/25/2019	0.2029	4.75	499	2.33 J-	8.4	44 J-	1630	0.00107 U	0.16358	0.04989	0.00022 U	0.00067 U	0.00145 U	0.00047 U	0.0017	0.00591	0.00016 U	0.13215	0.0034 U	0.00017 U	0.0976 U	0.461 U
14 (AM-4)	GW-22	7/29/2019	0.2037	5.1	617	2.02	8.21 J	44.9	1760	0.00107 U	0.16488	0.06967	0.00022 U	0.00067 U	0.00145 U	0.00047 U	0.00231	0.00755	0.00016 UJ	0.12276	0.0034 U	0.00017 U	--	--
13 (AM-3)	GW-23	2/7/2019	0.2161	756	12900	0.351	6.83	0.2664 J-	68500	0.00426 U	0.03247	9.76212	0.00022 U	0.0027 U	0.0058 U	0.00284	0.00052 U	0.15017	0.00016 U	0.00734	0.00068 U	0.00017 U	23.6 J	59.8 J
14 (AM-4)	GW-23	7/24/2019	1.3 J+	11.677	13700	0.025 U	7.14 J	0.372	62500	0.00533 U	0.03295	12.71739	0.0011 U	0.00337 U	0.00725 U	0.00325	0.0026 U	0.17117	0.00016 U	0.00666	0.017 U	0.00087 U	--	--
13 (AM-3)	GW-24	2/11/2019	0.3222	371	8520	0.266	6.88	0.0386 UJ	42400	0.00107 U	0.02855	9.25331	0.00022 U	0.00067 U	0.0029 U	0.00209	0.00052 U	0.04512	0.00016 U	0.00853	0.0068 U	0.00017 U	12.7 J	33.4 J
14 (AM-4)	GW-24	7/25/2019	0.2787 J+	1020	8110	1.25 U	7.06 J	0.0386 UJ	45100	0.00533 U	0.02649	12.57961	0.0011 U	0.00337 U	0.00725 U	0.00238 U	0.0026 U	0.05897	0.00016 U	0.00609	0.017 U	0.00087 U	--	--
13 (AM-3)	GW-25	2/7/2019	0.1709 J	335	7110	0.025 U	7.22	0.618	35900	0.00426 U	0.05652	7.62675	0.00025	0.0027 U	0.01045	0.00371	0.00505	0.03069	0.00016 U	0.01182	0.00068 U	0.00017 U	13.2	17.3
14 (AM-4)	GW-25	7/24/2019	0.186 J	329	7820	0.025 U	7.59 J	0.385	38100	0.00533 U	0.05792	9.75893	0.00022 U	0.00337 U	0.00915	0.00366	0.00313	0.03791	0.00016 U	0.01259	0.0034 U	0.00017 U	--	--
13 (AM-3)	GW-26	2/25/2019	0.15 U	33.509	433	1.58 J-	8.48	0.201 J-	1690	0.0107 U	0.03057	0.53473	0.00255	0.00675 U	0.0382	0.01594	0.01799	0.03863	0.00163 U	0.02644	0.034 U	0.00175 U	0.619	1.3
14 (AM-4)	GW-26	7/29/2019	0.1905 J	63.331	498	1.46	8.29 J	1.76	15500	0.00107 U	0.02522	1.33341	0.00437	0.00067 U	0.09467	0.0343	0.03931	0.08245	0.00016 UJ	0.00968	0.034 U	0.00033	--	--
13 (AM-3)	GW-27	2/5/2019	0.1046 J	55.651	128	0.305	7.56	4.25	576	0.00107 U	0.00035	0.91402	0.00022 U	0.00067 U	0.00145 U	0.00047 U	0.00052 U	0.01319	0.00016 U	0.00346	0.00068 U	0.00017 U	0.475	0.821
14 (AM-4)	GW-27	7/24/2019	0.1195 J	53.304	135	0.239	7.74 J	3.63	588	0.00107 U	0.00035 U	0.99454	0.00022 U	0.00067 U	0.00145 U	0.00047 U	0.00052 U	0.01469	0.00016 U	0.00389	0.0034 U	0.00017 U	--	--
13 (AM-3)	GW-28	2/19/2019	0.224	6.38	693	2.02	7.86	0.109 J	2220	0.00107 U	0.00554	0.24927	0.00022 U	0.00067 U	0.00145 U	0.00047 U	0.00052 U	0.01657	0.00016 U	0.0341	0.0034 U	0.00017 U	0.266	0.2 U
14 (AM-4)	GW-28	7/23/2019	0.2298	7.16	695	2.09	7.97 J	0.136 J	2280	0.00107 U	0.00458	0.26772	0.00022 U	0.00067 U	0.00145 U	0.00047 U	0.00052 U	0.01931	0.00016 U	0.03372	0.0034 U	0.00017 U	--	--
13 (AM-3)	GW-29 (D)	2/5/2019	0.3392	12.55	959	1.3	7.73	0.666 J	2896	0.00107 U	0.0179	1.06651	0.00022 U	0.00067 U	0.00145 U	0.00047 U	0.00052 U	0.03453	0.00016 U	0.00554	0.00068 U	0.00017 U	0.468	0.599
13 (AM-3)	GW-29	2/5/2019	0.3321	11.797	959	1.3	7.8	0.207 J	3720	0.00107 U	0.01856	1.05644	0.00022 U	0.00067 U	0.00145 U	0.00047 U	0.00052 U	0.03367	0.00016 U	0.00555	0.00068 U	0.00017 U	0.529	0.738
14 (AM-4)	GW-29	7/23/2019	0.3658	14.272	996	1.25	8 J	0.451	3760	0.00107 U	0.01422	1.17521	0.00022 U	0.00067 U	0.00145 U	0.00047 U	0.00052 U	0.03459	0.00016 U	0.00416	0.0034 U	0.00017 U	--	--

NOTES:

[1] Lab analyses were completed by Beta Lab and TestAmerica Laboratories, Inc., both of which are accredited/certified laboratories: Beta Lab ISO/IEC 17025 Cert No. 2489.01 (Exp. 11-30-20) and ISO/IEC 9001 Cert. No. 83761-IS7 (Exp. 01-16-21) and TestAmerica NELAP Identification Number: 68-00340, EPA Region: 3, Expiration Date: 08-31-20.

[2] Event Nos. 13 and 14 correspond to Assessment Monitoring (AM) sampling events AM-3 and AM-4, respectively.

[3] Field duplicate samples that were taken for Quality Control purposes are noted with a (D).

DATA QUALIFER DEFINITIONS:

The following definitions provide brief explanations of the validation qualifiers assigned to results in the data review process.

U	The analyte was analyzed for, but was not detected at a level greater than or equal to the level of the adjusted method detection limit for sample and method.
J	The analyte was positively identified and the associated numerical value is the approximate concentration of the analyte in the sample (due either to the quality of the data generated because certain quality control criteria were not met, or the concentration of the analyte was below the reporting limit).
J+	The result is an estimated quantity, but the result may be biased high.
J-	The result is an estimated quantity, but the result may be biased low.
UJ	The analyte was analyzed for, but was not detected. The reported detection limit is approximate and may be inaccurate or imprecise.
R	The sample result (detected) is unusable due to the quality of the data generated because certain criteria were not met. The analyte may or may not be present in sample
UR	The sample result (nondetected) is unusable due to the quality of the data generated because certain criteria were not met. The analyte may or may not be present in sample.

TABLE 4-1
CCR RULE INTERWELL COMPARISON OF SAMPLING EVENT AM-1, -2, AND -3 APPENDIX IV DATA

Northern Boundary							Event 11 (AM-1)							
							Downgradient Wells							
Parameter	Units	Data Distribution for Upgradient Well GW-7	UPL Type	UPL Value[a,b]	Federal MCLs/RSLs	GWPS	GW-9	GW-19	GW-20	GW-23	GW-24	GW-25	GW-26[e]	
Antimony	mg/L	Unknown	Poisson	0.00133	0.006	0.006	<0.00017	<0.00017	<0.00022	<0.00089	0.00045	<0.00025	NS	
Arsenic	mg/L	Unknown	Poisson	0.00682	0.01	0.01	0.00033	0.12848	0.00208	0.02904	0.02311	0.04674	NS	
Barium	mg/L	Log–Normal	Parametric	0.0934	2	2	0.05607	1.11921	0.18475	10.40809	8.53453	6.69065	NS	
Beryllium	mg/L	Unknown[c]	DQ[d]	NA	0.004	0.004	<0.00022	<0.00022	<0.00022	<0.00022	<0.00022	0.00024	NS	
Cadmium	mg/L	Unknown[c]	DQ[d]	NA	0.005	0.005	<0.00017	<0.00017	<0.00017	<0.00017	<0.00017	<0.00017	NS	
T. Chromium	mg/L	Unknown[c]	DQ[d]	NA	0.1	0.1	<0.00045	<0.00045	0.00188	<0.0009	0.0005	0.00947	NS	
Cobalt	mg/L	Unknown[c]	DQ[d]	NA	0.006	0.006	<0.00047	<0.00047	<0.00047	0.00217	0.00184	0.00213	NS	
Fluoride	mg/L	Normal	Parametric	9.291	4	9.291	0.224	1.59	***5.58***	<0.025	<0.025	<0.025	NS	
Lead	mg/L	Unknown[c]	DQ[d]	NA	0.015	0.015	<0.00052	<0.00052	<0.00052	<0.00052	<0.00052	0.00599	NS	
Lithium	mg/L	Normal	Parametric	0.023374	0.04	0.04	0.01629	0.01403	0.01344	0.1054	0.03662	0.02067	NS	
Mercury	mg/L	Unknown	Poisson	0.00031	0.002	0.002	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	NS	
Molybdenum	mg/L	Log–Normal	Parametric	0.006805	0.1	0.1	0.00033	<0.00028	0.09681	0.00568	0.00711	0.01146	NS	
Selenium	mg/L	Unknown[c]	DQ[d]	NA	0.5	0.5	<0.0011	<0.0044	0.01997	0.00279	<0.0011	<0.0011	NS	
Thallium	mg/L	Unknown[c]	DQ[d]	NA	0.002	0.002	<0.00017	<0.00017	<0.00017	<0.00017	<0.00017	<0.00017	NS	
Sum Ra226+Ra228	pCi/L	Unknown	Poisson	0.58	5	5	0.164	1.6	<1.603	86.6	49.2	24.2	NS	

Event 11 (AM-1) Upgradient Well GW-7	
<0.00017	U
<0.00075	U
0.0811	
<0.00022	UJ
<0.00017	UJ
<0.00045	U
<0.00047	UJ
7.89	J-
<0.00052	UJ
0.02062	J
<0.00004	UJ
<0.00028	U
<0.0055	UJ
<0.00017	UJ
<0.2838	U

[a] Prediction Limits calculated using 5% alpha.

[b] Upper Prediction Limit used for all parameters.

[c] Data distribution set to Unknown if all values non-detect in upgradient well.

[d] DQ is Double Quantification Rule. If Event 11 sample is detectible, will need to resample the downgradient well to see if two successive, independent detected values occur. If so, that would be an SSI. If value was detected in upgradient well in Event 11, would use Poisson PL instead.

[e] GW-26 not sampled (NS) due to insufficient recoverable water.

#.#### = UPL > Result > MCL/RSL
🟩 = SSI < GWPS
🟥 = SSI > GWPS
🟨 = DQ Parameter with Verification Sampling Needed

Northern Boundary							Event 12 (AM-2)							
							Downgradient Wells							
Parameter	Units	Data Distribution for Upgradient Well GW-7	UPL Type	UPL Value[a,b]	Federal MCLs/RSLs	GWPS	GW-9	GW-19	GW-20	GW-23	GW-24	GW-25	GW-26[e]	
Antimony	mg/L	Unknown	Poisson	0.00133	0.006	0.006	<0.00017	<0.00017	<0.00024	0.00068	0.00045	0.00041	NS	
Arsenic	mg/L	Unknown	Poisson	0.00682	0.01	0.01	0.00068	0.08846	0.00235	0.02875	0.02401	0.04887	NS	
Barium	mg/L	Log–Normal	Parametric	0.0934	2	2	0.05274	1.08458	0.18929	10.51039	10.27638	7.03146	NS	
Beryllium	mg/L	Unknown[c]	DQ[d]	NA	0.004	0.004	<0.00022	<0.00022	<0.00022	<0.00022	<0.00022	<0.00022	NS	
Cadmium	mg/L	Unknown[c]	DQ[d]	NA	0.005	0.005	<0.00017	<0.00017	0.00021	<0.00017	<0.00017	<0.00017	NS	
T. Chromium	mg/L	Unknown[c]	DQ[d]	NA	0.1	0.1	<0.00045	<0.00045	0.00138	<0.00045	<0.00045	0.00464	NS	
Cobalt	mg/L	Unknown[c]	DQ[d]	NA	0.006	0.006	<0.00047	<0.00047	<0.00047	0.00211	0.00162	0.00143	NS	
Fluoride	mg/L	Normal	Parametric	9.291	4	9.291	0.139	1.71	***5.61***	0.062	<0.25	0.536	NS	
Lead	mg/L	Unknown[c]	DQ[d]	NA	0.015	0.015	<0.00052	<0.00052	<0.00052	<0.00052	<0.00052	0.00306	NS	
Lithium	mg/L	Normal	Parametric	0.023374	0.04	0.04	0.01462	0.01314	0.01361	0.11306	0.03499	0.02258	NS	
Mercury	mg/L	Unknown	Poisson	0.00031	0.002	0.002	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	NS	
Molybdenum	mg/L	Log–Normal	Parametric	0.006805	0.1	0.1	<0.00028	<0.00028	0.09825	0.00481	0.00658	0.01186	NS	
Selenium	mg/L	Unknown[c]	DQ[d]	NA	0.5	0.5	<0.0011	<0.0011	0.01718	<0.0022	<0.0011	<0.0011	NS	
Thallium	mg/L	Unknown[c]	DQ[d]	NA	0.002	0.002	<0.00017	<0.00017	<0.00017	<0.00017	<0.00017	<0.00017	NS	
Sum Ra226+Ra228	pCi/L	Unknown	Poisson	0.58	5	5	1.116	1.843	<1.345	85.6	38.9	28.4	NS	

Event 12 (AM-2) Upgradient Well GW-7	
<0.00017	U
<0.0006	U
0.07365	
<0.00022	U
<0.00017	U
<0.00045	U
<0.00047	U
7.61	J-
<0.00052	U
0.01916	J
<0.00004	U
<0.00028	U
<0.0044	U
<0.00017	U
<1	

[a] Prediction Limits calculated using 5% alpha.

[b] Upper Prediction Limit used for all parameters.

[c] Data distribution set to Unknown if all values non-detect in upgradient well.

[d] DQ is Double Quantification Rule. If Event 12 sample is detectible but Event 11 was ND, need to resample the well to see if two successive, independent detected values occur. If so, that would be an SSI. If value was detected in upgradient well in Event 12, would use Poisson PL instead.

[e] GW-26 not sampled (NS) due to insufficient recoverable water.

#.#### = UPL > Result > MCL/RSL
🟩 = SSI < GWPS
🟥 = SSI > GWPS
🟨 = DQ Parameter with Verification Sampling Needed

TABLE 4-1
CCR RULE INTERWELL COMPARISON OF SAMPLING EVENT AM-1, -2, AND -3 APPENDIX IV DATA

Northern Boundary							Event 13 (AM-3)							
							Downgradient Wells							
Parameter	Units	Data Distribution for Upgradient Well GW-7	UPL Type	UPL Value[a,b]	Federal MCLs/RSLs	GWPS	GW-9	GW-19	GW-20	GW-23	GW-24	GW-25	GW-26	
Antimony	mg/L	Unknown	Poisson	0.00133	0.006	0.006	<0.00107	<0.00107	<0.00107	<0.00426	<0.00107	<0.00426	<0.0107	
Arsenic	mg/L	Unknown	Poisson	0.00682	0.01	0.01	0.0005	0.09721	0.00249	0.03247	0.02855	0.05652	0.03057	
Barium	mg/L	Log−Normal	Parametric	0.0934	2	2	0.06275	1.10111	0.24056	9.76212	9.25331	7.62675	0.53473	
Beryllium	mg/L	Unknown[c]	DQ[d]	NA	0.004	0.004	<0.00022	<0.00022	<0.00022	<0.00022	<0.00022	0.00025	0.00255	
Cadmium	mg/L	Unknown[c]	DQ[d]	NA	0.005	0.005	<0.00067	<0.00067	<0.00067	<0.0027	<0.00067	<0.0027	<0.00675	
T. Chromium	mg/L	Unknown[c]	DQ[d]	NA	0.1	0.1	<0.00145	<0.00145	<0.00354	<0.0058	<0.0029	0.01045	0.0382	
Cobalt	mg/L	Unknown[c]	DQ[d]	NA	0.006	0.006	<0.00047	<0.00047	0.00058	0.00284	0.00209	0.00371	0.01594	
Fluoride	mg/L	Normal	Parametric	9.291	4	9.291	0.203	1.63	***5.66***	0.351	0.266	<0.025	1.58	
Lead	mg/L	Unknown[c]	DQ[d]	NA	0.015	0.015	<0.00052	<0.00052	0.00099	<0.00052	<0.00052	0.00505	0.01799	
Lithium	mg/L	Normal	Parametric	0.023374	0.04	0.04	0.01743	0.01414	0.01607	0.15017	0.04512	0.03069	0.03863	
Mercury	mg/L	Unknown	Poisson	0.00031	0.002	0.002	<0.00016	<0.00016	<0.00016	<0.00016	<0.00016	<0.00016	<0.00163	
Molybdenum	mg/L	Log−Normal	Parametric	0.006805	0.1	0.1	<0.00113	<0.00113	0.10255	0.00734	0.00853	0.01182	0.02644	
Selenium	mg/L	Unknown[c]	DQ[d]	NA	0.5	0.5	<0.0034	<0.0034	0.00991	<0.00068	<0.0068	<0.00068	<0.034	
Thallium	mg/L	Unknown[c]	DQ[d]	NA	0.002	0.002	<0.00017	<0.00017	<0.00017	<0.00017	<0.00017	<0.00017	<0.00175	
Sum Ra226+Ra228	pCi/L	Unknown	Poisson	0.58	5	5	0.1854	2.64	0.389	83.4	46.1	30.5	1.919	

Event 13 (AM-3) Upgradient Well GW-7	
<0.00107	U
0.00042	
0.07666	
<0.00022	U
<0.00067	U
<0.00145	U
<0.00047	U
8.07	J-
<0.00052	U
0.01904	
<0.00016	U
<0.00113	U
<0.0034	U
<0.00017	U
0.4727	

[a] Prediction Limits calculated using 5% alpha.

[b] Upper Prediction Limit used for all parameters.

[c] Data distribution set to Unknown if all values non-detect in upgradient well.

[d] DQ is Double Quantification Rule. If Event 13 sample is detectible but Event 12 was ND, need to resample the well to see if two successive, independent detected values occur. If so, that would be an SSI. If value was detected in upgradient well in Event 13, would use Poisson PL instead.

#.#### = UPL > Result > MCL/RSL
🟩 = SSI < GWPS
🟥 = SSI > GWPS
🟨 = DQ Parameter with Verification Sampling Needed

TABLE 4-2
CCR RULE INTERWELL COMPARISON OF SAMPLING EVENT AM-1, -2, AND -3 APPENDIX IV DATA

Western Boundary							Event 11 (AM-1) Downgradient Wells							
Parameter	**Units**	**Data Distribution for Upgradient Well GW-7**	**UPL Type**	**UPL Value[a,b]**	**Federal MCLs/RSLs**	**GWPS**	**GW-27**	**GW-28**	**GW-29**					
Antimony	mg/L	Unknown	Poisson	0.00133	0.006	0.006	<0.00017	<0.00017	<0.00017					
Arsenic	mg/L	Unknown	Poisson	0.00682	0.01	0.01	0.00036	0.00494	0.01792					
Barium	mg/L	Log–Normal	Parametric	0.0934	2	2	0.81784	0.23483	1.01725					
Beryllium	mg/L	Unknown[c]	DQ[d]	NA	0.004	0.004	<0.00022	<0.00022	<0.00022					
Cadmium	mg/L	Unknown[c]	DQ[d]	NA	0.005	0.005	<0.00017	<0.00017	<0.00017					
T. Chromium	mg/L	Unknown[c]	DQ[d]	NA	0.1	0.1	<0.00045	<0.00045	<0.00045					
Cobalt	mg/L	Unknown[c]	DQ[d]	NA	0.006	0.006	<0.00047	<0.00047	<0.00047					
Fluoride	mg/L	Normal	Parametric	9.291	4	9.291	0.2705	1.91	1.1					
Lead	mg/L	Unknown[c]	DQ[d]	NA	0.015	0.015	<0.00052	<0.00052	<0.00052					
Lithium	mg/L	Normal	Parametric	0.023374	0.04	0.04	0.013105	0.01558	0.03304					
Mercury	mg/L	Unknown	Poisson	0.00031	0.002	0.002	<0.00004	<0.00004	<0.00004					
Molybdenum	mg/L	Log–Normal	Parametric	0.006805	0.1	0.1	0.004645	0.03037	0.00421					
Selenium	mg/L	Unknown[c]	DQ[d]	NA	0.5	0.5	<0.0011	<0.0011	<0.0011					
Thallium	mg/L	Unknown[c]	DQ[d]	NA	0.002	0.002	<0.00017	<0.00017	<0.00017					
Sum Ra226+Ra228	pCi/L	Unknown	Poisson	0.58	5	5	1.398	1.304	0.806					

Event 11 (AM-1) Upgradient Well GW-7	
<0.00017	U
<0.00075	U
0.0811	
<0.00022	UJ
<0.00017	UJ
<0.00045	U
<0.00047	UJ
7.89	J-
<0.00052	UJ
0.02062	J
<0.00004	UJ
<0.00028	U
<0.0055	UJ
<0.00017	UJ
<0.2838	U

[a] Prediction Limits calculated using 5% alpha.

[b] Upper Prediction Limit used for all parameters.

[c] Data distribution set to Unknown if all values non-detect in upgradient well.

[d] DQ is Double Quantification Rule. If Event 11 sample is detectible, will need to resample the downgradient well to see if two successive, independent detected values occur. If so, that would be an SSI. If value was detected in upgradient well in Event 11, would use Poisson PL instead.

#.#### = UPL > Result > MCL/RSL
🟩 = SSI < GWPS
🟥 = SSI > GWPS
🟨 = DQ Parameter with Verification Sampling Needed

Western Boundary							Event 12 (AM-2) Downgradient Wells							
Parameter	**Units**	**Data Distribution for Upgradient Well GW-7**	**UPL Type**	**UPL Value[a,b]**	**Federal MCLs/RSLs**	**GWPS**	**GW-27**	**GW-28**	**GW-29**					
Antimony	mg/L	Unknown	Poisson	0.00133	0.006	0.006	<0.00017	<0.00017	<0.00017					
Arsenic	mg/L	Unknown	Poisson	0.00682	0.01	0.01	0.00047	0.00512	0.01337					
Barium	mg/L	Log–Normal	Parametric	0.0934	2	2	0.850025	0.2713	0.94805					
Beryllium	mg/L	Unknown[c]	DQ[d]	NA	0.004	0.004	<0.00022	<0.00022	<0.00022					
Cadmium	mg/L	Unknown[c]	DQ[d]	NA	0.005	0.005	<0.00017	<0.00017	<0.00017					
T. Chromium	mg/L	Unknown[c]	DQ[d]	NA	0.1	0.1	<0.00045	<0.00045	<0.00045					
Cobalt	mg/L	Unknown[c]	DQ[d]	NA	0.006	0.006	<0.00047	<0.00047	<0.00047					
Fluoride	mg/L	Normal	Parametric	9.291	4	9.291	0.2735	2.06	1.23					
Lead	mg/L	Unknown[c]	DQ[d]	NA	0.015	0.015	<0.00052	<0.00052	<0.00052					
Lithium	mg/L	Normal	Parametric	0.023374	0.04	0.04	0.01269	0.01811	0.03224					
Mercury	mg/L	Unknown	Poisson	0.00031	0.002	0.002	<0.00004	<0.00004	<0.00004					
Molybdenum	mg/L	Log–Normal	Parametric	0.006805	0.1	0.1	0.00461	0.03482	0.0039					
Selenium	mg/L	Unknown[c]	DQ[d]	NA	0.5	0.5	<0.0011	<0.0011	<0.0011					
Thallium	mg/L	Unknown[c]	DQ[d]	NA	0.002	0.002	<0.00017	<0.00017	<0.00017					
Sum Ra226+Ra228	pCi/L	Unknown	Poisson	0.58	5	5	<2	<1.0411	<1.393					

Event 12 (AM-2) Upgradient Well GW-7	
<0.00017	U
<0.0006	U
0.07365	
<0.00022	U
<0.00017	U
<0.00045	U
<0.00047	U
7.61	J-
<0.00052	U
0.01916	J
<0.00004	U
<0.00028	U
<0.0044	U
<0.00017	U
<1	

[a] Prediction Limits calculated using 5% alpha.

[b] Upper Prediction Limit used for all parameters.

[c] Data distribution set to Unknown if all values non-detect in upgradient well.

[d] DQ is Double Quantification Rule. If Event 12 sample is detectible but Event 11 was ND, need to resample the well to see if two successive, independent detected values occur. If so, that would be an SSI. If value was detected in upgradient well in Event 12, would use Poisson PL instead.

#.#### = UPL > Result > MCL/RSL
🟩 = SSI < GWPS
🟥 = SSI > GWPS
🟨 = DQ Parameter with Verification Sampling Needed

TABLE 4-2
CCR RULE INTERWELL COMPARISON OF SAMPLING EVENT AM-1, -2, AND -3 APPENDIX IV DATA

Western Boundary							Event 13 (AM-3)							
							Downgradient Wells							
Parameter	**Units**	**Data Distribution for Upgradient Well GW-7**	**UPL Type**	**UPL Value[a,b]**	**Federal MCLs/RSLs**	**GWPS**	**GW-27**	**GW-28**	**GW-29**					
Antimony	mg/L	Unknown	Poisson	0.00133	0.006	0.006	<0.00017	<0.00017	<0.00017					
Arsenic	mg/L	Unknown	Poisson	0.00682	0.01	0.01	0.00035	0.00554	0.01823					
Barium	mg/L	Log–Normal	Parametric	0.0934	2	2	0.91402	0.24927	1.061475					
Beryllium	mg/L	Unknown[c]	DQ[d]	NA	0.004	0.004	<0.00022	<0.00022	<0.00022					
Cadmium	mg/L	Unknown[c]	DQ[d]	NA	0.005	0.005	<0.00067	<0.00067	<0.00067					
T. Chromium	mg/L	Unknown[c]	DQ[d]	NA	0.1	0.1	<0.00145	<0.00145	<0.00145					
Cobalt	mg/L	Unknown[c]	DQ[d]	NA	0.006	0.006	<0.00047	<0.00047	<0.00047					
Fluoride	mg/L	Normal	Parametric	9.291	4	9.291	0.305	2.02	1.3					
Lead	mg/L	Unknown[c]	DQ[d]	NA	0.015	0.015	<0.00052	<0.00052	<0.00052					
Lithium	mg/L	Normal	Parametric	0.023374	0.04	0.04	0.01319	0.01657	0.0341					
Mercury	mg/L	Unknown	Poisson	0.00031	0.002	0.002	<0.00016	<0.00016	<0.00016					
Molybdenum	mg/L	Log–Normal	Parametric	0.006805	0.1	0.1	0.00346	0.0341	0.005545					
Selenium	mg/L	Unknown[c]	DQ[d]	NA	0.5	0.5	<0.00068	<0.0034	<0.00068					
Thallium	mg/L	Unknown[c]	DQ[d]	NA	0.002	0.002	<0.00017	<0.00017	<0.00017					
Sum Ra226+Ra228	pCi/L	Unknown	Poisson	0.58	5	5	1.396	0.366	1.167					

Event 13 (AM-3) Upgradient Well GW-7	
<0.00107	U
0.00042	
0.07666	
<0.00022	U
<0.00067	U
<0.00145	U
<0.00047	U
8.07	J-
<0.00052	U
0.01904	
<0.00016	U
<0.00113	U
<0.0034	U
<0.00017	U
0.4727	

[a] Prediction Limits calculated using 5% alpha.

[b] Upper Prediction Limit used for all parameters.

[c] Data distribution set to Unknown if all values non-detect in upgradient well.

[d] DQ is Double Quantification Rule. If Event 13 sample is detectible but Event 12 was ND, need to resample the well to see if two successive, independent detected values occur. If so, that would be an SSI. If value was detected in upgradient well in Event 13, would use Poisson PL instead.

#.####	= UPL > Result > MCL/RSL
🟩	= SSI < GWPS
🟥	= SSI > GWPS
🟨	= DQ Parameter with Verification Sampling Needed

TABLE 4-3

CCR RULE NATURE AND EXTENT OF RELEASE CHARACTERIZATION SAMPLING ANALYTICAL RESULTS SUMMARY

McELROY'S RUN CCB DISPOSAL FACILITY - 2019 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

			APPENDIX III (all Chemical Constituents reported as TOTAL RECOVERABLE)[1]							APPENDIX IV (all Chemical Constituents reported as TOTAL RECOVERABLE)[1]															
SAMPLING EVENT NO.[2]	WELL ID	SAMPLE DATE	BORON METALS MG/L	CALCIUM METALS MG/L	CHLORIDE MISC MG/L	FLUORIDE MISC MG/L	PH MISC S.U.	SULFATE MISC MG/L	TDS MISC MG/L	ANTIMONY METALS MG/L	ARSENIC METALS MG/L	BARIUM METALS MG/L	BERYLLIUM METALS MG/L	CADMIUM METALS MG/L	CHROMIUM METALS MG/L	COBALT METALS MG/L	LEAD METALS MG/L	LITHIUM METALS MG/L	MERCURY METALS MG/L	MOLYBDENUM METALS MG/L	SELENIUM METALS MG/L	THALLIUM METALS MG/L	RADIUM-226 RADIOCHEM PCI/L	RADIUM-228 RADIOCHEM PCI/L
N&E-1	GW-12	7/25/2019	0.075 U	28.381	1.66	0.025 U	6.47 J	39.3	172	--	0.00041	0.06043	--	--	--	--	--	0.0005 U	--	--	--	--	--	--
N&E-1	GW-17	7/25/2019	1.6 J+	208	79.8	0.15	7.29 J	460	1025	--	0.00035 U	0.10882	--	--	--	--	--	0.01946	--	--	--	--	--	--

NOTES:

[1] Lab analyses were completed by Beta Lab and TestAmerica Laboratories, Inc., both of which are accredited/certified laboratories: Beta Lab ISO/IEC 17025 Cert No. 2489.01 (Exp. 11-30-20) and ISO/IEC 9001 Cert. No. 83761-IS7 (Exp. 01-16-21) and TestAmerica NELAP Identification Number: 68-00340, EPA Region: 3, Expiration Date: 08-31-20.

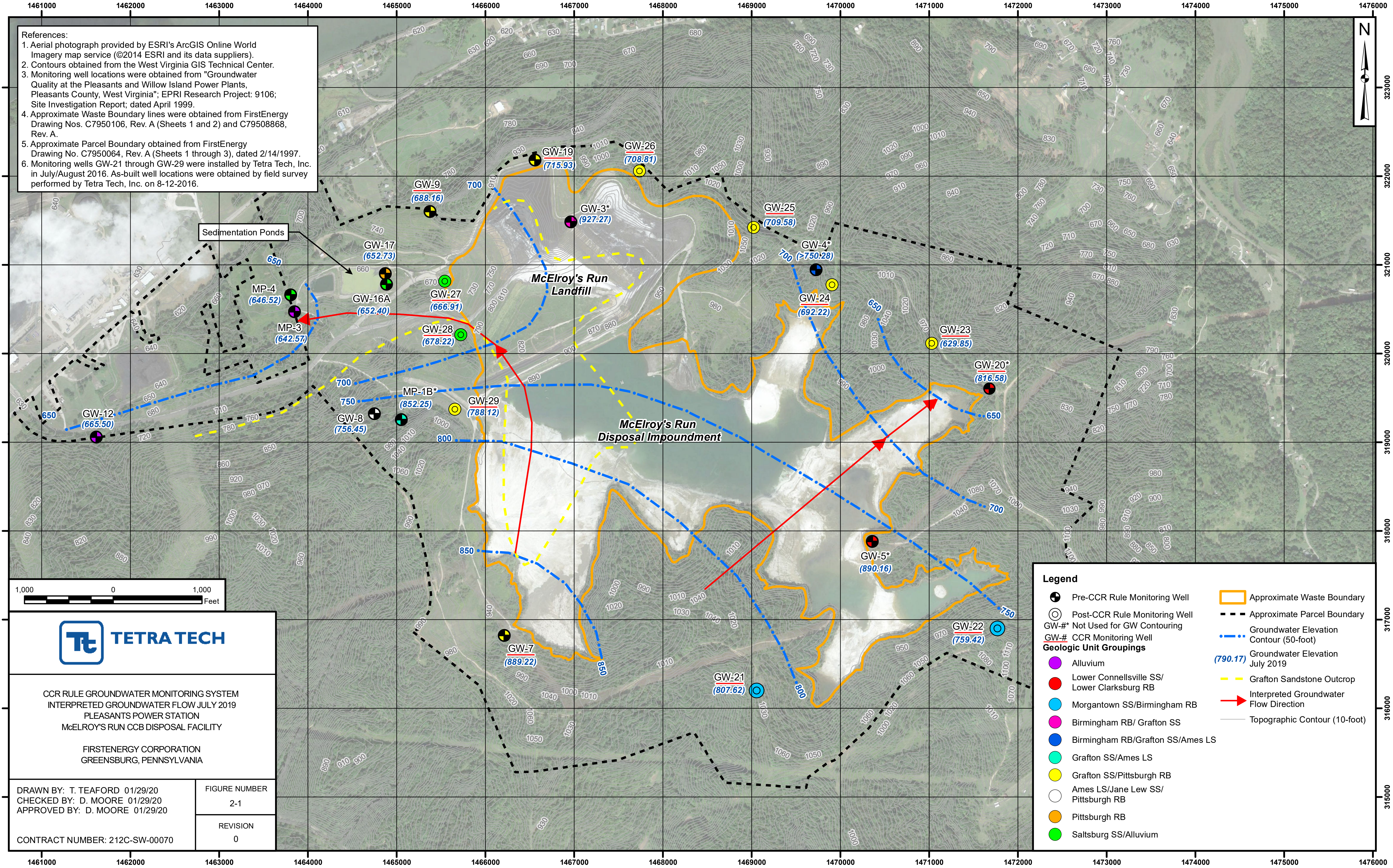
[2] Event No. N&E-1 was dedicated solely to Nature and Extent of Release Characterization purposes using two WVDEP monitoring program wells and analyzing for Appendix III parameters and for Appendix IV parameters exhibiting SSLs in the CCR monitoring program wells.

DATA QUALIFER DEFINITIONS:

The following definitions provide brief explanations of the validation qualifiers assigned to results in the data review process.

U	The analyte was analyzed for, but was not detected at a level greater than or equal to the level of the adjusted method detection limit for sample and method.
J	The analyte was positively identified and the associated numerical value is the approximate concentration of the analyte in the sample (due either to the quality of the data generated because certain quality control criteria were not met, or the concentration of the analyte was below the reporting limit).
J+	The result is an estimated quantity, but the result may be biased high.
J-	The result is an estimated quantity, but the result may be biased low.
UJ	The analyte was analyzed for, but was not detected. The reported detection limit is approximate and may be inaccurate or imprecise.
R	The sample result (detected) is unusable due to the quality of the data generated because certain criteria were not met. The analyte may or may not be present in sample
UR	The sample result (nondetected) is unusable due to the quality of the data generated because certain criteria were not met. The analyte may or may not be present in sample.

FIGURES



References:
1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (©2014 ESRI and its data suppliers).
2. Contours obtained from the West Virginia GIS Technical Center.
3. Monitoring well locations were obtained from "Groundwater Quality at the Pleasants and Willow Island Power Plants, Pleasants County, West Virginia"; EPRI Research Project: 9106; Site Investigation Report; dated April 1999.
4. Approximate Waste Boundary lines were obtained from FirstEnergy Drawing Nos. C7950106, Rev. A (Sheets 1 and 2) and C79508868, Rev. A.
5. Approximate Parcel Boundary obtained from FirstEnergy Drawing No. C7950064, Rev. A (Sheets 1 through 3), dated 2/14/1997.
6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

Legend

◐	Pre-CCR Rule Monitoring Well	▭	Approximate Waste Boundary
◎	Post-CCR Rule Monitoring Well	- - -	Approximate Parcel Boundary
GW-#*	Not Used for GW Contouring	-·-	Groundwater Elevation Contour (50-foot)
GW-#	CCR Monitoring Well	(790.17)	Groundwater Elevation July 2019
	Geologic Unit Groupings	- -	Grafton Sandstone Outcrop
●	Alluvium	→	Interpreted Groundwater Flow Direction
●	Lower Connellsville SS/ Lower Clarksburg RB	—	Topographic Contour (10-foot)
●	Morgantown SS/Birmingham RB		
●	Birmingham RB/ Grafton SS		
●	Birmingham RB/Grafton SS/Ames LS		
●	Grafton SS/Ames LS		
●	Grafton SS/Pittsburgh RB		
○	Ames LS/Jane Lew SS/ Pittsburgh RB		
●	Pittsburgh RB		
●	Saltsburg SS/Alluvium		

TETRA TECH

CCR RULE GROUNDWATER MONITORING SYSTEM
INTERPRETED GROUNDWATER FLOW JULY 2019
PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: T. TEAFORD 01/29/20
CHECKED BY: D. MOORE 01/29/20
APPROVED BY: D. MOORE 01/29/20

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
2-1

REVISION
0

ATTACHMENT A

CCR Rule Appendix IV Alternative Source Demonstration Report – 2018/2019 Assessment Monitoring

McElroy's Run Coal Combustion Byproduct Disposal Facility

Pleasants Power Station
Pleasants County, West Virginia

Prepared for:

FirstEnergy

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Tetra Tech Project No. 212C-SW-00070

October 2019

CCR RULE APPENDIX IV ALTERNATIVE SOURCE DEMONSTRATION REPORT
2018/2019 ASSESSMENT MONITORING

McELROY'S RUN COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY

PLEASANTS POWER STATION
PLEASANTS COUNTY, WEST VIRGINIA

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Tetra Tech Project No. 212C-SW-00070

October 2019

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1.0 INTRODUCTION/BACKGROUND

FirstEnergy (FE) owns and operates the coal-fired Pleasants Power Station (hereinafter referred to as the "Station") located in Pleasants County, West Virginia. Coal Combustion Residuals (CCRs) produced at the Station are placed in the facility's Coal Combustion Byproduct Disposal Facility (CCBDF or "CCR unit"), which is located approximately one mile east-southeast of the Station (see Figure 1). The facility consists of both a wet disposal area (impoundment) and dry disposal area (landfill) developed in the McElroy's Run watershed. Taken together, the landfill and impoundment are regulated under West Virginia Department of Environmental Protection (WVDEP) Solid Waste/National Pollutant Discharge Elimination System (NPDES) Water Pollution Control Permit No. WV0079171, and the United States Environmental Protection Agency (USEPA) Disposal of Coal Combustion Residuals from Electric Utilities rule (40 CFR Part 257, hereinafter referred to as the "CCR Rule" or "Rule"). As per the CCR Rule, the landfill and impoundment are considered two separate, existing CCR units that share a common boundary (the impoundment dam). As provided by the CCR Rule, a multiunit groundwater monitoring system has been established for the CCBDF.

In accordance with § 257.94 of the Rule, the initial Detection Monitoring (DM) sampling and analysis event for the CCR unit was completed in October 2017, and the statistical evaluation of the resulting data was completed in January 2018. As required by § 257.90(e), the results and findings from the 2017 groundwater monitoring program were documented in the 2017 Annual Groundwater Monitoring and Corrective Action Report (AGWMCA Report) that was posted in both the CCR unit's operating record and on its publicly accessible website in January 2018 (Tetra Tech, 2018). In that report, Statistically Significant Increases (SSIs) for boron, calcium, chloride, fluoride, pH, sulfate, and total dissolved solids (TDS) were determined in several downgradient monitoring wells. Based on the various parameters for which SSIs were identified, an Appendix III Alternative Source Demonstration (ASD) was undertaken as discussed in the 2018 AGWMCA Report (Tetra Tech, 2019). However, all of the Appendix III SSIs that were identified for DM-1 could not be attributed to alternative sources.

During the transition period between completing the statistical evaluation of the DM-1 data and performing the Appendix III ASD, FE performed another round of DM sampling (event DM-2) in order to have data available should the ASD prove to be successful and the facility remained in the DM program. DM-2 sampling occurred in February 2018, with laboratory analysis and data validation completed by April 2018. However, before statistical evaluation of the DM-2 data commenced, it was determined that a transition to Assessment Monitoring (AM) was required which precluded the need to statistically evaluate the DM-2 data. As such, a transition to the applicable requirements of AM per § 257.95 of the CCR Rule commenced.

In accordance with 40 CFR § 257.95(b) and (d)(1), two AM sampling events (AM-1 and AM-2) were performed in May and August 2018. Pursuant to §§ 257.94(e)(3), 257.105(h)(5), and 257.106(h)(4), a notice was posted to the facility's Operating Record and issued to the WVDEP in August 2018, to provide notification that a groundwater Assessment Monitoring program for the CCR unit had been established. Pursuant to § 257.107(h)(4), the subject notice was posted to the facility's publicly accessible website in September 2018. Analytical data summary tables and a description of the 2018 AM program results can be found in the 2018 AGWMCA Report (Tetra Tech, 2019). Once initiated, the AM program continued in 2019 with two additional sampling events performed in February (AM-3) and July (AM-4).

Statistical evaluation of the AM sampling events was completed in January 2019 for AM-1 and -2 and in August 2019 for AM-3 (validated AM-4 results were not available in time to be included in this report). The statistical evaluations indicated Appendix IV constituent concentrations in downgradient wells at Statistically Significant Levels (SSLs) above applicable Groundwater Protection Standards (GWPS). In accordance with 40 CFR § 257.106(h)(6), a notice was prepared and posted to the facility's Operating Record, issued to the WVDEP, and then posted on the facility's publicly accessible website in April 2019, to provide notification of the SSLs for arsenic, barium, fluoride, lithium, and radium at the CCR unit.

During this same notification period and in accordance with 40 CFR § 257.95(g)(3)(ii), an Appendix IV ASD was initiated to assess if the SSLs determined for the AM-1, AM-2, and AM-3 events were attributable to a release from the CCR unit, from a demonstrable alternative source(s), or if they resulted from errors in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. Pursuant to § 257.95(g)(4), if a successful ASD has not been completed within 90 days from the date of determining that an SSL has occurred, the CCR unit owner or operator must initiate an Assessment of Corrective Measures (ACM) in accordance with 40 CFR § 257.96. Due to the additional monitoring points, sampling events, laboratory analyses, and evaluations needed to complete a successful ASD, the work to complete the ASD had to be extended. Therefore, and in accordance with 40 CFR § 257.106(h)(7), a separate notice was prepared and posted to the facility's Operating Record, issued to the WVDEP, and then posted on the facility's publicly accessible website in April 2019, to provide notification of the initiation of the assessment of corrective measures for arsenic, barium, fluoride, lithium, and radium at the Site.

Subsequent to the above-referenced AM notifications, additional rounds of groundwater level data were collected and evaluated which resulted in a modified interpretation of current groundwater flow patterns along the northern boundary of the Site than were described in the *CCR Rule Groundwater Monitoring System Evaluation Report for the Pleasants Power Station* (Tetra Tech, 2017). In the subject report there were two, separate upgradient/background wells identified for the western and northern boundaries of the CCR unit. The current understanding of groundwater flow based on the additional rounds of groundwater level measurements is such that one upgradient well, GW-7, is now considered the upgradient/background well for both the western and northern boundaries of the CCR unit (Figure 2). This change in groundwater flow pattern is likely attributable to the low permeability of the formation and long stabilization period required for the wells installed along the northern boundary. As such, the AM statistical evaluations that have recently been conducted have incorporated upper prediction limits (UPLs) associated with GW-7 for both boundaries.

The table shown on the following page summarizes the results of the statistical evaluation of the CCR Rule Appendix IV parameters based upon utilizing the updated groundwater flow interpretation (i.e., utilizing the GW-7 UPL for comparison with downgradient constituent concentrations) and lists which wells (labeled “GW-#”) have parameters that were determined to be above their GWPS. The revised statistical evaluation based on the updated understanding of groundwater flow patterns determined that arsenic SSLs occurred in more wells than previously indicated (due to the lower arsenic GWPS for MW-7), but that fluoride was no longer an SSL in the single well it was previously found in (GW-20) due to the higher fluoride GWPS for MW-7. As such, fluoride is no longer considered an SSL and was not evaluated in this ASD. A detailed discussion of the revised interpretation of groundwater flow patterns at the site and the associated impacts on statistical evaluations of AM data will be provided in the forthcoming 2019 AGMCA Report that will be issued in January 2020.

After initiating the ACM in April 2019, the ongoing ASD activities were continued as they indicated a strong possibility that the barium, lithium, and radium SSLs were attributable to demonstrable alternative source(s). As such, this ASD report has been prepared to document the evaluation of the AM-1, -2, and -3 Appendix IV SSLs and to incorporate the findings into the CCR unit’s ACM.

	Northern Boundary (Upgradient Well GW-7)					Western Boundary (Upgradient Well GW-7)
Appendix IV Parameters [GWPS]	**GW-19**	**GW-23**	**GW-24**	**GW-25**	**GW-26**	**GW-29**
Arsenic (As) [0.01 mg/L]	**SSL**	**SSL**	**SSL**	**SSL**	**SSL**	**SSL**
AM-1	0.1285	0.0290	0.0231	0.0467	n/s	0.0179
AM-2	0.0885	0.0288	0.0240	0.0489	n/s	0.0134
AM-3	0.0972	0.0325	0.0286	0.0565	0.0306	0.0186
Barium (Ba) [2 mg/L]		**SSL**	**SSL**	**SSL**	**SSL**	
AM-1	<GWPS	10.41	8.53	6.69	n/s	<GWPS
AM-2	<GWPS	10.51	10.28	7.03	n/s	<GWPS
AM-3	<GWPS	9.76	9.25	7.63	0.53473	<GWPS
Lithium (Li) [0.04 mg/L]		**SSL**	**SSL**			
AM-1	<GWPS	0.1054	<GWPS	<GWPS	n/s	<GWPS
AM-2	<GWPS	0.1131	<GWPS	<GWPS	n/s	<GWPS
AM-3	<GWPS	0.1502	0.0451	<GWPS	<GWPS	<GWPS
Radium (Ra 226 + 228) [5 pCi/L]		**SSL**	**SSL**	**SSL**		
AM-1	<GWPS	86.5	49.3	24.2	n/s	<GWPS
AM-2	<GWPS	85.6	38.8	28.4	n/s	<GWPS
AM-3	<GWPS	83.4	46.1	30.5	<GWPS	<GWPS

Note: Downgradient well GW-26 was not sampled (n/s) during the AM-1 and AM-2 events due to insufficient available water.

2.0 APPROACH

For this ASD, a multiple Line of Evidence (LOE) approach as presented in *Guidance for Development of Alternative Source Demonstrations at Coal Combustion Residual Sites* (EPRI, 2017) was followed. This approach divides LOEs into five separate ASD categories (types):

- Sampling causes (ASD Type I);
- Laboratory causes (ASD Type II);
- Statistical evaluation causes (ASD Type III);
- Natural variation not accounted for in the basic DM statistics (ASD Type IV); and
- Potential natural or anthropogenic sources (ASD Type V).

EPRI (2017) includes detailed checklists that provide a standardized, incremental approach that is followed to determine whether additional LOE evaluations are warranted or not. These checklists include:

- Checklist 1: Sampling, Laboratory, or Statistical Causes (ASD Types I, II, and III);
- Checklist 2: LOEs Associated with the CCR Unit (ASD Type IV); and
- Checklist 3: LOEs Associated with Alternative Natural or Anthropogenic Sources (ASD Type V).

For this ASD all three Checklists were completed and are attached as Tables 1, 2, and 3. Based on indications from these checklists as well as the CCR unit's topographic and geologic setting, development and operational history, and currently available information and data, it was determined that additional evaluations of the following site-specific LOEs were warranted:

- Regional groundwater chemistry studies/reports; and
- Potential existing and historic oil and/or gas production well effects.

The findings from the checklist completion activities and site-specific LOE evaluations are summarized in Section 3.0.

3.0 SUMMARY OF FINDINGS

3.1 ASD CHECKLIST 1

ASD Checklist 1 is attached as Table 1 of this report. The checklist evaluations were performed by re-reviewing the CCR groundwater monitoring program's field sampling notes and chain-of-custody forms, laboratory data validation (Level 2) reports, statistical evaluation spreadsheets, and results from field-filtered duplicate samples that were obtained during events where turbid unfiltered samples had been obtained. As indicated in Table 1, for many potential sampling, laboratory, or statistical evaluation causes, no instances/issues/indications were identified. Sample contamination with petroleum and/or brine from on-site oil and gas exploration and production activities could be a contributing factor for the SSIs and SSLs for barium, lithium, and radium in GW-23, -24, and -25 (as discussed in Section 3.5 of this report, barium, lithium, and radium have been documented as being associated with oil and gas well brines). For other potential causes where some issues were identified, it was determined that they most likely did not contribute to the Appendix IV SSLs.

Based on these LOE findings, laboratory analysis and statistical evaluations are not demonstrable alternative sources of all the Appendix IV SSLs determined for the AM-1, -2, and -3 events, while sample turbidity and contamination are potential sources of the SSIs and SSLs determined for barium, lithium, and radium in some of the downgradient monitoring wells.

3.2 ASD CHECKLIST 2

ASD Checklist 2 is attached as Table 2 of this report. The checklist evaluations were performed by re-reviewing the groundwater analytical results (background, DM, and AM) for both Appendix III and IV parameters, leachate data for the CCR unit (specifically for arsenic, barium, lithium, and radium) provided by FE, and hydrogeologic and design information and data included in *CCR Rule Groundwater Monitoring System Evaluation Report for the Pleasants Power Station* (Tetra Tech, 2017). For the LOEs in Checklist 2, the following evaluation criteria were used:

- Primary Indicators – As per Table A-1 in EPRI (2017), primary indicator constituents for CCRs include the CCR Rule parameters Boron (Appendix III), Calcium (Appendix III), Chloride (Appendix III), Fluoride (Appendix III and IV), Lithium (Appendix IV), Molybdenum (Appendix IV), and Sulfate (Appendix III), as well as Bromide, Potassium, and Sodium, which are parameters that are not listed in the CCR Rule.

- Secondary Indicators – For this ASD, secondary indicator constituents for CCRs include those Appendix III and IV constituents that are not considered primary indicators.
- Leachate Data – Analytical results from five leachate sampling events performed at the CCR unit between October 2017 and July 2019 at three locations (LM1, LM5, and LM7) were used for comparison to the February 2019 AM-3 groundwater results, as shown in Table 4. The comparison of data for barium and radium indicates that barium is found at higher concentrations in groundwater in both the upgradient well and in all the downgradient wells than in leachate, whereas radium is found at higher concentrations in only the downgradient wells than in leachate, indicating a localized, non-CCR source exists along the northern boundary of the CCR unit. Alternatively, concentrations of arsenic and lithium in the leachate samples are several times higher than those of the upgradient well and the downgradient wells, indicating that the arsenic and lithium SSLs in groundwater are likely attributable to a release from the CCR unit.
- Site Hydrogeology - As discussed in the *CCR Rule Groundwater Monitoring System Evaluation Report* (Tetra Tech, 2017), groundwater in the CCBDF area occurs primarily within the fractured bedrock of multiple Conemaugh Group sandstone units including the Morgantown, Grafton, Jane Lew, and Saltsburg, which have been collectively identified as the uppermost aquifer for CCR Rule groundwater monitoring for the combined landfill and impoundment units. The CCR groundwater monitoring well network at the site is shown on Figure 1 and consists of three upgradient (background) wells (GW-7, -21, and -22), six downgradient wells to monitor the northern side of the combined CCR units (GW-19, -20, -23, -24, -25, and -26), and four downgradient wells to monitor the western side of the combined CCR units (GW-9, -27, -28, and -29). Historic and recent groundwater level data indicate groundwater flow at the site as flowing north from the topographically higher areas located to the south and southeast of the impoundment. Groundwater flow northwest of the dam and under the landfill is in the downstream direction of McElroy's Run toward the west. Flow in all of the rock units exhibit little seasonal and temporal fluctuations.

  Having sufficient recoverable volumes of groundwater from one of the upgradient (GW-21) and three of the downgradient wells (GW-23, -24, and -25) was found to be problematic during both the background and initial DM sampling events. These four wells were noted to have low to very low yields during their installation and development which was anticipated given that historical well borings drilled at the site under the WVDEP groundwater monitoring program were abandoned over time due to a lack of water in the same rock units. During the initial DM sampling event, sufficient recoverable groundwater volumes were found to be available in GW-23 and -24 but not in GW-21, -25, or in an additional downgradient well, GW-26. Geologic and hydrogeologic characteristics of the site, the monitoring well network, and the initial DM results are discussed in greater detail in both Tetra Tech 2017 and 2018.

It was originally intended that upgradient wells GW-21 and GW-22, which are both screened in the Morgantown sandstone, would be grouped for statistical evaluation purposes. However, after both the background and the initial DM sampling events were completed, it was determined that the two wells did not have the level of statistical similarity needed for grouping and that the availability of sufficient volumes of recoverable water was a recurring problem for GW-21. As such, it was decided that only GW-22 would be used to establish background chemistry for the northern side of the CCR units since it exhibited lower concentrations of all the Appendix III parameters than those measured in GW-21 and it also provided a reliable water yield while GW-21 did not. GW-21 was left in place (i.e., it was not abandoned) and it has been sampled when sufficient volumes of recoverable water were available. GW-21's water levels have also continued to be used to verify groundwater flow patterns at the site. FE intends is to keep GW-21 as a part of the CCR monitoring network until a sufficiently-sized data set can be compiled and used to determine whether or not it's statistically appropriate to group its results with the data set for GW-22. As discussed in Section 1.0, recent groundwater elevation measurements and mapping of the potentiometric surface indicate that GW-7, instead of a combination of GW-7 and GW-22 for the western and northern boundaries, respectively, acts as the upgradient well for the CCR network for both the western and northern boundary CCR wells as shown on Figure 2.

- CCR Unit Design - As shown on Figure 1, the CCR unit consists of two conterminous disposal areas, an impoundment and a landfill, that share a common boundary (the impoundment dam). The majority of the CCR material that has been disposed of at the site is managed in an unlined impoundment formed by a dam constructed across McElroy's Run. The dam was constructed with a clay-filled cutoff trench at the upstream toe and a clay blanket on the upstream face to function as a low permeability barrier. The downstream portion of the dam was constructed using compacted fly ash and periodic layers of bottom ash for blanket drains connected to sloping chimney drains that collect seepage to discharge pipes for monitoring. The downstream face of the dam is covered by the landfill facility which WVDEP considers to be a buttress to the dam.

The landfill consists of three primary development stages which are further subdivided into construction subareas. At this time, development and disposal operations have only been performed in Stages 1 and 2 and the Stage 3 area remains undeveloped. Up until 2009 all of the landfill subareas were constructed with a compacted clay liner system that included an underlying combined groundwater underdrain/leak detection system and an overlying leachate collection system. Since 2009 a composite geosynthetic liner system (geosynthetic clay liner and geomembrane) has been utilized which also includes an underlying combined groundwater underdrain/leak detection system and an overlying leachate collection system. For all portions of the landfill that overlie the downstream face of the impoundment dam, a bottom ash blanket drain layer has also been utilized. Leachate and contact stormwater runoff from the landfill disposal areas are managed in Sedimentation Pond Nos. 1 and 2, which are lined impoundments located immediately down-valley of the future Stage 3 landfill development area. These impoundments also accept flows from the groundwater underdrain/leak detection zones and stormwater runoff from portions of the landfill's South Haul Road. Discharges from Sedimentation Pond Nos. 1 and 2 are pumped up to the CCR disposal impoundment and, ultimately, routed through the impoundment's dewatering system.

Based on the various LOE findings presented in Table 2, arsenic and possibly lithium SSLs determined for the AM-1, -2, and -3 events can most likely be attributed to a release from the CCR unit. However, the comparison of leachate data to upgradient and downgradient wells indicates that a source other than the CCR unit may be contributing to the occurrence of barium and radium in groundwater.

3.3 ASD CHECKLIST 3

ASD Checklist 3 is attached as Table 3 of this report. The checklist evaluations were performed similar to those of ASD Checklist 2 by re-reviewing the groundwater analytical results (background, DM, and AM) for both Appendix III and IV parameters, leachate data for the CCR unit (specifically for barium, lithium, and radium) provided by FE, and hydrogeologic and design information and data included in *CCR Rule Groundwater Monitoring System Evaluation Report for The Pleasants Power Station* (Tetra Tech, 2017). For the LOEs in Checklist 3, the following evaluation criteria were used in addition to those used for ASD Checklist 2:

- Results of AM/Nature and Extent of Release (N&E) groundwater sampling conducted in February and July 2019 indicate that an alternate source of barium, lithium, and radium appears to exist along the northern boundary as shown on Figures 3, 4, and 5, respectively. Isoconcentration contour lines located around these northern boundary wells indicate a localized source of all three parameters in this area. Historical and current oil and gas exploration and production activities have occurred in this area and are documented sources of barium, radium, and lithium that could be the source of the SSLs in the northern boundary wells. These results and associated comparisons are discussed in greater detail in Section 3.5 of this report.
- Review of site-wide boring logs for observations of potential oil and gas well impacts to groundwater during previous investigations identified several wells in which oil and gas impacts were noted. Observations of petroleum/hydrocarbon odor, sheen, and/or crude oil product were noted for the following wells at the time of their installation (copies of the relevant pages from each log are included as Attachment A of this report):
    - GW-3 – light hydrocarbon odor
    - GW-4 – oil odor
    - GW-5 – oil odor and sheen
    - GW-6 – black crude in rock cuttings
    - GW-7 – hydrocarbon odor, black crude in rock cuttings
    - P-96-4 – oil odor
    - P-96-5 – crude oil odor
    - N-3 – oil odor
    - GW-13 – crude oil in sandstone, visual staining
    - GW-15 – 0.32 feet of crude oil-fingerprinted product
    - GW-19 – crude oil odor
    - GW-24 – petroleum hydrocarbon odor
    - GW-25 – petroleum hydrocarbon odor

Based on the LOE findings presented in Table 3 and the discussion above, the barium, radium, and lithium SSLs determined for the AM-1, -2, and -3 events can most likely be attributed to historical and current oil and gas exploration and production activities. While lithium has also been shown to be a component of oil and gas well brine, the relatively high concentrations of lithium in the leachate is an indication that the CCR unit may be the source of the lithium SSLs.

3.4 REGIONAL GROUNDWATER STUDY

In an effort to evaluate the natural variation in groundwater quality in the various water producing units of the Conemaugh Group (e.g., Morgantown, Grafton, Jane Lew, and Saltsburg sandstones) which comprise the CCR Rule uppermost aquifer, *Ground-Water Hydrology of the Minor Tributary Basins of the Ohio River, West Virginia* (USGS, 1984) was reviewed. The report review did not yield any specific information regarding natural variation of arsenic, barium, lithium, or radium in regional groundwater. However, the following table presents the range and mean concentrations reported for Appendix III constituents with SSIs in the Conemaugh Group wells which can be compared with CCR unit well data that point to oil and gas exploration activities as an alternative source:

	Dissolved Chloride (mg/L)	Dissolved Sulfate (mg/L)	TDS (mg/L)
No. of Wells	6	6	6
Range	2.6 - 130	10 - 88	241 - 589
Mean	31	37	371

Based on these reported values, the following observations were made:

- **Chloride -** The reported mean concentration of 31 mg/L is below the UPL for upgradient well GW-7 (104 mg/L), and the reported maximum concentration of 130 mg/L is slightly higher than the GW-7 UPL. With respect to downgradient wells along the northern boundary with Appendix IV SSLs, the reported maximum chloride concentration of 130 mg/L is well below the concentrations of chloride in GW-23 (12,900 mg/L), GW-24 (8,520 mg/L), and GW-25 (7,110 mg/L).
- **Sulfate** – Sulfate concentrations tend to have an inverse relationship with other parameters typically present in groundwater impacted by oil and gas activities. Accordingly, the reported minimum concentration of 10 mg/L is significantly higher than both the GW-7 UPL of 0.5 mg/L and the sulfate concentrations in downgradient wellsGW-23 (0.2664 mg/L), GW-24 (<0.0386 mg/L), and GW-25 (0.618 mg/L).
- **TDS** – The reported mean concentration of 371 mg/L is well below the UPL for GW-7 (1,260 mg/L). The reported maximum TDS concentration of 589 mg/L is also well below

the GW-7 UPL. With respect to downgradient wells with Appendix IV SSLs, the reported maximum TDS concentration of 589 mg/L is well below the concentrations of TDS for GW-23 (68,500 mg/L), GW-24 (42,400 mg/L), and GW-25 (35,900).

The comparisons noted above indicate that upgradient chloride and TDS concentrations (all indicators of oil and gas brine) at the site appear to be higher than the concentrations measured in regional Conemaugh Group groundwater during the USGS study period, while upgradient sulfate concentrations appear to be within the range of or below the concentrations measured in the study. However, comparing the maximum reported study results to the results for the corresponding downgradient wells with Appendix IV SSL concentrations indicates that all of the wells exhibit chloride and TDS concentrations that are higher to much higher than those for regional groundwater. Reduced sulfate, elevated chloride and, to a lesser extent, elevated TDS concentrations are typically observed with oil and gas exploration and production activities as discussed in the following section.

3.5 POTENTIAL FOR OIL AND GAS WELL IMPACTS

In an effort to evaluate the potential for oil and gas well development on and near the site to have impacted groundwater for the SSL constituents, particularly barium, lithium, and radium, and to substantiate the results of Checklist 3, several lines of evidence related to oil and gas impacts were evaluated including a review of nearby oil and gas wells and their completion records, historical research related to oil and gas exploration activities near the site, research related to the occurrence of the site's SSL constituents in oil and gas activities, and historical investigations and studies performed at the site regarding oil and gas impacts.

3.5.1 Nearby Oil and Gas Well Locations and Completion Information

The locations of oil and gas wells and basic information on the wells (e.g., total depth, date drilled, status, etc.) were obtained from the West Virginia Geologic and Economic Survey (WVGES) online oil and gas well database (http://ims.wvgs.wvnet.edu/WVOG/viewer.htm). Figure 6 presents the locations of these wells relative to the CCR monitoring well network and includes field observations of existing on-site oil and gas wells and associated infrastructure as well as groundwater sampling field notes that indicate oil and gas well-related impacts (e.g., sheen, odor, free product). A total of more than 100 existing or plugged/abandoned oil and gas wells were identified as shown on Figure 6. The table below summarizes key information for these wells obtained from the online database records:

API #	Completion Year	Well Type	Operator	Total Depth (ft)	Deepest Formation
4707300005		Oil	Oper in Min.owner fld,no code assgn(Orphan well proj)	1052	Undiff Price below Big Injun
4707300008		Oil	Oper in Min.owner fld,no code assgn(Orphan well proj)	512	Undetermined unit
4707300043	1935	Dry w/ Oil Show	All In One Producing & Refining Co., The	71	Big Injun (Price & equivs)
4707300069	1936	Oil w/ Gas Show	Feeney Oil & Gas	1600	Squaw
4707300069	1941	Dry w/ O&G Show	Feeney Oil & Gas	3379	Berea Sandstone
4707300073		Dry	Love, C. E.	1903	
4707300124	1939	Oil w/ Gas Show	Columbian Carbon Co.	5311	Oriskany Sandstone
4707300170	1940	Oil w/ Gas Show	Columbian Carbon Co.	2280	Up Devonian undiff:Berea to Lo Huron
4707300179	1940	Dry w/ Gas Show	Columbian Carbon Co.	2930	Berea Sandstone
4707300183	1940	Dry	Columbian Carbon Co.	2930	Berea Sandstone
4707300192	1941	Dry w/ Oil Show	Faith Oil Co.	430	Buffalo Ss (Lit Dunkard)/1st Cow Run
4707300578	1959	Dry w/ O&G Show	Smellie & Myers	2527	Up Devonian undiff:Berea to Lo Huron
4707300588	1960	Dry	Daugherty, John	1217	Maxton
4707300611	1962	Dry w/ O&G Show	Quaker State Oil Refining Co.	1727	Berea Sandstone
4707300646	1968	Dry	Holton, Harry A.	5684	Salina
4707300682	1974	Gas	McDuff, Inc.	3297	Up Devonian undiff:Berea to Lo Huron
4707300684	1974	Gas	McDuff, Inc.	3179	Up Devonian undiff:Berea to Lo Huron
4707300913	1980	Oil and Gas	Haught, Inc.	3911	Lower Huron (undifferentiated)
4707300914	1980	Oil and Gas	Haught, Inc.	4011	Lower Huron (undifferentiated)
4707300915	1980	Oil and Gas	Haught, Inc.	4286	Lower Huron (undifferentiated)
4707300975	1980	Oil and Gas	Prior, Ferrell L.	3906	Java Formation
4707300976	1980	Oil and Gas	Prior, Ferrell L.	3646	Java Formation
4707300976	1989	Gas w/ Oil Show	Dupke, Roger	3646	Lower Huron (undifferentiated)
4707300996	1980	Oil and Gas	Prior, Ferrell L.	4129	Java Formation
4707301025	1980	Oil and Gas	Prior, Ferrell L.	3100	Lower Huron (undifferentiated)
4707301026	1981	Oil and Gas	Prior, Ferrell L.	3557	Lower Huron (undifferentiated)
4707301033	1980	Oil and Gas	Haught, Inc.	3990	Angola Formation
4707301087	1981	Oil and Gas	Prior, Ferrell L.	4050	Java Formation
4707301368	1981	Gas	Shafer Oil & Gas Corp.	4350	Rhinestreet Shale
4707301594	1983	Gas w/ Oil Show	Jenkins Energy Corp. & H. Davis Jenkins	4761	Rhinestreet Shale
4707301595	1983	Gas w/ Oil Show	Jenkins Energy Corp. & H. Davis Jenkins	4940	Rhinestreet Shale
4707301595	2011	not available	Ritchie Petroleum Corp., Inc.		
4707301596	1983	Gas w/ Oil Show	Jenkins Energy Corp. & H. Davis Jenkins	4769	Rhinestreet Shale

API #	Completion Year	Well Type	Operator	Total Depth (ft)	Deepest Formation
4707301597	1984	Dry w/ O&G Show	Stalnaker, Gene, Inc.	5059	Angola Formation
4707301604	1983	Oil and Gas	Jenkins Energy Corp. & H. Davis Jenkins	2038	Up Devonian undiff:Berea to Lo Huron
4707301630	1983	Dry w/ O&G Show	Stalnaker, Gene, Inc.	5050	Rhinestreet Shale
4707301635	1983	Dry w/ O&G Show	Stalnaker, Gene, Inc.	5060	Middlesex Shale
4707302514	2009	Gas w/ Oil Show	Patchwork Oil & Gas, LLC	2514	Up Devonian undiff:Berea to Lo Huron
4707302514	2009	Dry w/ Oil Show	Patchwork Oil & Gas, LLC	2125	Up Devonian undiff:Berea to Lo Huron
4707330089		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330090		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330113		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330115		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330127		not available	Faith Oil Co.		
4707330196		not available	Delong, J. R.		
4707330250		Oil and Gas	Oper in Min.owner fld,no code assgn(Orphan well proj)	884	Big Injun (undifferentiated)
4707330251		Oil and Gas	Oper in Min.owner fld,no code assgn(Orphan well proj)	820	Maxton
4707330258		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330270		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330271		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330593		not available	Dinsmoor & Co.		
4707330596		not available	Dinsmoor & Co.		
4707330597		not available	Dinsmoor & Co.		
4707330831		not available	Daugherty, John		
4707330885		not available	Daugherty, John		
4707331095		not available	WV Department of Mines, Oil & Gas Division		
4707331114		not available	Monongahela Power Company		
4707331115		not available	Monongahela Power Company		
4707331116		not available	Monongahela Power Company		
4707331117		not available	Monongahela Power Company		
4707331118		not available	Monongahela Power Company		
4707331119		not available	Monongahela Power Company		
4707331120		not available	Monongahela Power Company		
4707331121		not available	Monongahela Power Company		
4707331122		not available	Monongahela Power Company		
4707331123		not available	Monongahela Power Company		
4707331124		not available	Monongahela Power Company		

API #	Completion Year	Well Type	Operator	Total Depth (ft)	Deepest Formation
4707331125		not available	Monongahela Power Company		
4707331126		not available	Monongahela Power Company		
4707331127		not available	Monongahela Power Company		
4707331128		not available	Monongahela Power Company		
4707331129		not available	Monongahela Power Company		
4707331130		not available	Monongahela Power Company		
4707331131		not available	Monongahela Power Company		
4707331132		not available	Monongahela Power Company		
4707331133		not available	Monongahela Power Company		
4707331135		not available	Monongahela Power Company		
4707331136		not available	Monongahela Power Company		
4707331137		not available	Monongahela Power Company		
4707331138		not available	Monongahela Power Company		
4707331139		not available	Monongahela Power Company		
4707331141		not available	Lauderman Oil & Gas Drilling		
4707370016		not available	---------- unknown ----------		
4707370048		not available	Jennings Brothers, E. H., Company		
4707301119	1981	Dry w/ Gas Show	Vessel Resources Corp.	4000	Lower Huron (undifferentiated)
4707301606	1983	Gas w/ Oil Show	Beacon Resources Corp.	4110	Lower Huron (undifferentiated)
4707302524	2010		WVDEP Office Of Oil & Gas		
4707390126					
4707391316					

Note: Wells having API #s from 4707390041 through 4707390140 are also listed but have no associated information.

The completion dates for most of the wells are unknown, implying they were drilled as part of historic oil and gas well exploration in the area and potentially could have been drilled in the early 1900s or possibly in the late 1800s. A review of data for the other wells indicates they were drilled between 1935 and 2011. The total depths of the wells range from 71 ft to 5,684 ft and they've produced from formations including undifferentiated Upper Devonian Sandstone units. Many of the wells are reported as orphan wells and some have little or no information provided. As indicated on Figure 6, the wells are distributed across much of the site and adjoining areas. Considering the age of the wells there would seem to be potential for groundwater impacts from corroded/damaged well casing, degraded seals, etc., which could result in out-of-interval migration of oil and gas and formation brine. Any leaking oil and gas gathering lines/pipelines and wellhead brine storage tanks at currently producing locations could be another potential source of releases. As discussed further below, potential constituents known to be associated with oil and gas wells include barium, radium, chloride, sodium, lithium, and elevated TDS levels.

3.5.2 Occurrence of SSL Constituents in Oil and Gas Brines

It is noted in the "Chemistry and Origin of Oil and Gas Well Brines in Western Pennsylvania," (Dresel, P.E., and Rose, A.W., 2010) that brine samples collected from oil and gas operations indicate "…radium shows a general correlation with barium and strontium and an inverse correlation with sulfate." The data presented in Section 3.4, in which sulfate concentrations are inversely low compared to barium concentrations, supports this conclusion. The following table presents the range and mean concentrations reported in Dresel and Rose (2010) for applicable Appendix III/IV constituents in western Pennsylvania brines (assumed to be similar to those in West Virginia based on age and depositional environment):

	Dissolved Barium (mg/L)	**Dissolved Chloride (mg/L)**	**Dissolved Lithium (mg/L)**	**Radium 226 (pCi/L)**
No. of Brine Samples	33	40	33	6
Range	0.80 – 4,370	5,760 – 207,000	0.30 - 315	0 – 5,300
Mean	877.37	104,544	61	2,150

Based on these reported values, the following observations were made:

- **Barium -** The reported mean concentration of 877.37 mg/L is well above the UPL for upgradient well GW-7 (0.0934 mg/L). With respect to downgradient wells with SSLs for barium, the reported mean concentration of 877.37 mg/L is also well above the concentrations of barium in GW-23 (9.76212 mg/L), GW-24 (9.25331 mg/L), and GW-25 (7.62675 mg/L). However, brine impacts to those wells would be expected to be diluted by groundwater and, hence, a potential reason they are lower.
- **Chloride -** The reported mean concentration of 104,544 mg/L is three orders of magnitude greater than the UPL for upgradient well GW-7 (104 mg/L), and the reported minimum concentration of 5,760 mg/L is also higher than the GW-7 UPL. With respect to downgradient wells along the northern boundary with Appendix IV SSLs, the reported minimum chloride concentration in brines of 5,760 mg/L is below the concentrations of chloride in GW-23 (12,900 mg/L), GW-24 (8,520 mg/L), and GW-25 (7,110 mg/L)

indicating the groundwater in those wells is within the range of the minimum and maximum concentrations of chloride found in brine.

- **Lithium** – The reported mean concentration of 61 mg/L is significantly higher than the GW-7 UPL of 0.023374 mg/L. With respect to the downgradient well with an SSL for lithium, the reported mean concentration of 61 mg/L is higher than the concentration of lithium in GW-23 (0.150178 mg/L). However, brine impacts to GW-23 would also be expected to be diluted by groundwater and, hence, a potential reason they are lower.
- **Radium 226** – The reported mean concentration of 2,150 pCi/L is significantly higher than the GW-7 UPL of 0.58 pCi/L for the sum of both radium-226 and radium-228. With respect to downgradient wells with Appendix IV SSLs, the reported mean radium-226 concentration of 2,150 pCi/L in brine is higher than the concentration of radium-226 in GW-23 (23.6 pCi/L), GW-24 (12.7 pCi/L), and GW-25 (13.2 pCi/L). However, brine impacts to GW-23, GW-24, and GW-25 would also be expected to be diluted by groundwater and, hence, a potential reason they are lower.

An additional study regarding the occurrence of radium with oil and gas produced waters conducted by the USGS identified median radium concentrations of 2,460 pCi/L and 734 pCi/L, for Marcellus Shale and non-Marcellus Shale produced water samples, respectively (USGS, 2011). An increase in concentration of radium was directly correlated with increases in TDS and salinity of the produced water.

3.5.3 Previous Oil and Gas Impact Studies at the Site

In March 2004, Hydrosystems Management, Inc. (HMI) prepared a report for Allegheny Power Supply Company (a predecessor company of FirstEnergy) which evaluated increased barium concentrations in groundwater samples from monitoring well GW-4. GW-4 is part of the state Solid Waste/NPDES groundwater monitoring system, is located in the north-northeastern portion of the site (as shown on Figure 1), and has a total depth of 255 feet and a screen length of 55 feet. Barium concentrations in the well consistently exceeded the Ground-Water Quality Standard (GWQS) established in the facility's Solid Waste/NPDES permit. The HMI report concluded that leakage of brine from surrounding oil and gas wells was the most probable cause of the barium GWQS exceedances. GW-4 also showed increases in sodium and chloride levels. The HMI report indicated two known oil and gas wells were within 1,000 feet of GW-4 and referenced the existence of numerous orphaned wells in the area. As noted in Section 3.3 of this report, the boring log for GW-4 indicated oil and gas odors at the time of drilling; additionally, some oil associated with groundwater and oil sheen were both present during well installation and development.

In 2017, oil observed in GW-23 sample water was submitted for fingerprinting laboratory analysis to determine the exact oil type. Results of that fingerprinting analysis indicated that the oil from GW-23 was representative of a straight chain hydrocarbon mineral oil. This oil is likely a result of historical oil and gas exploration activities that have occurred in the area over the past 150 years. A copy of the fingerprinting analysis results is provided as Attachment B.

3.5.4 Historical Oil and Gas Activities in the Surrounding Area

Historical references regarding local oil and gas exploration activities in the Pleasants County area were also reviewed. In "A History of Pleasants County, West Virginia," (Pemberton, 1929) the Burning Springs-Eureka anticline is noted as having its "ridge" eroded and exposing lower (older) strata with oil-bearing rocks located at or near the surface. Additionally, the First Cow Run sand mentioned in the text (from which oil and gas have been produced) is also known as the Saltsburg Sandstone, the formation in which numerous on-site wells have penetrated. Bearing more relevance to the site is the following anecdote:

> "Brown and Company of New York drilled in a well on McElroy Run back of Eureka on the Giles Hammett farm, which came to be known as the 'Burnt Well,' heretofore mentioned. At a depth of 1,100 feet a copious quantity of oil was found filling the hole to a depth of 100 feet. This was on April 27, 1886. A few days later the well was shot, and for a time flowed at a rate of forty barrels a day. Unfortunately, the rig caught fire, the cable was burned, and the heavy tools fell into the hole, where they remained about a year."

The 1974 Environmental Impact Statement (EIS) (U.S. Army Engineer District, 1974) completed for the Pleasants Power Station noted that several oil and gas wells were drilled in 1958 and 1959 in the vicinity of the plant with one drilled to 740 feet producing 11 barrels of oil the first day. Four additional wells drilled to depths between 1,600 and 2,527 feet produced similar quantities of oil. It was stated in the EIS that "…it is presumed locally that these oil wells are those which have contaminated the water wells in the site area."

In summary, the potential for impacts to groundwater by oil and gas wells on the site and in nearby upgradient areas appears to be significant, particularly in light of the historical and well-documented oil and gas well impacts in many of the groundwater monitoring wells located on-site. The data presented in this section indicate that the Appendix IV parameters barium and radium are likely attributable to oil and gas (brine) impacts. Lithium, which was reported at very high concentrations in oil and gas well brines for formations present at the site, may also be related to oil and gas brines, but since it is also present in site leachate at concentrations well above concentrations reported in the upgradient and downgradient CCR monitoring wells, it is not possible to clearly differentiate the source of lithium SSLs. However, as indicated by comparing the radium and barium isoconcentration maps (Figures 3 and 4, respectively) with the lithium isoconcentration map (Figure 5), the location of the highest concentrations for all three of these constituents occurs at GW-23, located along the northern property boundary, suggesting that lithium may exhibit a potential relationship with the barium and radium impacts from oil and gas well activities. Additionally, wells immediately downgradient of the leachate collection system along the western boundary (GW-27, GW-28, and GW-29) do not exhibit elevated concentrations of lithium, barium or radium, indicating that the presence of the three constituents in concentrations greater than their respective GWPS along the northern boundary are likely correlated and associated with oil and gas well impacts.

4.0 CERTIFICATION STATEMENT

In accordance with § 257.95(g)(3)(ii) of the CCR Rule, an ASD for Appendix IV constituents was undertaken for the CCR unit identified herein. Based on the information and data that were available for review, the following determinations have been made with respect to the AM-1, -2, and -3 events:

- The barium and radium SSLs can be attributed to historical and current oil and gas exploration and production activities that have occurred on-site. As such, in accordance with the applicable requirements of § 257.95 of the CCR rule, no corrective measures are required for these parameters and assessment monitoring for barium and radium will continue.
- The lithium SSLs are currently considered indeterminate based on the LOE's presented herein, but the available evidence indicates a high potential for the elevated lithium concentrations to also be attributable to oil and gas impacts at the site based on the occurrence of the barium, radium, and lithium concentrations above the GWPS occurring in the northern boundary in which extensive oil and gas activities have occurred historically. To resolve this uncertainty, the applicability of leachate and groundwater lithium isotopic analysis at the site will be evaluated and lithium sampling of brine from on-site production equipment will be considered. Pending completion of that work and for the purposes of this ASD, lithium has not been categorized as attributable to either the CCR unit or to an alternate source. It will continue to be analyzed as part of the assessment monitoring program and will transition to the applicable requirements of assessment of corrective measures per § 257.96 of the CCR Rule, should isotopic analysis and/or brine sampling indicate the CCR unit is the likely source of the lithium exceedances.
- The arsenic SSLs could not be attributed to sources other than the CCR unit, to errors in sampling, analysis, or statistical evaluation, or from natural variation in groundwater quality. As such, a transition to the applicable requirements of assessment of corrective measures for arsenic per § 257.96 of the CCR Rule appears to be warranted and assessment monitoring of this parameter will also continue.

5.0 REFERENCES

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TABLES

Table 1 - ASD Checklist 1: Sampling, Laboratory, or Statistical Causes

ASD Type	Potential Cause	Evaluation Summary
Sampling Causes (ASD Type I)	Sample mislabeling	No mislabeling found by comparing all COCs and lab data identifiers.
	Contamination	Field notes identified sheens and petroleum odors in GW-23 for Events 4 through 13, GW-24 for Events 6 through 13, and GW-25 for Events 4 through 6 (well was dry and not sampled in Events 7 through 10) and had odor in Events 11-13 when sampled again. Petroleum contamination could be a contributing factor for SSIs in these wells for Ba and Ra226 and 228.
	Sampling technique	HydraSleeves™ used instead of bladder pumps on some dates in wells GW-21 (upgradient), -23, -24, -25, and -26 due to limited available water.
	Turbidity	High turbidity (>10 NTU) in GW-19 (Events 1 and 2), GW-20 (Events 1, 4 through 11, and 13), GW-22 (Events 1 and 8 through 13), GW-24 (Event 12), GW-26 (Events 1 through 7), GW-28 (Event 1), and GW-29 (Event 1). When HydraSleeves™ used, turbidity not always reported. Turbidity may be a contributing factor to SSIs in GW-20.
	Sampling anomalies	Insufficient water for sampling in GW-21 (upgradient) for Events 5 through 10, GW-24 for Events 3 and 4, GW-25 for Events 1 and 7 through 10, and GW-26 for Events 8 through 12.
Laboratory Causes (ASD Type II)	Calibration	No comments on lab calibration in Data Validation Reports for Appendix IV parameters As, Ba, Li, or Ra226/228..
	Contamination	Barium detected in lab blank in Event 1, so GW-22 qualified "J" and in Event 8, but results >10X blank so no action taken. Arsenic detected in lab blank in Event 3, but all results >10X blank so no action taken. In Event 10, Ba was outside recovery range, so GW-27, -28, and -29 were qualified "J". Arsenic detected in lab blank in Event 4, so GW-7, -9, and -27 qualified "U. In Event 7, Ra226 and 228 detected in lab blank, so GW-9, -19, and -26, GW-9 qualified "U". In Event 8, Ra226 detected in lab blank, so GW-7 and its duplicate, GW-27, -28, and -29 qualified "U". In Event 11, Ra228 detected in lab blank, but results for GW-23 and -24 were >10X blank or were non-detect. In Event 12, Ra226 detected in lab blank, so GW-7, -9, -20, -21 and its duplicate, GW-27, -28, and -29 qualified "U" but no action taken for GW-23, -24 and -25, since results were >10X blank; Ra228 also detected in lab blank, so GW-21 and its duplicate, and GW-27 qualified "U". In Event 5 for Li, GW-24 qualified "J" due to conflicting directional bias. In Event 6, GW-27 was qualified "J" for Ra228 due to field imprecision.
	Digestion methods	No differences for Appendix IV parameters As, Ba, Li, and Ra226/228.
	Dilution corrections	Dilution factors in some events different for As and Ba between wells in the same event and for As for the same well in different events. Dilution factors high for As and Ba in some events in wells GW-7, -23, -24, and -25.
	Interference	Possible interference was noted in Data Validation Reports for Ra226 and 228 in Events 10 & 11. Barium carrier gas had radiation counts > limit, so Ra226 and 228 in GW-23 qualified "J" in Events 8, 10, 11, 12 and 13 and in Event 11, GW-24 also qualified "J".
	Analytical methods	Methods same as in CCR GW Monitoring Plan for As, Ba, Li, and Ra226/228.
	Laboratory technique / qualifier flags	Had high recovery for MS/MSD for Ba in Event 1 (GW-20, -26, -27, and -29 and its duplicate). Had high recovery for MS/MSD for As in Event 4 (GW-23 and -22 and its duplicate). Had low recovery for MS/MSD for Li in Event 5 (GW-24). Had high recovery for LCS for Ra228 in Event 12 (GW-9 and -22). In Event 11, had low recoveries for MS/MSD for As with GW-19, -21, -24, -27 and its duplicate, GW-28, and -29) qualified "J" due to directional bias. Qualifier flags added appropriately.
	Transcription error(s)	None identified.
Statistical Evaluation Causes (ASD Type III)	Lack of statistical independence	Sampling interval was at least 4-5 weeks in upgradient wells GW-7 and -22 which are 2.5-inch and 4-inch diameter, respectively, wells in fractured bedrock, so not likely to be a concern. GW-7 was used as upgradient comparison well.
	Outliers	Possible outlier for Li identified in GW-23.
	False positives	In general, for the case of small sample sizes (e.g., n < 10-20), there is no mathematical algorithm to statistically prove a false positive result without resampling.
	Non-detect processing	Appendix IV parameters were non-detect in upgradient well GW-7 except for As, Ba, Li, and Ra226/228. In downgradient wells used for AM-1, AM-2 and AM-3, As, Ba, Li, and Ra226/228 detected in wells GW-9, -19, -20, -23, -24, -25, -26, -27, -28, and -29.
	Background data / change in normality	No new background data used for Assessment Monitoring (Events 11, 12, and 13).

Table 2 - ASD Checklist 2: Lines of Evidence Associated with the CCR Unit

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Primary CCR Indicators						
1a	If the CCR unit contains fly ash, is there an SSI/SSL for boron and sulfate?	Yes	CCR Release	Key	Monitoring Point	Northern Boundary: Boron SSIs in GW-19, -20, and -24; No Sulfate SSIs. Western Boundary: No Boron SSIs; Sulfate SSIs in GW-9, -27, and -29.
1b	If the CCR unit contains FGD gypsum (only) is there an SSI/SSL for sulfate?	Yes	CCR Release	Key	Monitoring Point	Northern Boundary: No. Western Boundary: Sulfate SSIs in GW-9, -27, and -29.
1c	Are there other constituents in the groundwater that represent primary indicators? List the applicable constituents.	Yes	CCR Release	Supporting	Monitoring Point	Northern Boundary: Calcium, Chloride, Fluoride, Lithium, and Molybdenum are all found at detectible levels in multiple downgradient monitoring wells. Western Boundary: Calcium, Chloride, Fluoride, Lithium, and Molybdenum are all found at detectible levels in multiple downgradient monitoring wells.
1d	Is there an SSI/SSL for any of the other primary indicators?	Yes	CCR Release	Key if No	Monitoring Point	Northern Boundary: Calcium (GW-23 and -24), Chloride (GW-19, -20, -23, and -24), Fluoride (GW-20), and Molybdenum (Gw-20, ,-24, and -25) have exhibited SSIs. Lithium is an SSI in GW-24 and an SSL in GW-23. Western Boundary: Calcium (GW-27, -28, and -29) and Chloride (GW-27, -28, and -29) have exhibited SSIs. Lithium has exhibited SSIs in GW-29; Molybdenum has exhibited SSIs in (GW-28).
1e	Is the leachate concentration for any of the primary indicators (including boron and sulfate) with an SSI/SSL statistically higher than background? List the applicable constituents.	Yes	CCR Release	Key if No	Constituent	Northern Boundary: Boron, Calcium, and Chloride – Yes; Fluoride - No. It is noted that statistical analysis has not been performed on leachate results; evaluation is based on four leachate sampling events conducted between October 2017 and April 2019. Western Boundary: Calcium, Chloride, and Sulfate – Yes. It is noted that statistical analysis has not been performed on leachate results; evaluation is based on four leachate sampling events conducted between October 2017 and April 2019.
1f	Are concentrations for the primary indicators increasing?	No	Uncertain	Supporting	Monitoring Point	Northern Boundary: No. It should be noted that the CCR dataset covers a very limited time range (~1.5 year) for trend analysis. Western Boundary: No. It should be noted that the CCR dataset covers a very limited time range (~1.5 year) for trend analysis.
Secondary Indicators						
2a	Are there other SSI(s) or SSL(s) of Appendix III or IV parameters?	Yes	CCR Release	Supporting	Monitoring Point	Northern Boundary: SSIs for pH (GW-23 and -24), TDS (GW-19, -20, -23, and -24), Barium (GW-19 and GW-20), Chromium (GW-20), Radium 226+228 (GW-9 and -19), and Selenium (GW-20); SSLs for Arsenic (GW-19, -23, -24, and -25), Barium (GW-23, -24, and -25), and Radium 226+228 (GW-9 and -19).

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Secondary Indicators (Continued)						
2a (con't)	(These are potential secondary indicators. List the applicable constituents.)					Western Boundary: SSIs for pH (GW-27, -28, and -29), TDS (GW-28 and -29), Barium (GW-27, -28, and -29), and Radium 226+228 (GW-27, -28, and -29); SSLs for Arsenic (GW-29).
2b	Are the constituents identified in 2a present in leachate in concentrations statistically higher than background?	Yes / No	Uncertain	Key if No	Constituent	Northern Boundary: pH, TDS, and Arsenic – Yes; Barium – No; Radium 226+228 not historically analyzed in leachate sampling program, but sampled once in July 2019 for this ASD. Statistical analysis has not been performed on leachate results; evaluation based on four sampling events conducted between October 2017 and April 2019 plus July 2019 sampling for Radium 226+228. Western Boundary: pH, TDS, and Arsenic – Yes; Barium – No; Radium 226+228 not historically analyzed in leachate sampling program, but sampled once in July 2019 for this ASD. Statistical analysis has not been performed on leachate results; evaluation based on four sampling events conducted between October 2017 and April 2019 plus July 2019 sampling for Radium 226+228.
2c	Are concentrations for any of the secondary indicators increasing? List the applicable constituents.	No	Uncertain	Supporting	Monitoring Point	Northern Boundary: No. It should be noted that the CCR dataset covers a very limited time range (~1.5 years) for trend analysis. Western Boundary: No. It should be noted that the CCR dataset covers a very limited time range (~1.5 years) for trend analysis.
Other Chemistry						
3a	Are organic constituents present in concentrations statistically higher than background?	N/A	-----	Supporting	Monitoring Point	Organics not analyzed as part of groundwater testing program at site.
3b	Is major ion chemistry similar to leachate?	ND	-----	Key	Monitoring Point	Based on primary and secondary indicator LOE's listed above, major chemistry analysis was not performed as part of Appendix IV ASD.
3c	Does major ion chemistry suggest a mixture of leachate and background groundwater?	ND	-----			Based on primary and secondary indicator LOE's listed above, major chemistry analysis was not performed as part of Appendix IV ASD.
3d	Does tritium age dating indicate that the groundwater was recharged after the facility was first used?	N/A	-----	Key if No	Monitoring Point	Disposal site development initiated in the late 1970's.
3e	Does isotopic analysis show evidence of mixing with CCR leachate?	ND	-----	Key	Monitoring Point	Based on primary and secondary indicator LOE's listed above, isotopic analysis was not performed as part of Appendix IV ASD.
Hydrogeology						
4a	Is the monitoring well with an SSI/SSL downgradient from CCR unit at any point during year?	Yes	CCR Release	Key if No	Monitoring Point	Multiple SSIs and SSLs were identified in the downgradient wells, all of which are positioned downgradient of the disposal site during all times of the year.

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Hydrogeology (Continued)						
4b	Review the Hydrogeological vs Leachate Scenario Table (EPRI, Table A-2) and identify the most representative scenario for each SSI or SSL case. List cases and scenario numbers.	-----	-----	Key	Monitoring Point	**Northern Boundary** Boron - CCR Leachate Release (Row c) Calcium - CCR Leachate Release + Possible Alternative Source (Row b) Chloride - CCR Leachate Release + Possible Alternative Source (Row c) Fluoride – Alternative Source Release (Row b) pH – Alternative Source Release (Row a) TDS - CCR Leachate Release + Possible Alternative Source (Row b) Arsenic – CCR Leachate Release (Row c) Barium – Alternative Source Release (Row a) Chromium – Leachate data not available for comparison Lithium – CCR Leachate Release + Possible Alternative Source (Row c) Molybdenum – Leachate data not available for comparison Radium 226+228 - Alternative Source Release (Row a) Selenium – Leachate data not available for comparison **Western Boundary** Calcium - CCR Leachate Release (Row a) Chloride - CCR Leachate Release + Possible Alternative Source (Row b) pH – CCR Leachate Release (Row a) Sulfate - CCR Leachate Release (Row a) TDS - CCR Leachate Release (Row a) Arsenic – CCR Leachate Release (Row c) Barium – Alternative Source Release (Row a) Lithium – CCR Leachate Release + Possible Alternative Source (Row c) Molybdenum – Leachate data not available for comparison Radium 226+228 - Alternative Source Release (Row a)
4c	Is the CCR unit immediately underlain by clay, shale, or other geologic media with low hydraulic conductivity?	Varies	Uncertain	Supporting	Unit	Some areas of site are underlain by clayey colluvial soils, mostly along what were the lower portions of tributary valleys.
4d	Is the monitoring point distant from the facility AND does the constituent with an SSI/SSL have low mobility in groundwater given the hydrogeologic environment at the monitoring location (EPRI, Table A-3)?	No	CCR Release	Supporting	Case	All downgradient monitoring wells are located at the waste boundary except for GW-23 (Northern Boundary) and GW-9 (Western Boundary).

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Hydrogeology (Continued)						
4e	Are the background monitoring wells screened in the same hydrostratigraphic unit, and along the same groundwater flow path, as the monitoring location with the SSI?	No / Yes	CCR Release	Supporting	Monitoring Point	The CCR Rule-defined uppermost aquifer at the site is comprised of multiple water-bearing strata that are hydraulically connected. The site's upgradient well (GW-7) is located along the appropriate groundwater flow path to its corresponding downgradient wells, however, it is are also positioned stratigraphically higher than some of the downgradient wells.
CCR Unit Design						
5a	Does the entire footprint of the monitored CCR unit have a liner?	Yes / No	Potential Alternate Source / CCR Release	Supporting	Unit	The landfill area does have a liner system while the impoundment area (including the dam) does not.
5b	If the facility is lined, is it a composite liner?	Yes / No	Potential Alternate Source / CCR Release	Supporting	Unit	A portion of the landfill area is lined with only 24-inches of compacted clay, while the remainder utilizes a composite system comprised of a geosynthetic clay liner (GCL) overlain by a high density polyethylene (HDPE) geomembrane.
5c	Does the entire footprint of the CCR unit have a leachate collection system?	Yes / No	Potential Alternate Source / CCR Release	Supporting	Unit	The entire footprint of the landfill area does have a leachate collection system. The impoundment area does not have a leachate collection system, but the dam does include a blanket drain/chimney drain system.
5d	If the CCR unit is unlined, is it known to have or is it likely to have groundwater intersecting the CCR?	Yes	CCR Release	Supporting	Unit	Both the landfill and impoundment areas are situated within a valley (the impoundment at the head and the landfill at the mouth) and the CCR Rule-defined uppermost aquifer at the site is comprised of multiple water-bearing strata that are hydraulically connected. Most of the uppermost aquifer rock strata all outcropped within the valley before the disposal site was developed so it is very likely that groundwater intersects the CCRs, particularly in the impoundment area.

Table Notes:

[1] ND (not determined) indicates that this line of evidence was not tested or there are insufficient data to make a determination; N/A means lines of evidence not applicable to the CCR unit.

[2] Line of Evidence (LOE) Types:
Key lines of evidence are based on relationships that must be observed in order for an SSI/SSL to be due to a release from a CCR unit. If these relationships are not observed, then they are critical to establishing an ASD. It is difficult to build a strong ASD without any key lines of evidence. It may be possible to build an ASD with a single key line of evidence, but the ASD will be stronger with additional key or supporting lines of evidence.
Supporting lines of evidence provide additional information that supports the ASD. Supporting lines of evidence are generally not sufficient to build an ASD unless there is at least one key line of evidence, although it may be possible if there are many supporting lines of evidence.

[3] This LOE applies to:
Constituent: An SSI/SSL for that constituent at any monitoring point
Monitoring Point: All SSIs/SSLs at a specific monitoring point
Case: An SSI/SSL for a specific constituent at a specific monitoring point
Unit: All SSIs/SSLs at the monitored unit

Table 3 - ASD Checklist 3: Lines of Evidence Associated with Alternative Natural and Anthropogenic Sources

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
General						
6a	Are there any known alternative sources for any of the constituents of concern on-site or off-site?	Yes	Potential Alternate Source	Supporting	Unit	Historical and current oil and gas exploration and production activities have the potential to cause brine water and associated constituents of concern to migrate into the monitored aquifer. Several hundred oil and gas wells dating back as far back as the late 1880s have the potential to have been improperly drilled, plugged, or produced, resulting in releases to the environment.
6b	Are any current or former potential alternative sources upgradient of the monitoring location?	Yes	Potential Alternate Source	Supporting	Monitoring Point	Historical and current oil and gas exploration and production activities have occurred in all areas surrounding the CCR unit, including areas upgradient/background of the monitoring locations.
6c	Do monitoring locations between a potential upgradient source and CCR unit have concentrations at SSI/SSL levels?	N/A	N/A	Supporting	Constituent	There are currently no monitoring locations situated between the potential upgradient sources and the CCR unit.
On-Site Alternative Source						
7a	Is the monitoring point downgradient of or near a coal pile, or coal pile runoff, or coal pile leachate management area?	No	No Alternate Source	Supporting	Monitoring Point	There are no coal pile, coal pile runoff, or coal pile leachate management areas near the downgradient monitoring points.
7b	Are there former coal mines, mine spoil, or conveyers near the CCR unit or upgradient from the facility?	No	No Alternate Source	Supporting	Unit	There are no known coal mining operations that have occurred on-site or in the surrounding area.
7c	Does the site have other CCR units that are upgradient or side gradient of the affected monitoring location?	No	No Alternate Source	Supporting	Monitoring Point	There are no other CCR units located upgradient or side gradient of the affected monitoring locations.
7d	Is the CCR unit built on top of a former CCR disposal area (i.e., has a lined impoundment been built on top of a former unlined impoundment, or has a lined landfill been built on top of a portion of an unlined impoundment)?	No	No Alternate Source	Supporting	Unit	The landfill area is lined (refer to Table 2, LOE 5b) and constructed atop the downstream face of the unlined impoundment's dam. However, the two disposal areas share a multi-unit groundwater monitoring network that does not allow for differentiation of impacts from one area or the other.

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
On-Site Alternative Source (Continued)						
7e	Do the CCR unit or adjacent units have an active underdrain piping system or groundwater pumping system, or are there any groundwater pumping activities nearby, that could have localized influence on groundwater flow and quality?	Yes/No	No Alternate Source	Supporting	Unit	The entire footprint of the landfill area does have a combined groundwater underdrain/leak detection system and the impoundment dam has a blanket drain/chimney drain system. However, the impoundment area does not have any type of groundwater control system. As such, the landfill system is not expected to have a measurable localized influence on groundwater flow and quality.
7f	Is there evidence that water used for dust suppression on uncovered CCR or coal piles flowed off the footprint of the liner or runoff containment system near the monitoring point?	No	No Alternate Source	Supporting	Monitoring Point	There is no evidence of dust suppression water to have flowed off the footprint of the landfill liner or runoff containment systems and near the monitoring points.
7g	Is leachate or sluice water used for dust control close to the monitoring location?	No	No Alternate Source	Supporting	Monitoring Point	Dust control water is obtained from non-potable sources from the power station.
7h	Is the monitoring point downgradient of or near a CCR handling area (silo, storage area, dewatering bin, sump, truck loading/unloading or washing area, etc.) or haul road?	No/Yes	No Alternate Source/Potential Alternate Source	Supporting	Monitoring Point	Northern Boundary: No. Western Boundary: GW-27 and -28 are located near the CCR landfill haul road.
7i	Is the monitoring point downgradient of or near sluice water lines, handling equipment, or storage areas?	No/Yes	No Alternate Source/Potential Alternate Source	Supporting	Monitoring Point	Northern Boundary: No. Western Boundary: GW-27, -28, and -29 are positioned downgradient of the impoundment influent sluice line and effluent siphon line.
7j	Is the monitoring point downgradient of or close to a leachate collection pipeline or leachate storage structure?	No/Yes		Supporting	Monitoring Point	Northern Boundary: No. Western Boundary: GW-27 is located near the landfill's leachate collection and detection discharge lines.
7k	Have there been any documented spills of CCR or leachate or sluice water in upgradient or nearby locations?	No	No Alternate Source	Supporting	Monitoring Point	There are no known spills of CCRs, leachate, or sluice water in upgradient or nearby locations.

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
On-Site Alternative Source (Continued)						
7l	Were CCRs ever drained or stockpiled in unlined areas and/or without run-off/leachate control in upgradient or nearby areas?	No	No Alternate Source	Supporting	Monitoring Point	All known CCR management activities at the site have been performed in the landfill or impoundment disposal areas..
7m	Is there any history of on-site or upgradient oil or chemical spills or leaking underground storage tanks?	Yes	Potential Alternate Source	Supporting	Monitoring Point	There are numerous historical and current oil and gas tank batteries and underground pipelines on the site with at least one known release from an oil pipeline that occurred near GW-7 approximately 15 years ago.
7n	Does a significant amount of road salting occur on-site? (also see 9b)	No	No Alternate Source	Supporting	Monitoring Point	The portion of the site access road that is paved and salted is located downgradient of the CCR unit monitoring wells.
7o	Are fertilizers being used on-site for cap vegetation or other uses?	Yes	Potential Alternate Source	Supporting	Monitoring Point	Fertilizers are used in the hydroseeding of all disturbed areas at the site (capped areas, borrow areas, etc.)
7p	Is there any history of on-site or background ash utilization (structural fill, landfill, road base, berm construction, soil stabilization, etc.)?	Yes	Potential Alternate Source	Supporting	Monitoring Point	The downstream portion of the impoundment dam is constructed of compacted fly ash and includes blanket and chimney drains that are constructed of bottom ash.
7q	Was the power plant site subgrade prepared with CCR, dredge spoils, incinerator residue, construction debris, industrial waste, or non-native soils?	N/A	N/A	Supporting	Monitoring Point	The Power Plant is located downgradient and distant from the CCR unit.
Natural Variation						
8a	Are background wells screened in the same geomedia as the monitoring point?	Yes/No	Potential Alternate Source/No Alternate Source	Supporting	Monitoring Point	The CCR Rule-defined uppermost aquifer at the site is comprised of multiple water-bearing strata that are hydraulically connected. The site's upgradient well (GW-7) and other background wells (GW-21 and -22) are located along the appropriate groundwater flow paths to the downgradient wells, however, it they are also positioned stratigraphically higher than some of the downgradient wells.
8b	Is the aquifer comprised of poorly buffered media such as sand and gravel?	No	No Alternate Source	Supporting	Unit	The aquifer is comprised of cyclic sequences of sandstone, shale, claystone, coal, and limestone and is not considered to be poorly buffered.
8c	Is the pH at the monitoring point similar to the background pH?	Varies	Uncertain	Supporting	Monitoring Point	The pH of the background well is typically moderately higher than the downgradient monitoring points.
8d	Is the monitoring point near a river?	No	No Alternate Source	Supporting	Monitoring Point	The Ohio River is located approximately 2000 feet downgradient of the closed CCR monitoring points (GW-9 and -19).

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Natural Variation (Continued)						
8e	Is the constituent chemically reactive in groundwater, such that dissolution or desorption is possible (EPRI, Table A-3)?	Yes/No	Potential Alternate Source/No Alternate Source	Supporting	Constituent	Arsenic: Reactive and influenced by pH and redox; sorption usually decreases with pH. Barium: Reactive; has limited solubility and is usually sorbed to clay, soils, and sediment. Lithium: Non-reactive. Radium: Reactive; subject to cation exchange.
8f	Is there a difference in redox indicators between background and compliance monitoring data?	ND	ND	Supporting	Monitoring Point	Redox parameters were not analyzed as part of the Appendix IV ASD.
8g	Has there been a recent flood, recharge event, or dry period that caused groundwater elevation to rise or fall to elevations higher or lower than observed during the background monitoring period?	No	No Alternate Source	Supporting	Unit	Groundwater conditions have generally remained consistent with changes not being attributable to flooding and drought conditions.
8h	Does the aquifer contain saline water at depth?	No	No Alternate Source	Supporting	Unit	Saline conditions are not observed in Site groundwater.
8i	Was the direction of groundwater flow prior to or during the sample event different than observed during the background prior?	No	No Alternate Source	Supporting	Monitoring Point	Groundwater flow has consistently been to the north and west and to the northeast for the western and northern boundaries, respectively.
Off-Site Anthropogenic						
9a	Are there former coal mines, mine spoil, or conveyers near the CCR unit or upgradient from the facility (also consider under "On-site")?	No	Uncertain	Supporting	Unit	There are no former coal mine, mine spoil, or conveyor systems upgradient of or near the CCR unit.
9b	Does a significant amount of road salting occur off-site?	N/A	N/A	Supporting	Unit	CCR unit is a captive site situated above the surrounding off-site roadways that are typically salted.
9c	Does the surrounding land use include agriculture (crops)?	Yes/No	No Alternate Source	Supporting	Unit	The neighboring properties appear to have limited agricultural uses (crops) which are determined to present little to no impacts to groundwater as it relates to the CCR unit.
9d	Does the surrounding land use include agriculture (animal)?	Yes/No	No Alternate Source	Supporting	Unit	The neighboring properties appear to have limited agricultural uses (animal) which are determined to present little to no impacts to groundwater as it relates to the CCR unit.

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Off-Site Anthropogenic (Continued)						
9e	Are there current or former underground or aboveground storage tanks that have had a release? (Consider gas stations and surrounding industrial activities.)	Yes	Potential Alternate Source	Supporting	Unit	There are numerous historical and current oil and gas production tank batteries surrounding the CCR unit. Documented spills from those tanks were not identified, but given the age of the tanks there is the potential that leaks and spills have resulted in impacts to groundwater.
9f	Are there, or were there, oil and gas production wells in the vicinity of the site?	Yes	Potential Alternate Source	Supporting	Unit	There are several hundred historical and existing oil and gas exploration and production wells on and in the vicinity of the site. Observations of oil and gas impacts to groundwater have been noted during the installation of several groundwater monitoring wells at the site and during groundwater sampling activities.
9g	Are there existing or historical commercial and/or industrial sources of impacts, such as metal manufacturing, mining, landfills, Superfund or brownfield sites, wood treatment, etc.?	No	No Alternate Source	Supporting	Unit	Other than the oil and gas activities discussed in LOE 9f, there are no other known historical off-site commercial and/or industrial sources.
9h	Could any potential anthropogenic sources be causing changes to groundwater chemistry that would result in release of the constituent of concern through changes to pH, redox, etc.?	Yes	Potential Alternate Source	Supporting	Unit	Historical and current oil and gas exploration and production activities have likely allowed for the migration of brine water and other constituents of interest in the overlying aquifer of the CCR unit that could be affecting groundwater geochemistry.
Time-of-Travel Analysis						
10	Has groundwater flowing beneath potential sources had enough time to migrate to the affected monitoring well location?	Yes	Potential Alternate Source	Supporting	Monitoring Point	Given the age of the CCR unit and history of disposal activities dating back to the late 1970s, there has been enough time for potentially impacted groundwater to flow to the affected monitoring wells.

Table Notes:

[1] ND (not determined) indicates that this line of evidence was not tested or there are insufficient data to make a determination; N/A means line of evidence not applicable to the CCR unit.

[2] Line of Evidence (LOE) Types:
Key lines of evidence are based on relationships that must be observed in order for an SSI/SSL to be due to a release from a CCR unit. If these relationships are not observed, then they are critical to establishing an ASD. It is difficult to build a strong ASD without any key lines of evidence. It may be possible to build an ASD with a single key line of evidence, but the ASD will be stronger with additional key or supporting lines of evidence.
Supporting lines of evidence provide additional information that supports the ASD. Supporting lines of evidence are generally not sufficient to build an ASD unless there is at least one key line of evidence, although it may be possible if there are many supporting lines of evidence.

[3] This LOE applies to:
Constituent: An SSI/SSL for that constituent at any monitoring point
Monitoring Point: All SSIs/SSLs at a specific monitoring point
Case: An SSI/SSL for a specific constituent at a specific monitoring point
Unit: All SSIs/SSLs at the monitored unit

Table 4 - Leachate Data Summary

	Leachate Concentrations (mg/L)				GW Concentrations (mg/L) Northern Boundary															
Parameters	**LM1 Average**	**LM5 Average**	**LM7 Average**	**Leachate Avg.**	**UG UPL (GW-7)**	**GW-9**	**GW-19**	**GW-20**	**GW-23**	**GW-24**	**GW-25**	**GW-26**	**DG Avg.**	**Leachate Avg. > UG UPL?**	**DG Avg. > UG UPL?**	**GW-9 < Leachate Avg.?**	**GW-19 < Leachate Avg.?**	**GW-20 < Leachate Avg.?**	**GW-23 < Leachate Avg.?**	**GW-24 < Leachate Avg.?**
Arsenic	0.055321	0.1667684	1.133410	0.451833	0.00682	0.00050	0.09721	0.00250	0.03248	0.02855	0.05652	0.03058	0.03548	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Barium	0.0204316	0.0233133	0.0344573	0.026067	0.0934	0.062755	1.10111	0.240567	9.76212	9.25331	7.62675	0.534738	4.08305	No	Yes	No	No	No	No	No
Lithium	3.29002	6.35006	4.26817	4.636083	0.023374	0.017431	0.014145	0.01607	0.150178	0.045126	0.030696	0.038631	0.04461	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Radium (226+228) (pCi/L)	0.5	1.81	0.0748	0.7949	0.58	ND	2.44	0.505	83.4	46.1	30.5	1.92	27.478	Yes	Yes	No	No	Yes	No	No

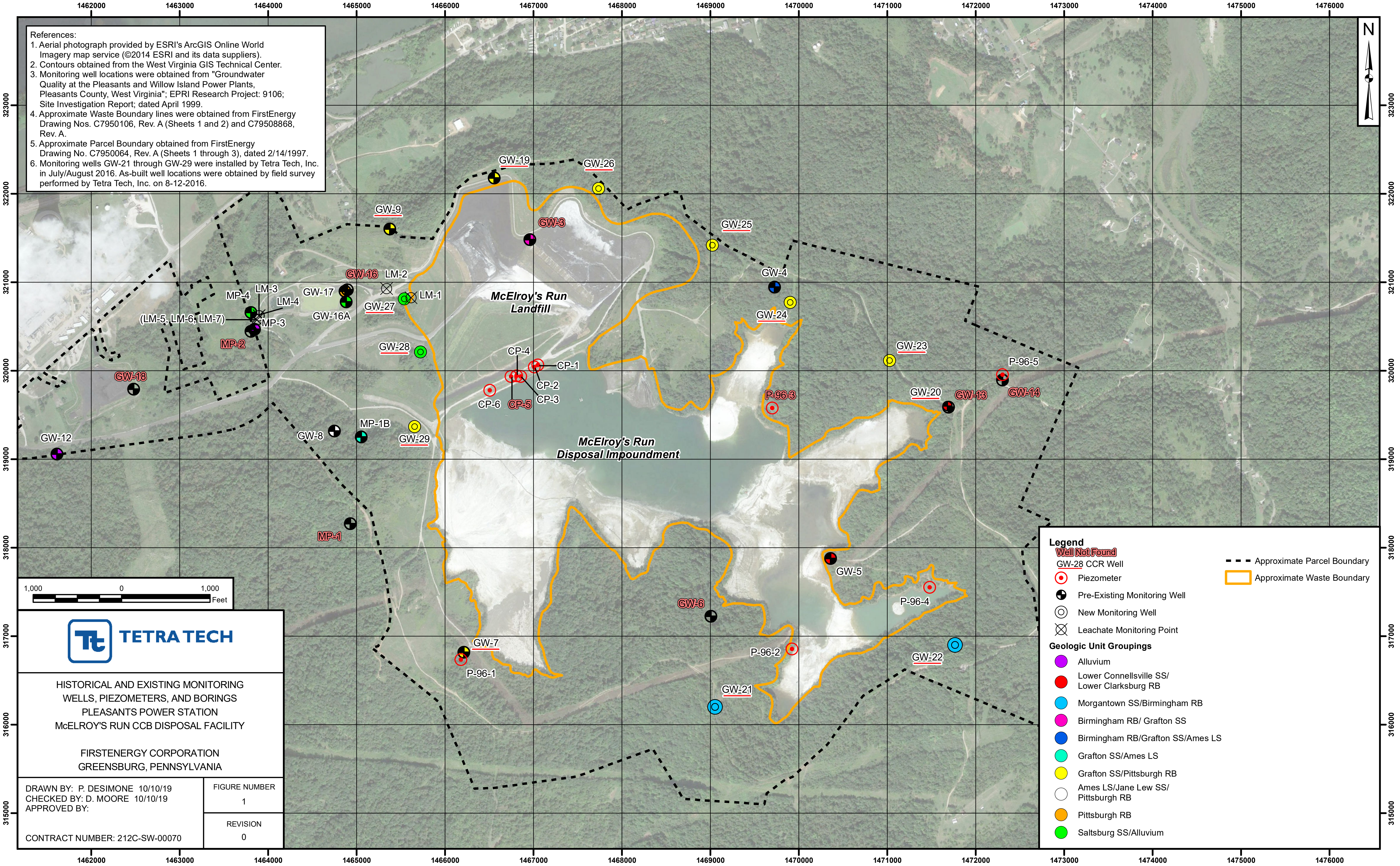
	Leachate Concentrations (mg/L)				GW Concentrations (mg/L) Western Boundary															
Parameters	**LM1 Average**	**LM5 Average**	**LM7 Average**	**Leachate Avg.**	**UG UPL (GW-7)**	**GW-27**	**GW-28**	**GW-29**					**DG Avg.**	**Leachate Avg. > UG UPL?**	**DG Avg. > UG UPL?**	**GW-27 < Leachate Avg.?**	**GW-28 < Leachate Avg.?**	**GW-29 < Leachate Avg.?**		
Arsenic	0.055321	0.1667684	1.133410	0.451833	0.00682	0.000352	0.005549	0.018564					0.00816	Yes	Yes	Yes	Yes	Yes		
Barium	0.020432	0.023313	0.034457	0.026067	0.0934	0.914027	0.249275	1.05644					0.73991	No	Yes	No	No	No		
Lithium	3.29002	6.35006	4.26817	4.636083	0.023374	0.013196	0.016578	0.033673					0.02115	Yes	No	Yes	Yes	Yes		
Radium (226+228) (pCi/L)	0.5	1.81	0.0748	0.7949	0.58	1.3	0.466	1.27					1.012	Yes	Yes	No	Yes	No		

Notes: DG -Downgradient; GW - Groundwater; UG - Upgradient; UPL - Upper Prediction Limit
Leachate Concentrations averaged from 5 sampling events performed between October 2017 and July 2019, except for Lithium and Radium which was from one event in July 2019.
GW Concentrations of App. III parameters from sampling and analysis completed in February 2019.
GW Concentrations of App. IV parameters from sampling and analysis completed in February 2019.
UG UPL's based on 8 baseline sampling events.

LM1 - Leachate Collection from Dam Blanket/Chimney Drains
LM5 - Stage 1G LCS
LM7 - Stage 2B LCS

FIGURES

PGH P:\GIS\FIRST_ENERGY\MAPDOCS\PLEASANTS_POWERSTATION__BORING_PIEZOS_WELLS_CCR_20190801.MXD 10/10/19 PD



References:
1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (©2014 ESRI and its data suppliers).
2. Contours obtained from the West Virginia GIS Technical Center.
3. Monitoring well locations were obtained from "Groundwater Quality at the Pleasants and Willow Island Power Plants, Pleasants County, West Virginia"; EPRI Research Project: 9106; Site Investigation Report; dated April 1999.
4. Approximate Waste Boundary lines were obtained from FirstEnergy Drawing Nos. C7950106, Rev. A (Sheets 1 and 2) and C79508868, Rev. A.
5. Approximate Parcel Boundary obtained from FirstEnergy Drawing No. C7950064, Rev. A (Sheets 1 through 3), dated 2/14/1997.
6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

Legend

Well Not Found
GW-28 CCR Well
◉ Piezometer
◐ Pre-Existing Monitoring Well
◎ New Monitoring Well
⊗ Leachate Monitoring Point

Geologic Unit Groupings

- ● Alluvium
- ● Lower Connellsville SS/ Lower Clarksburg RB
- ● Morgantown SS/Birmingham RB
- ● Birmingham RB/ Grafton SS
- ● Birmingham RB/Grafton SS/Ames LS
- ● Grafton SS/Ames LS
- ● Grafton SS/Pittsburgh RB
- ○ Ames LS/Jane Lew SS/ Pittsburgh RB
- ● Pittsburgh RB
- ● Saltsburg SS/Alluvium

- - - Approximate Parcel Boundary
▭ Approximate Waste Boundary

TETRA TECH

HISTORICAL AND EXISTING MONITORING
WELLS, PIEZOMETERS, AND BORINGS
PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 10/10/19
CHECKED BY: D. MOORE 10/10/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
1

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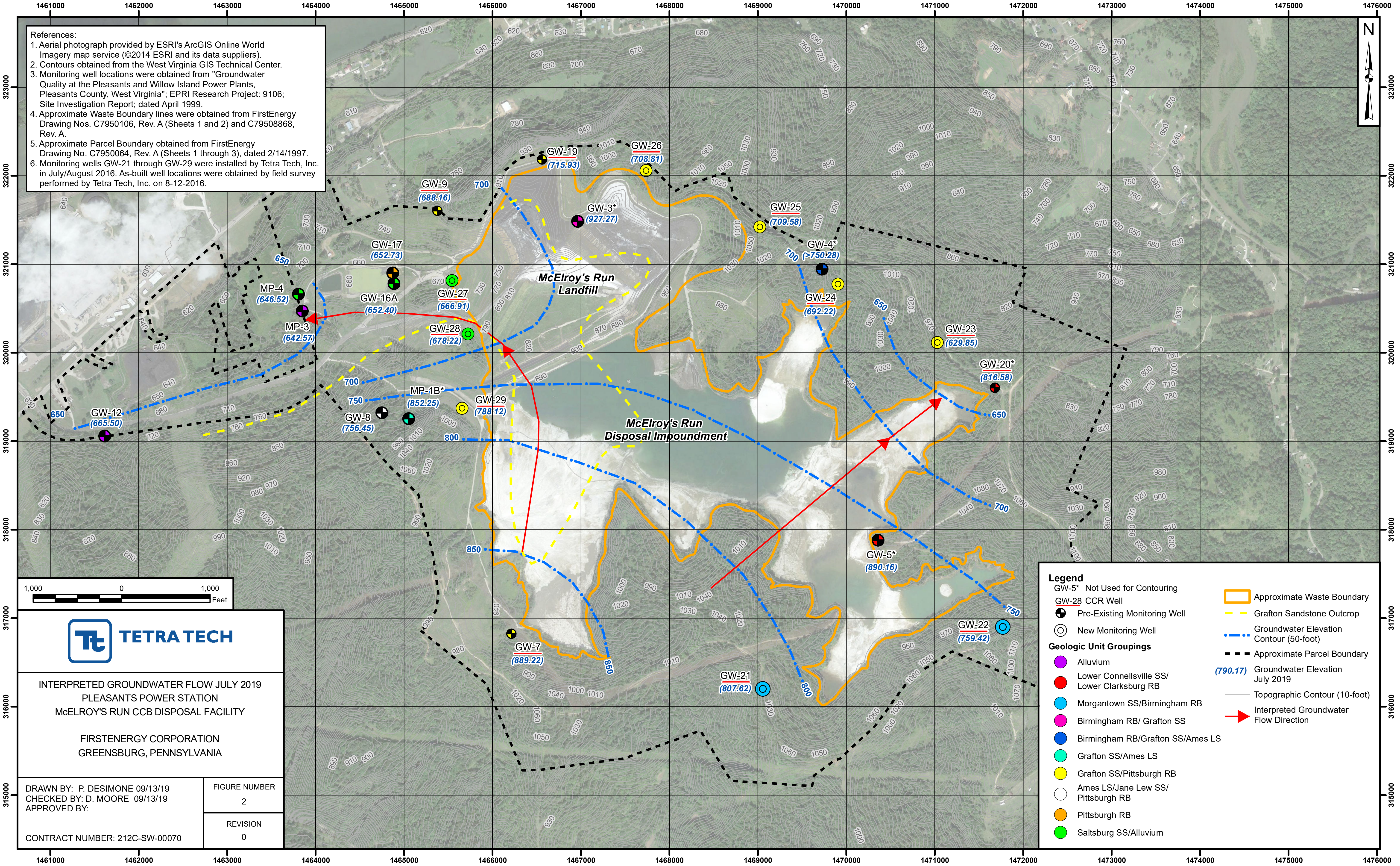

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4. Approximate Waste Boundary lines were obtained from FirstEnergy Drawing Nos. C7950106, Rev. A (Sheets 1 and 2) and C79508868, Rev. A.
5. Approximate Parcel Boundary obtained from FirstEnergy Drawing No. C7950064, Rev. A (Sheets 1 through 3), dated 2/14/1997.
6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

Legend

GW-5* Not Used for Contouring
GW-28 CCR Well
◐ Pre-Existing Monitoring Well
◎ New Monitoring Well

Geologic Unit Groupings

● Alluvium
● Lower Connellsville SS/ Lower Clarksburg RB
● Morgantown SS/Birmingham RB
● Birmingham RB/ Grafton SS
● Birmingham RB/Grafton SS/Ames LS
● Grafton SS/Ames LS
● Grafton SS/Pittsburgh RB
○ Ames LS/Jane Lew SS/ Pittsburgh RB
● Pittsburgh RB
● Saltsburg SS/Alluvium

▭ Approximate Waste Boundary
- - Grafton Sandstone Outcrop
-·- Groundwater Elevation Contour (50-foot)
- - Approximate Parcel Boundary
(790.17) Groundwater Elevation July 2019
— Topographic Contour (10-foot)
→ Interpreted Groundwater Flow Direction

TETRA TECH

INTERPRETED GROUNDWATER FLOW JULY 2019
PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 09/13/19 CHECKED BY: D. MOORE 09/13/19 APPROVED BY:	FIGURE NUMBER 2
CONTRACT NUMBER: 212C-SW-00070	REVISION 0

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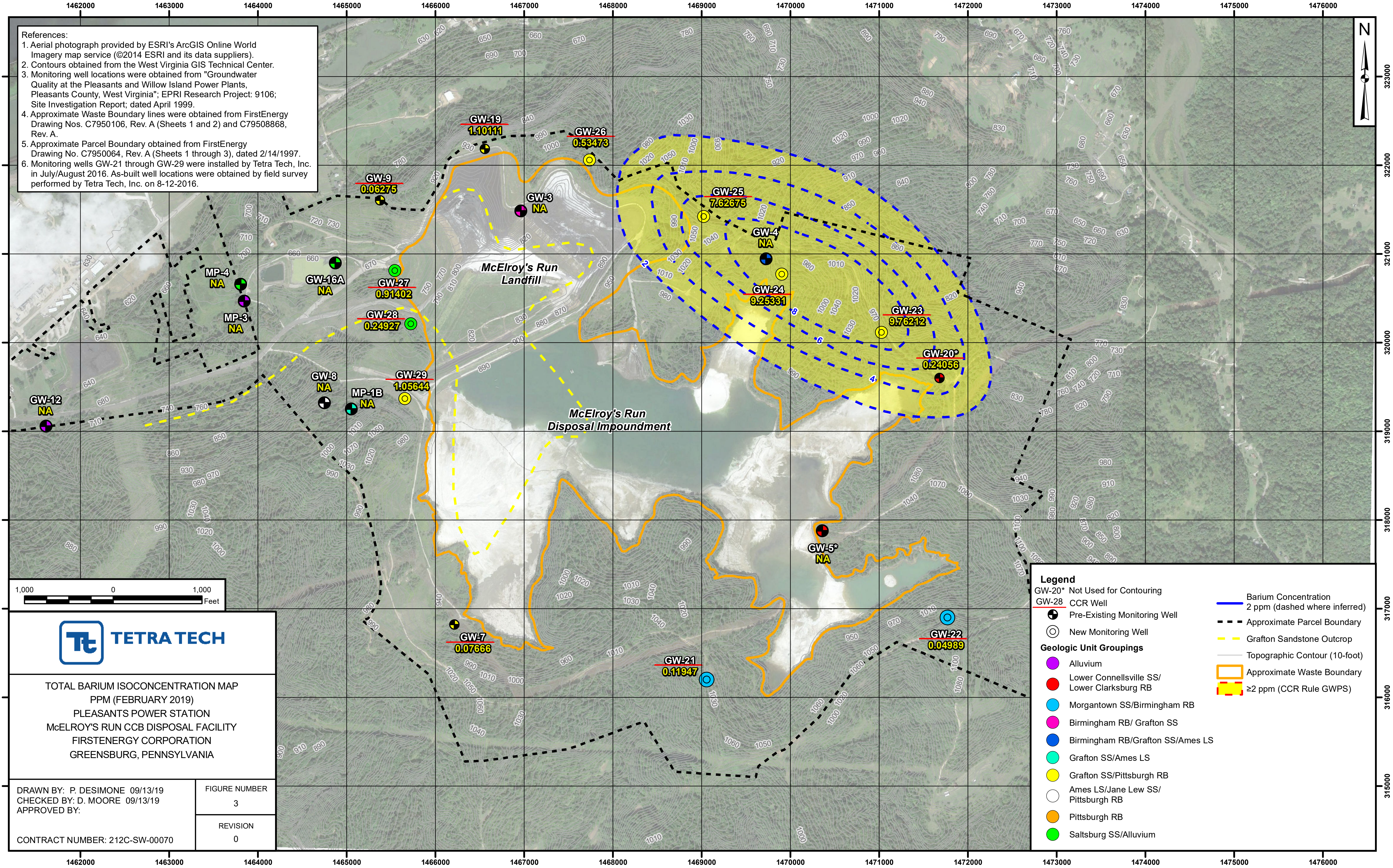

References:
1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (©2014 ESRI and its data suppliers).
2. Contours obtained from the West Virginia GIS Technical Center.
3. Monitoring well locations were obtained from "Groundwater Quality at the Pleasants and Willow Island Power Plants, Pleasants County, West Virginia"; EPRI Research Project: 9106; Site Investigation Report; dated April 1999.
4. Approximate Waste Boundary lines were obtained from FirstEnergy Drawing Nos. C7950106, Rev. A (Sheets 1 and 2) and C79508868, Rev. A.
5. Approximate Parcel Boundary obtained from FirstEnergy Drawing No. C7950064, Rev. A (Sheets 1 through 3), dated 2/14/1997.
6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

Legend

GW-20* Not Used for Contouring
GW-28 CCR Well
◐ Pre-Existing Monitoring Well
◎ New Monitoring Well

Geologic Unit Groupings

- ● Alluvium
- ● Lower Connellsville SS/ Lower Clarksburg RB
- ● Morgantown SS/Birmingham RB
- ● Birmingham RB/ Grafton SS
- ● Birmingham RB/Grafton SS/Ames LS
- ● Grafton SS/Ames LS
- ● Grafton SS/Pittsburgh RB
- ○ Ames LS/Jane Lew SS/ Pittsburgh RB
- ● Pittsburgh RB
- ● Saltsburg SS/Alluvium

Barium Concentration 2 ppm (dashed where inferred)
Approximate Parcel Boundary
Grafton Sandstone Outcrop
Topographic Contour (10-foot)
Approximate Waste Boundary
≥2 ppm (CCR Rule GWPS)

TETRA TECH

TOTAL BARIUM ISOCONCENTRATION MAP
PPM (FEBRUARY 2019)
PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY
FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 09/13/19
CHECKED BY: D. MOORE 09/13/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
3

REVISION
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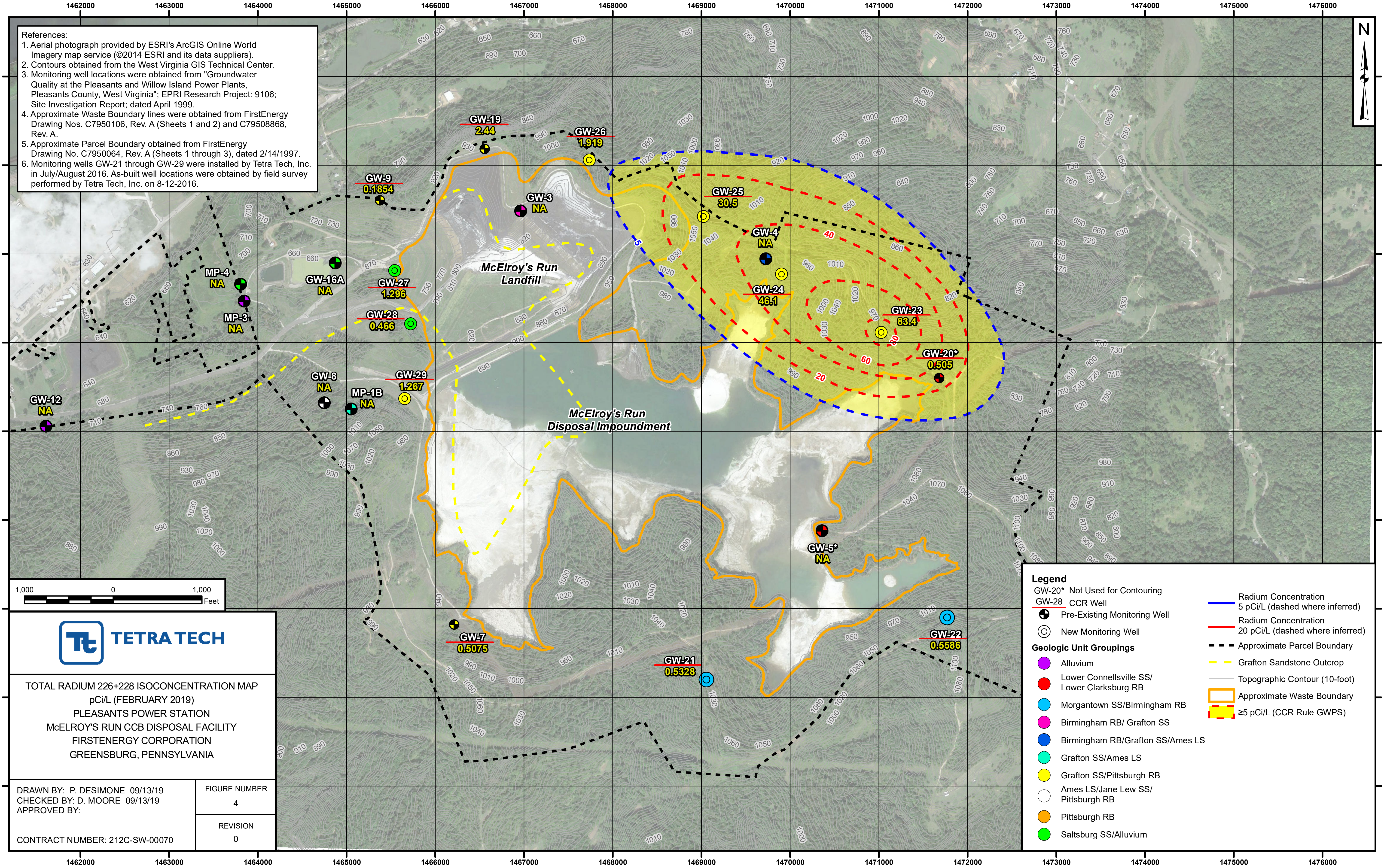

References:
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3. Monitoring well locations were obtained from "Groundwater Quality at the Pleasants and Willow Island Power Plants, Pleasants County, West Virginia"; EPRI Research Project: 9106; Site Investigation Report; dated April 1999.
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5. Approximate Parcel Boundary obtained from FirstEnergy Drawing No. C7950064, Rev. A (Sheets 1 through 3), dated 2/14/1997.
6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

Legend

GW-20* Not Used for Contouring
GW-28 CCR Well
⊕ Pre-Existing Monitoring Well
◎ New Monitoring Well

Geologic Unit Groupings

- ● Alluvium
- ● Lower Connellsville SS/ Lower Clarksburg RB
- ● Morgantown SS/Birmingham RB
- ● Birmingham RB/ Grafton SS
- ● Birmingham RB/Grafton SS/Ames LS
- ● Grafton SS/Ames LS
- ● Grafton SS/Pittsburgh RB
- ○ Ames LS/Jane Lew SS/ Pittsburgh RB
- ● Pittsburgh RB
- ● Saltsburg SS/Alluvium

Radium Concentration 5 pCi/L (dashed where inferred)
Radium Concentration 20 pCi/L (dashed where inferred)
Approximate Parcel Boundary
Grafton Sandstone Outcrop
Topographic Contour (10-foot)
Approximate Waste Boundary
≥5 pCi/L (CCR Rule GWPS)

TETRA TECH

TOTAL RADIUM 226+228 ISOCONCENTRATION MAP
pCi/L (FEBRUARY 2019)
PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY
FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 09/13/19
CHECKED BY: D. MOORE 09/13/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
4

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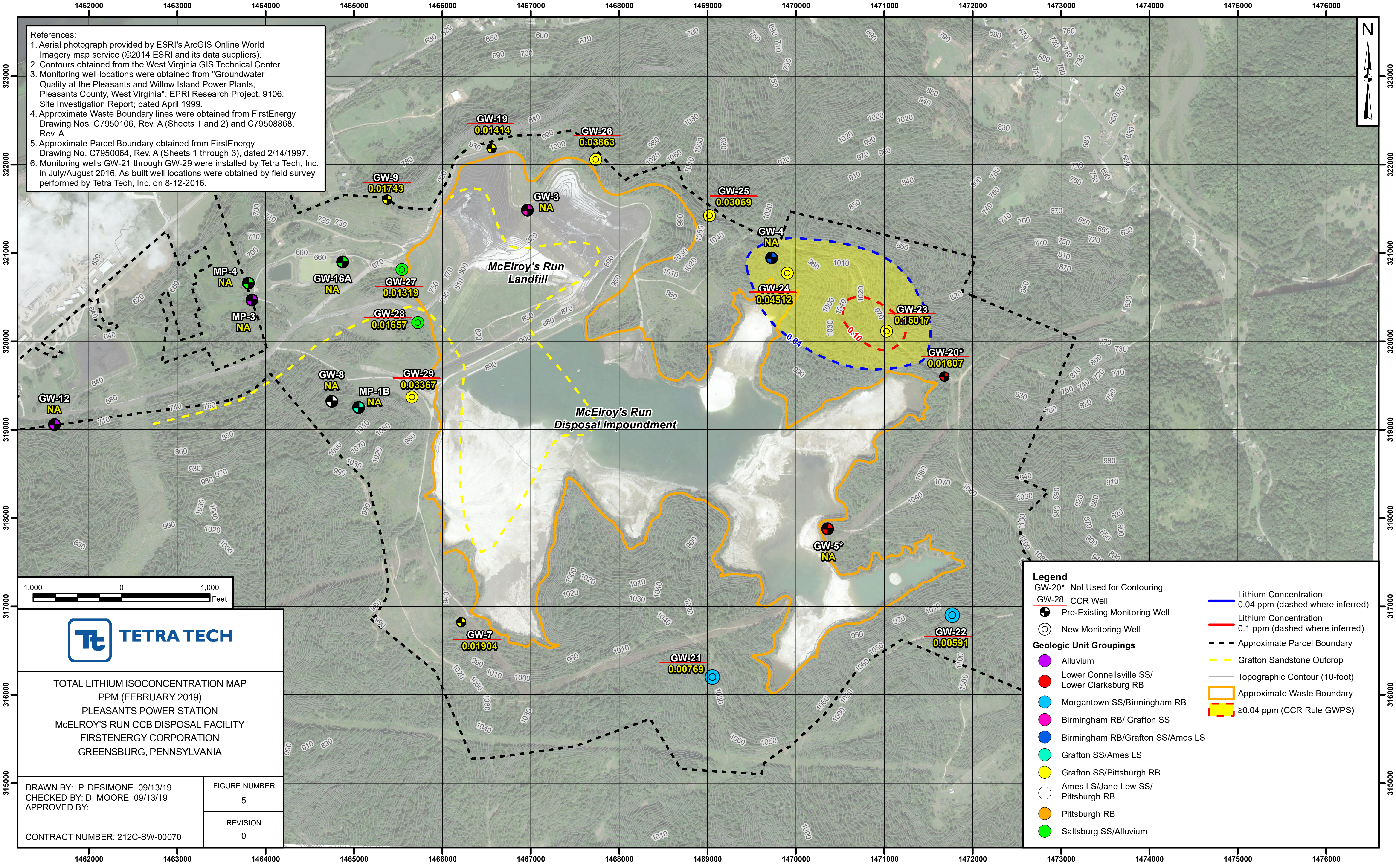

References:
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3. Monitoring well locations were obtained from "Groundwater Quality at the Pleasants and Willow Island Power Plants, Pleasants County, West Virginia"; EPRI Research Project: 9106; Site Investigation Report; dated April 1999.
4. Approximate Waste Boundary lines were obtained from FirstEnergy Drawing Nos. C7950106, Rev. A (Sheets 1 and 2) and C79508868, Rev. A.
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6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

Legend

GW-20* Not Used for Contouring
GW-28 CCR Well
⊕ Pre-Existing Monitoring Well
◎ New Monitoring Well

Geologic Unit Groupings

● Alluvium
● Lower Connellsville SS/ Lower Clarksburg RB
● Morgantown SS/Birmingham RB
● Birmingham RB/ Grafton SS
● Birmingham RB/Grafton SS/Ames LS
● Grafton SS/Ames LS
● Grafton SS/Pittsburgh RB
○ Ames LS/Jane Lew SS/ Pittsburgh RB
● Pittsburgh RB
● Saltsburg SS/Alluvium

Lithium Concentration 0.04 ppm (dashed where inferred)
Lithium Concentration 0.1 ppm (dashed where inferred)
Approximate Parcel Boundary
Grafton Sandstone Outcrop
Topographic Contour (10-foot)
Approximate Waste Boundary
≥0.04 ppm (CCR Rule GWPS)

TETRA TECH

TOTAL LITHIUM ISOCONCENTRATION MAP
PPM (FEBRUARY 2019)
PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY
FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 09/13/19
CHECKED BY: D. MOORE 09/13/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
5

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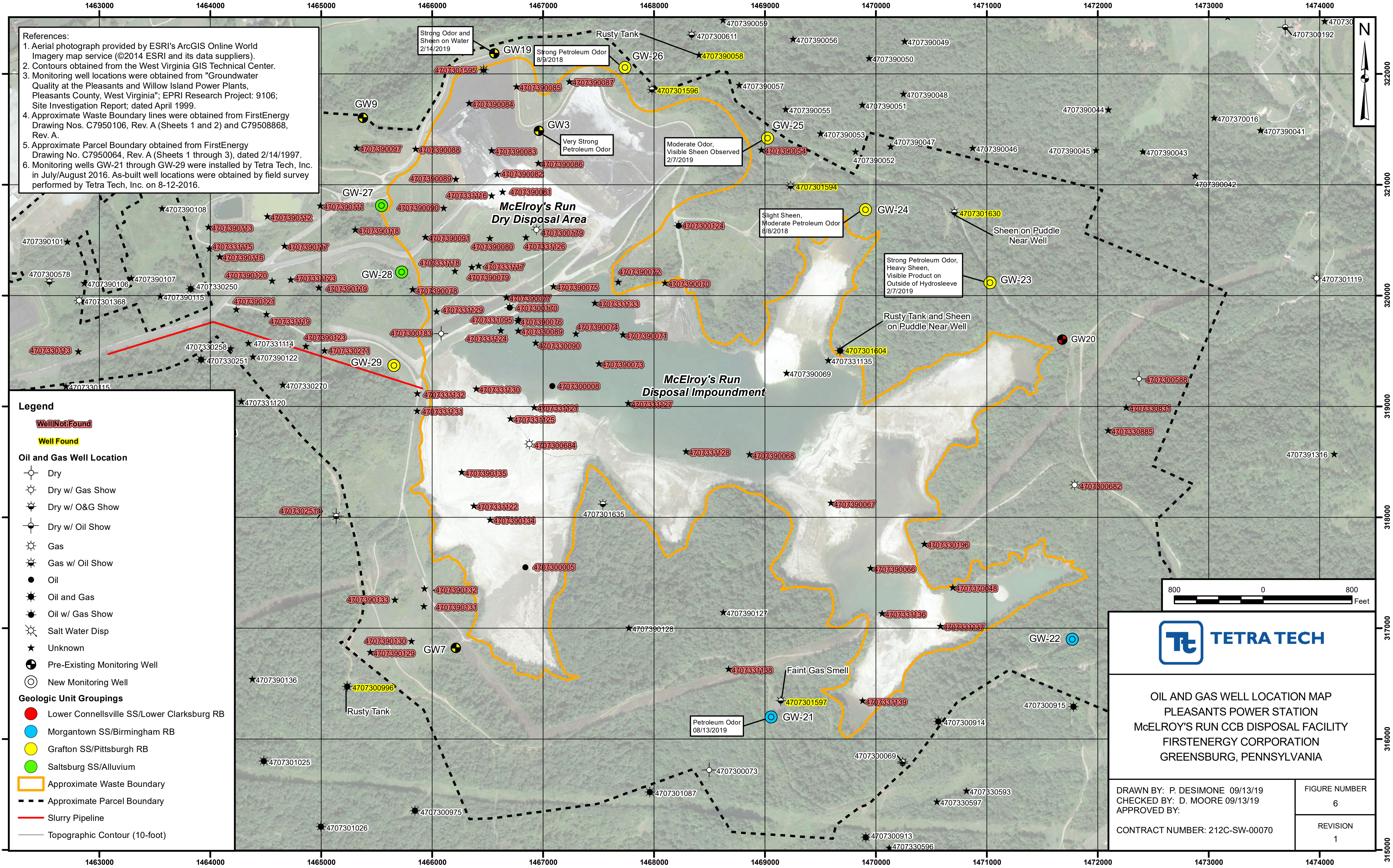


Strong Odor and Sheen on Water 2/14/2019

Strong Petroleum Odor 8/9/2018

Rusty Tank

Very Strong Petroleum Odor

Moderate Odor, Visible Sheen Observed 2/7/2019

Slight Sheen, Moderate Petroleum Odor 8/8/2018

Sheen on Puddle Near Well

Strong Petroleum Odor, Heavy Sheen, Visible Product on Outside of Hydrosleeve 2/7/2019

Rusty Tank and Sheen on Puddle Near Well

Faint Gas Smell

Petroleum Odor 08/13/2019

Rusty Tank

References:
1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (©2014 ESRI and its data suppliers).
2. Contours obtained from the West Virginia GIS Technical Center.
3. Monitoring well locations were obtained from "Groundwater Quality at the Pleasants and Willow Island Power Plants, Pleasants County, West Virginia"; EPRI Research Project: 9106; Site Investigation Report; dated April 1999.
4. Approximate Waste Boundary lines were obtained from FirstEnergy Drawing Nos. C7950106, Rev. A (Sheets 1 and 2) and C79508868, Rev. A.
5. Approximate Parcel Boundary obtained from FirstEnergy Drawing No. C7950064, Rev. A (Sheets 1 through 3), dated 2/14/1997.
6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

Legend

Well Not Found

Well Found

Oil and Gas Well Location
- ⌖ Dry
- ☼ Dry w/ Gas Show
- ☼ Dry w/ O&G Show
- ⌖ Dry w/ Oil Show
- ☼ Gas
- ☼ Gas w/ Oil Show
- ● Oil
- ✷ Oil and Gas
- ✷ Oil w/ Gas Show
- ☼ Salt Water Disp
- ★ Unknown
- ◐ Pre-Existing Monitoring Well
- ◎ New Monitoring Well

Geologic Unit Groupings
- 🟥 Lower Connellsville SS/Lower Clarksburg RB
- 🟦 Morgantown SS/Birmingham RB
- 🟨 Grafton SS/Pittsburgh RB
- 🟩 Saltsburg SS/Alluvium
- ▭ Approximate Waste Boundary
- ---- Approximate Parcel Boundary
- — Slurry Pipeline
- — Topographic Contour (10-foot)

TETRA TECH

OIL AND GAS WELL LOCATION MAP
PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY
FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 09/13/19
CHECKED BY: D. MOORE 09/13/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
6

REVISION
1

ATTACHMENT A

Boring Logs with Observations of Potential Oil and Gas Well Impacts

Figur 1.

PROJECT McElroys Run

GAI PROJECT NO. 81-237-44

CONTRACT NO.

DATES DRILLED: 9-2-93 thru. 9-7-93 & 9-21-93

DATES INSTRUMENTED:

CONSULTANTS, INC.

NON - SAMPLED BOREHOLE LOG

BOREHOLE NO. GW-3

NORTH COORDINATE: 500,943.98

EAST COORDINATE: 2,346,506.67

SURFACE ELEVATION: 942.98

INSPECTOR: A. Caffas

DEPTH		MATERIAL DESCRIPTION					REMARKS
FROM	TO						
0.0	3.0	Tan-Brn Silty Clay trace Dec. Shale					
3.0	12.0	Tan-Brn Dec. to Highly Weathered Silty Shale					
12.0	12.5	Red/Brn Clayey Shale					
12.5	26.0	Tan Highly Weathered to Dec. Silty Shale					
26.0	30.0	Tan-Gry Highly Weathered Shale					
30.0	38.0	Gry Silty Shale w/ Sandy Zones					Stopped @ 30.0' 9-2-93, Casing set to ~30.0'
38.0	40.0	Red w/ Gry Claystone					Resumed drilling 9-7-93 @ ~1030
40.0	41.0	Tan-Gry Fine grained Sandstone to Siltstone					
41.0	47.0	Tan Sandstone					Limy
47.0	50.0	Gry Siltstone					
50.0	51.0	Tan Siltstone					
51.0	52.0	Brn Sandstone					Moist
52.0	57.0	Tan & Gry Sandstone					
57.0	60.0	Gry Sandstone w/ Shale Partings					
60.0	69.0	Gry (w/ Tan-Brn Zones) Sandstone					Driller started adding water @ 61.0' (hole dry to 61.0') Iron Staining 65.0'-69.0'
69.0	73.0	Gry Interbedded Sandstone & Clayey Shale					Light Hydrocarbon odor
73.0	81.0	Gry Sandstone					Slightly limy cementation, weakly cemented sand particles Iron Staining 76.0'-80.0'
81.0	86.0	Gry Sandstone					Limy
86.0	90.0	DK Gry-BL Limestone & Sandstone					
90.0	95.0	Gry Sandstone					Limy

SUMMARY:

DRILLING (LF): 13 3/4" ~~13 7/8"~~ 30.0, 10 5/8" ~~12 1/4"~~ 235.0, 9 7/8" , 7 7/8" , 5 7/8"

CASING (LF): 12" 31.3, 10" , 8" , 6"

THERMOCOUPLE (LF): GAS SAMPLING TUBE (LF): INSTRUMENTATION: CAP:

STANDBY TIME: EXPLANATION: *BOREHOLE NO.* GW-3

BOREHOLE SEAL: EXPLANATION:

PAGE 1 of 3

REMARKS: Davey-Kent DR-30 Trackmounted Air Rotary Drill used to drill borehole.

Field Classification Sheet for Non-Sampled Borehole

Figur 1.

PROJECT: McElroys Run Disposal Site
GAI PROJECT NO.: 81-237-44
CONTRACT NO.:
DATES DRILLED: 8/30 - 8/31/93
DATES INSTRUMENTED:

gai CONSULTANTS, INC.

NON - SAMPLED BOREHOLE LOG

BOREHOLE NO.: GW-4
NORTH COORDINATE:
EAST COORDINATE:
SURFACE ELEVATION: ~ 920.0 Ft.
INSPECTOR: F. Lotito

DEPTH		MATERIAL DESCRIPTION					REMARKS
FROM	TO						
0	14.5	Decomposed Tan Silty shale					- large Tan sandstone Fragments
14.5	20.0	Gray claystone					
20.0	23.0	Red silty shale					
23.0	24.0	Gray shale					
24.0	27.5	Gray Sandstone					
27.5	36.0	Gray and Gray/green shale					
36.0	37.0	Red shale					
37.0	38.5	Gray Sandstone					
38.5	40.0	Gray sandy shale					
40.0	58.0	Gray Sandstone					57.0' Hydrocarbon odor
58.0	60.0	Dk. Gray Claystone					
60.0	65.0	Gray Sandstone					
65.0	67.0	Lt. Gray Sandstone					Thin limestone layer between
67.0	75.0	Red/Brn. Claystone					65.0' - 74.0'
75.0	77.0	Dk. Gray Claystone					
77.0	82.0	Red/Brn. Claystone					stopped at 80.0' on 8-30-93
82.0	83.0	Limestone					started at 80.0' on 8-31-93
83.0	89.0	Red/Brn. Claystone/shale					
89.0	91.5	Blue/Gray Limy Claystone					
91.5	93.0	Red/Gray Limy Claystone					

SUMMARY:

DRILLING (LF): ~~13 7/8"~~ 13 3/4" 27.0 , 12 1/4" ____ , ~~9 7/8"~~ 10 5/8" 199.5 , 7 7/8" ____ , 5 7/8" ____

CASING (LF): ~~12"~~ 12 3/4" 28.5 , 10" ____ , 8" ____ , 6" ____

THERMOCOUPLE (LF): ____ GAS SAMPLING TUBE (LF): ____ INSTRUMENTATION: ____ CAP: ____

STANDBY TIME: ____ EXPLANATION: ____

BOREHOLE NO. GW-4

BOREHOLE SEAL: ____ EXPLANATION: ____

PAGE 1 of 4

REMARKS: Lambert Drilling Co., Jim Crockett - Foreman, Nick Cursi - Driller, Helpers - Randy Kennedy, Bill Minor, Dale Myers, Aux; Davey Kent DR-30 Track-mounted Drill Rig

Field Classification Sheet for Non-Sampled Borehole

rigur 1.

PROJECT APS-McElroys Run
GAI PROJECT NO. 81-237-44
CONTRACT NO.
DATES DRILLED: 9/13-9/14/93
DATES INSTRUMENTED:

gai CONSULTANTS, INC.

NON - SAMPLED BOREHOLE LOG

BOREHOLE NO. GW-5
NORTH COORDINATE:
EAST COORDINATE:
SURFACE ELEVATION:
INSPECTOR: F.J. Lotito

DEPTH		MATERIAL DESCRIPTION					REMARKS
FROM	TO						
130.0	133.0	Grey Clayshale					
133.0	134.0	Grey Fine-grained Sandstone					
134.0	136.5	Brn. Clayshale					~135.0' Hydrocarbon odor
136.5	138.0	Dark Grey Clayshale					
138.0	146.0	Red/Brn. Clayshale					
146.0	158.0	Grey to Grey/Red Clayshale					
158.0	159.0	Grey Silty Clayshale					
159.0	173.0	Grey Sandstone					
173.0	174.0	Grey Clayshale					
174.0	177.0	Grey Sandstone					
177.0	178.5	Grey Clayshale					
178.5	179.0	Grey Sandstone					
179.0	179.5	Grey Clayshale					
179.5	193.0	Grey Sandstone					~180.0' Excess water coming
193.0	199.0	Grey to Red/Brn. Clayshale					out of borehole, water
199.0	210.0	Grey Medium-grained Sandstone					has Hydrocarbon odor
210.0	213.0	Grey Clayshale					and sheen
213.0	214.0	Grey Sandstone					
214.0	215.0	Grey Clayshale					
215.0	240.0	Grey Sandstone					~225.0' Drilling resumed 0815 on 9/14, no water being added to air rotary, borehole producing alot of water.

SUMMARY:

DRILLING (LF): 13 7/8" _____, 12 1/4" _____, 9 7/8" _____, 7 7/8" _____, 5 7/8" _____

CASING (LF): 12" _____, 10" _____, 8" _____, 6" _____

THERMOCOUPLE (LF): _____ GAS SAMPLING TUBE (LF): _____ INSTRUMENTATION: _____ CAP: _____

STANDBY TIME: _____ EXPLANATION: _____ BOREHOLE NO. GW-5

BOREHOLE SEAL: _____ EXPLANATION: _____

PAGE 2 of 3

REMARKS: _____

Field Classification Sheet for Non-Sampled Borehole

Figur 1.

PROJECT APS - McElroys Run

GAI PROJECT NO. 81-237-44

CONTRACT NO.

DATES DRILLED: 9/23/93, 9/27/93

DATES INSTRUMENTED:

gai CONSULTANTS, INC.

NON - SAMPLED BOREHOLE LOG

BOREHOLE NO. GW-6

NORTH COORDINATE:

EAST COORDINATE:

SURFACE ELEVATION:

INSPECTOR: F.J. Lotito

DEPTH		MATERIAL DESCRIPTION					REMARKS
FROM	TO						
112.0	114.5	Grey shale					
114.5	118.0	Grey Sandstone					
118.0	120.0	Red/Brn Claystone					
120.0	121.0	Grey shale					
121.0	140.0	Grey Fine-Med. grained Sandstone					
140.0	145.0	Grey Shale					
145.0	147.0	Grey Claystone					
147.0	168.0	Grey to Red/Brn Claystone					
168.0	169.0	Grey Silty Shale					Top of Grafton
169.0	172.0	Grey Fine-Med. grained Sandstone					
172.0	173.0	Red/Brn Claystone					
173.0	186.0	Grey Fine-Med. grained Sandstone					
186.0	190.0	Grey shale to silty shale					
193.0	195.0	Grey Fine-Med. grained Sandstone					Blk. crude w/ cuttings & water
195.0	196.0	Grey/Red Silty Shale					~193.0 - 250.0'
196.0	198.0	Grey Sandstone					
198.0	207.0	Grey Siltstone					
207.0	210.0	Red/Brn. Siltstone					
210.0	214.0	Grey Siltstone					
214.0	221.0	Red/Brn Claystone					

SUMMARY:

DRILLING (LF): 13 7/8" ______, 12 1/4" ______, 9 7/8" ______, 7 7/8" ______, 5 7/8" ______

CASING (LF): 12" ______, 10" ______, 8" ______, 6" ______

THERMOCOUPLE (LF): ______ GAS SAMPLING TUBE (LF): ______ INSTRUMENTATION: ______ CAP: ______

STANDBY TIME: ______ EXPLANATION: ______

BOREHOLE NO. GW-6

BOREHOLE SEAL: ______ EXPLANATION: ______

PAGE 2 of 3

REMARKS: ______

Field Classification Sheet for Non-Sampled Borehole

.igu.   d.

PROJECT APS- McElroys Run
GAI PROJECT NO. 81-237-44
CONTRACT NO.
DATES DRILLED: 9/29/93
DATES INSTRUMENTED:

GAI CONSULTANTS, INC.

NON - SAMPLED BOREHOLE LOG

BOREHOLE NO. GW-7
NORTH COORDINATE:
EAST COORDINATE:
SURFACE ELEVATION:
INSPECTOR: F.J. Lotito

DEPTH		MATERIAL DESCRIPTION					REMARKS
FROM	TO						
0.0	20.0	Brn Silty Clay					
20.0	35.0	Brn Silty clay w/ Red/Grey Claystone					
35.0	38.0	Red/Brn silty clay					
38.0	42.0	Brn silty clay; Grey Sandstone 38-40.0'					
42.0	109.0	Grey And Red/Brn Claystone					
109.0	138.0	Grey Fine-Med. grained Sandstone					~114.0' Hydrocarbon odor, Black
138.0	146.0	Grey Claystone					Crude w/ cuttings
146.0	148.5	Grey Fine-Med. grained Sandstone					Top of Grafton 109.0'
148.5	150.0	Grey Sandy Siltstone					
150.0	153.5	Grey Fine-Med. grained Sandstone					
153.5	166.0	Grey Sandy Siltstone					
166.0	169.0	Grey Siltstone					
169.0	170.0	Brn. Fossiliferous Limestone					Ames LS

SUMMARY:

DRILLING (LF): ~~13 7/8"~~ 12 1/4" 20.0', ~~12 1/4"~~ 10 5/8" 150.0', 9 7/8" ______, 7 7/8" ______, 5 7/8" ______
CASING (LF): 12" 20.0', 10" ______, 8" ______, 6" ______
THERMOCOUPLE (LF): ______ GAS SAMPLING TUBE (LF): ______ INSTRUMENTATION: ______ CAP: ______
STANDBY TIME: ______ EXPLANATION: ______ *BOREHOLE NO.* GW-7
BOREHOLE SEAL: ______ EXPLANATION: ______ PAGE 1 of 2
REMARKS: Lambert Drilling Co., Davey-Kent DR-30 Track-mounted Drill Rig, Driller- Nick Cursi; Helpers- Randy Kennedy, Auz Kennedy

Field Classification Sheet for Non-Sampled Borehole

PROJECT APS - McElroys Run
GAI PROJECT NO. 81-237-44
CONTRACT NO.
DATES DRILLED: 10/25/93
DATES INSTRUMENTED:

gai CONSULTANTS, INC.

NON - SAMPLED BOREHOLE LOG

BOREHOLE NO. GW-7
NORTH COORDINATE: 496,263.30
EAST COORDINATE: 2,345,907.90
SURFACE ELEVATION: 916.83
INSPECTOR: F. I. Lotito

DEPTH		MATERIAL DESCRIPTION					REMARKS
FROM	TO						
0.0	6.0	Brn./Yellow Clay					
6.0	6.5	Brn. Clay w/ Grey Limestone nodules					
6.5	18.0	Red/Brn. and Brn./Yellow Clay					
18.0	22.0	Grey Sandy Shale					
22.0	30.0	Grey Fine-grained Sandstone					
30.0	39.0	Grey Silty Claystone					
39.0	40.0	Red/Brn Claystone					
40.0	45.0	Grey Claystone w/ Tan Cherty Limestone					
45.0	49.5	Grey Fine-grained Sandstone					
49.5	51.0	Grey Claystone					
51.0	53.0	Grey Fine-grained Sandstone w/ Cherty Matrix					
53.0	60.0	Grey Fine-grained Sandstone					
60.0	77.5	Grey Silty Claystone					~77.0' Blk. Natural Crude w/ odor
77.5	80.0	Dk. Grey Fossilliferous Limestone					Ames LS
80.0	84.0	Dk. Grey Limestone					
84.0	87.0	Blk. Coal					
87.0	99.0	Dk. Grey Claystone					
99.0	102.0	Grey Limestone					
		Bottom of Boring 102.0'					

SUMMARY:

DRILLING (LF): ~~137/8"~~ 13¼" 20.0', ~~121/4"~~ 10⅝" 82.0', 97/8" ______, 77/8" ______, 57/8" ______

CASING (LF): ~~12"~~ 12¼" 19.5', 10" ______, 8" ______, 6" ______

THERMOCOUPLE (LF): ______ GAS SAMPLING TUBE (LF): ______ INSTRUMENTATION: ______ CAP: ______

STANDBY TIME: ______ EXPLANATION: ______

BOREHOLE SEAL: ______ EXPLANATION: ______

REMARKS:

BOREHOLE NO. GW-7

PAGE 1 of 1

GAI CONSULTANTS, INC.

PROJECT APS- McELROYS RUN PROJECT NO. 81-237-66
ELEVATION 903.19 GWL 0 HRS 17' (AFTER HOLE PLUG) BORING NO. P-96-4
24 HRS 23'
DATE 5/20/96 FIELD ENGINEER RON ARCURI PAGE NO. 9 OF 16

DEPTH FEET	BLOWS PER SIX INCHES OR CORE RECOVERY/RUN	SAMPLE NO., TYPE & RECOVERY OR % ROCK RECOVERY	RQD (%)	DESCRIPTION PROFILE	SOIL DENSITY— CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS OR ROCK BROKENNESS	REMARKS*
1	2	3	4	5	6	7	8	9	10
			9.8/		MED. SOFT	GRAY	SILTSTONE	M	
		9.8/	/10.0				(CLAYSTONE 242.3'-242.3' & 242.7'-343.5')		
		/10.0 98%	98%						
245.0				244.8	MED. SOFT	GRAY	SANDY SILTSTONE	M	
			10.0/						
		10.0/	/10.0						
		/10.0 100%	100%						
250.0									
				253.1	MED. HARD	GRAY	SANDSTONE	M	
355.0				254.8					
									RUN SMELLS LIKE OIL
			[illegible]/						
		9.8/	/10.0						
		/10.0 [illegible]	[illegible]						
360.0									
									ENDED DRILLING ON
365.0				264.8					5/20/96 AT 264.8'
			10.0/						
		10.0/	/10.0						
		/10.0 100%	100%						
370.0									

REMARKS** HQ ROCK CORING WITH WATER

PROJECT NO. 81-237-66
BORING NO. P-96-4

*POCKET PENETROMETER READINGS
**METHOD OF ADVANCING AND CLEANING BORING

GAI CONSULTANTS, INC.

PROJECT ALLEGHENY POWER - MCELROY'S RUN PROJECT NO. 81-237-72

ELEVATION ______ GWL 0 HRS ______ BORING NO. P-96-5

HRS

DATE 7 OCT 96 FIELD ENGINEER J.M. GALVIN PAGE NO. 14 OF 19

DEPTH FEET	BLOWS PER SIX INCHES OR CORE RECOVERY/RUN	SAMPLE NO., TYPE & RECOVERY OR % ROCK RECOVERY	RQD (%)	DESCRIPTION: PROFILE	DESCRIPTION: SOIL DENSITY—CONSISTENCY OR ROCK HARDNESS	DESCRIPTION: COLOR	DESCRIPTION: MATERIAL CLASSIFICATION	USCS OR ROCK BROKENNESS	REMARKS*
1	2	3	4	5	6	7	8	9	10
					MED HARD	GRAY	SILTSTONE	M	
394.8	◆								
400	10.0 10.0	100%	100						
404.8	◆								
				406.1			↓		
				406.8	↓		LIMESTONE (AMES)		FOSSILIFEROUS
					MED HARD		SILTSTONE		
410	10.0 10.0	100 %	100						
				411.8	↓		↓		
					HARD		SANDSTONE (JANE LEW)		MID ∠ CLOSED
									FRACS AT 412.8,
414.8	◆								413.1 FT. MID ∠
									OPEN FRAC AT
									413.2, CRUDE
									OIL ODOR 411.8
									-442.6 FT
420	10.0 10.0	100%	100		↓	↓	↓	↓	

REMARKS** ______

PROJECT NO. 81-237-72

BORING NO. P-96-5

*POCKET PENETROMETER READINGS

**METHOD OF ADVANCING AND CLEANING BORING

GAI CONSULTANTS, INC.

PROJECT ALLEGHENY POWER - MCELROY'S RUN PROJECT NO. 81-237-72
ELEVATION ________ GWL 0 HRS ________ BORING NO. P-96-5
HRS
DATE 7 OCT 96 FIELD ENGINEER J.M. GALVIN PAGE NO. 15 OF 19

DEPTH FEET	BLOWS PER SIX INCHES OR CORE RECOVERY/RUN	SAMPLE NO., TYPE & RECOVERY OR % ROCK RECOVERY	RQD (%)	DESCRIPTION PROFILE	SOIL DENSITY— CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS OR ROCK BROKENNESS	REMARKS*
1	2	3	4	5	6	7	8	9	10
					HARD	GRAY	SANDSTONE (JANE LEW)	M	CRUDE OIL ODOR
									411.8 - 442.6 FT
424.8									
									OPEN, MID TO LOW
									∠ FRACS AT 430.9,
430	10.0 10.0	100%	96						431.6, 432.7,
									432.9, 436.4
434.8									
									CLAY FILLED
									HORIZ FRAC AT
									437.8
440	10.0 10.0	100%	96						
				442.6					
					MED SOFT	RED +	CLAYSTONE (PITTSBURGH	BR	MID ∠ OPEN
444.8						GRAY	RED BEDS)		FRAC AT 446.4
									450.6 FT
									WEATHERED ZONE
450	10.0 10.0	100%	72						AT 449.2 FT

REMARKS** ________

PROJECT NO. 81-237-72
BORING NO. P-96-5

*POCKET PENETROMETER READINGS
**METHOD OF ADVANCING AND CLEANING BORING

PROJECT McELROY'S RUN
GAI PROJECT NO.: 81-237-31
CONTRACT NO.:
DATE STARTED: 7/26/90
DATE COMPLETED: 7/31/90
SIGNATURE OF INSPECTOR:

BOREHOLE NO.: N-3
DRILLING COMPANY: LAMBERT DRILLING CO.
DRILL TYPE: ACKER AD-2
NAME OF DRILLER: DON REMERER
CORE SIZE: NQ (2" DIAM.)
NUMBER OF CORE BOXES: 28

NORTH COORDINATE: S 6384
EAST COORDINATE: E 9352
SURFACE ELEVATION: 916.4
DEPTH OF HOLE: 414.8
GWL @ COMPLETION: 12.3
24 HR 33.1

DRILLING DATA						ROCK DESCRIPTION				DISCONTINUITIES						
DEPTH (FT.)	CORE BOX NO.	CORE RECOVERY (FT.)	CORE RUN (FT.)	CORE RECOVERY (%)	RQD (%)	COLOR	ROCK HARDNESS	MATERIAL CLASSIFICATION	ROCK BROKENNESS	TYPE	ORIENTATION	TIGHTNESS	DEGREE OF WEATHERING	FILLING MATERIAL	AVG. FRACTURE SPACING (FT.)	REMARKS
400.0																
						GRAY	M.HARD	SANDSTONE – FINE	MASSIVE							
							-HARD	GRAINED								
404.6								404.6								
	27+28	10	10	100	100	GREEN/		SANDSTONE –								
						GRAY		FINE TO MEDIUM								OILY ODOR
								408.0 GRAINED								
								OIL SEAM								SANDSTONE SEAM
410.0																SATURATED WITH
								410.6								NATURAL CRUDE
																OIL. 408-410.6
414.6																
								BOTTOM OF BORING								
								EL. 501.8								

EPRI West Virginia
Groundwater Study

Allegheny Power System

Log of Well GW-13

McElroy's Run Disposal Facility
Pleasants/Willow Island Power Station

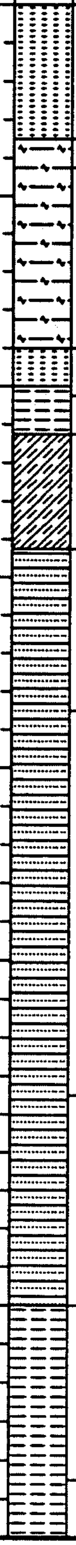
Sheet 6 of 7

JOB NUMBER: 2008-202

LOGGED BY: G. Goldstein

Sample No./ Type	Sample Depth From/To	SPT (Blows/6")/ ROP (ft/min)	Recovery/ RQD (%)
20/NQ	193.5-203.5'	1.4	100/92
21/NQ	203.5-213.5'	0.6	100/96
22/NQ	213.5-223.5'	0.4	100/100
23/NQ	223.5-233.5'	1.6	100/82
24/NQ	233.5-243.5'		100/100

Depth (feet): 200, 205, 210, 215, 220, 225, 230



Materials Description

CLAYSTONE, 10 R 3/4, dark reddish brown, soft, weathered, highly fractured/faulted, not reactive to dilute HCL.

CLAYSTONE, N3, dark gray, fresh soft, not reactive to dilute HCL.

CLAYEY SILTSTONE, N4, medium dark gray, soft, fresh, not reactive to dilute HCL.

CLAYSTONE, 5 YR 4/1, brownish gray, soft, fresh, not reactive to dilute HCL.

CLAYEY SILT, N4, medium dark gray, interbedded silt and clayey silt.

SANDSTONE, N5, medium gray, medium sand grain size, hard, fresh, with quartz, not reactive to dilute HCL. Crude oil odor.

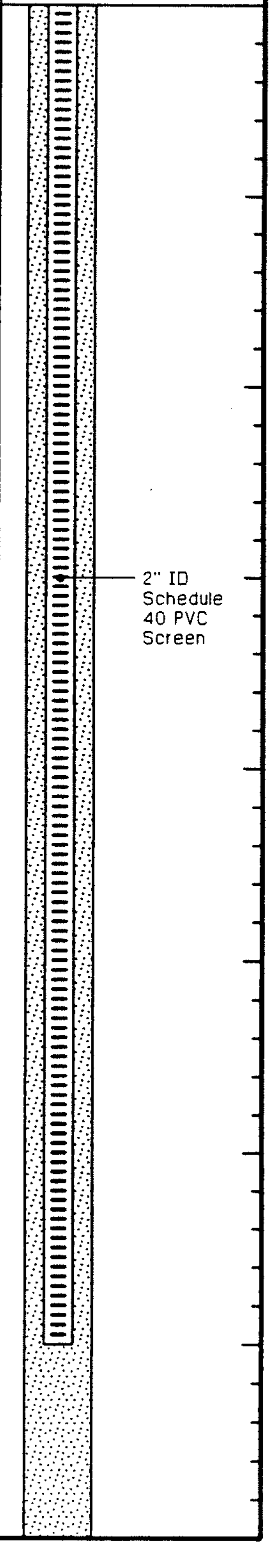
SANDSTONE, 5 G 4/1, dark greenish gray, medium sand grain size, fresh, hard, with quartz and chlorite. 3" limey seam at 217' BGS. Visual crude oil staining, crude oil odor.

10" vertical fracture at 218.5' BGS.

Same

CLAYSTONE, N4, medium dark gray, very soft, fresh, not reactive to dilute HCL.

Same



cementation, and fracturing. In accordance with stress relief fracture theory, well yields are highest in the valleys, moderate on the hillsides, and minimal on the ridges (Shultz, 1984).

FIELD INVESTIGATION METHODS

Seven new monitoring wells (GW-13, GW-14, and GW-16 through GW-20) were installed for this study in 1995 (Figure 3-1). The wells were installed at locations where the bedrock aquifer has the potential for significant fracture development due to stress relief. In addition, ten existing monitoring wells were sampled for the study, and numerous boring logs from previous studies were available for geologic interpretation.

Monitoring wells GW-13, GW-14, and GW-20 are located on the east side of the McElroy's Run watershed. The wells were aligned along an eastward-trending transect identified as a potential groundwater flow path from the impoundment toward the neighboring French Creek watershed. The location of the transect coincides with small tributary valleys in the two watersheds. Wells GW-13 and GW-20 were installed as a cluster in order to investigate vertical gradients and water quality near the impoundment. Well GW-14 is located about 600 ft farther along the transect from the impoundment than the cluster. Boring GW-15 was drilled about 500 ft farther along the transect than GW-14. However, a thin layer (0.34 ft) of floating petroleum, analyzed as crude oil, was encountered in the borehole, and the borehole was abandoned.

Wells GW-16, GW-17, and GW-18 were installed in the valley bottom downstream from the impoundment dam. These three wells, along with existing wells MP-3 and MP-4, form a transect along the valley bottom from the dam to the Ohio River valley. Wells GW-16 and GW-17 were installed as a cluster to investigate vertical gradients and water quality near the toe of the dam. The MP-3/MP-4 well cluster is located approximately 1500 ft downgradient from the GW-16/17 cluster. MP-4 is installed in the shallow bedrock aquifer; MP-3 is an overburden well installed in the McElroy's Run valley alluvium. GW-18 is a bedrock well sited at the base of the McElroy's Run valley, near its junction with the Ohio River valley

Well GW-19 is located north of the impoundment. The well is aligned with pre-existing well GW-3 along a potential flow path through the ridge that separates the impoundment valley from the Ohio River.

Construction of these wells included coring, drilling, geophysical logging and packer testing. Each of these operations is summarized below. Additional detail is provided in Appendix A.

EPRI West Virginia
Groundwater Study

Allegheny Power System

Log of Well GW-19

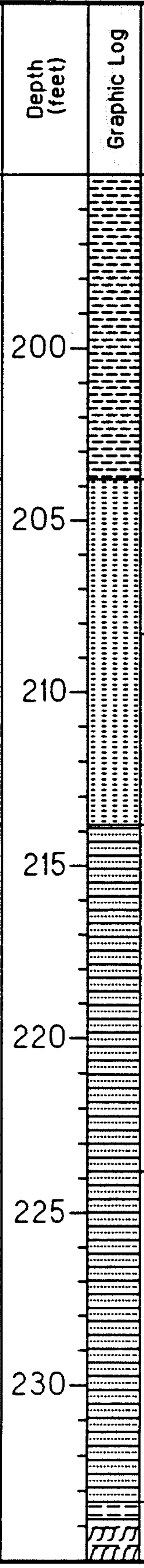
McElroy's Run Disposal Facility
Pleasant's/Willow Island Power Station

Sheet 6 of 7

JOB NUMBER: 2008-202

LOGGED BY: G. Goldstein

Sample No./ Type	Sample Depth From/To	SPT (Blows/6")/ ROP (ft/min)	Recovery/ RQD (%)
19/NQ	193.8-203.8'	1.4 1.2	100/87
20/NQ	203.8-213.8'	0.8	100/95
21/NQ	213.8-223.8'	0.8 0.6	100/25
22/NQ	223.8-233.8'	0.8	100/95
23/NQ	233.8-243.8'	1.2	100/95



Materials Description

CLAYSHALE, 5 G 6/1, greenish gray, hard, fresh, minor calcite viens, not reactive to dilute HCL.

Horizontal fracture at 198.8' BGS.

CLAYEY SILTSTONE, N7, light gray, medium hardness, fresh, minor calcite, not reactive to dilute HCL.

SILTSTONE, N7, light gray, hard, fresh, not reactive to dilute HCL.

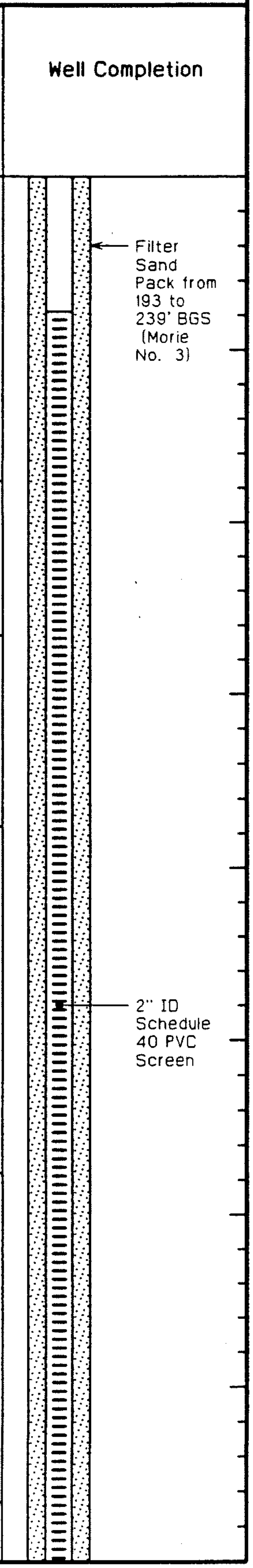
Large fracture at 211.8' BGS ~1' long.

SANDSTONE, N6, medium light gray, fine to medium sand grain size, hard fresh, not reactive to dilute HCL. Crude oil odor.

Series of fractures in bottom 5' of core.

SANDSTONE, N7, light gray, hard, fresh, small 3" clay seam at ~229' BGS, minor quartz, not reactive to dilute HCL. Crude oil odor.

CLAYSTONE, N7, light gray, soft, fresh, few fossils, not reactive to dilute HCL.



LOG OF BORING GW-24

(Page 2 of 6)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

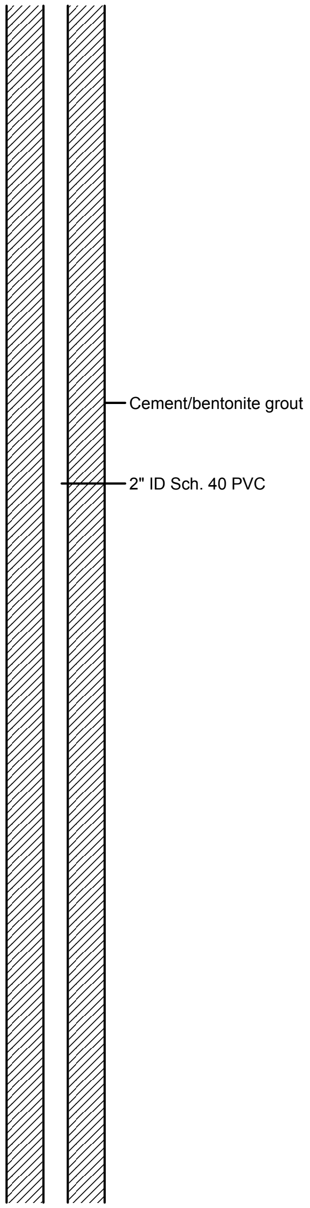
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/12/16	Ground Elevation	: 944.56
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1469894.54	Northing	: 320797.11

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
50						Sst
					Claystone, red/gray, soft No HCL Reaction	Clst
					Siltstone, green, soft No HCL reaction	Sltst
					Shale, red, soft No HCL reaction	Sh
60 70					Siltstone, green, soft No HCL reaction	Sltst
					At 73 0.25 gpm water, hydrocarbon odor Sandstone w/Pyrite, green, hard	Sst
80					Siltstone to Sandstone, brown/red, soft No HCL reaction	Sltst
					Sandstone to Siltstone, green/gray, hard No HCL reaction	Sst
90 100					Shaley Siltstone, red, soft No HCL reaction	Sltst



LOG OF BORING GW-25

(Page 5 of 7)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

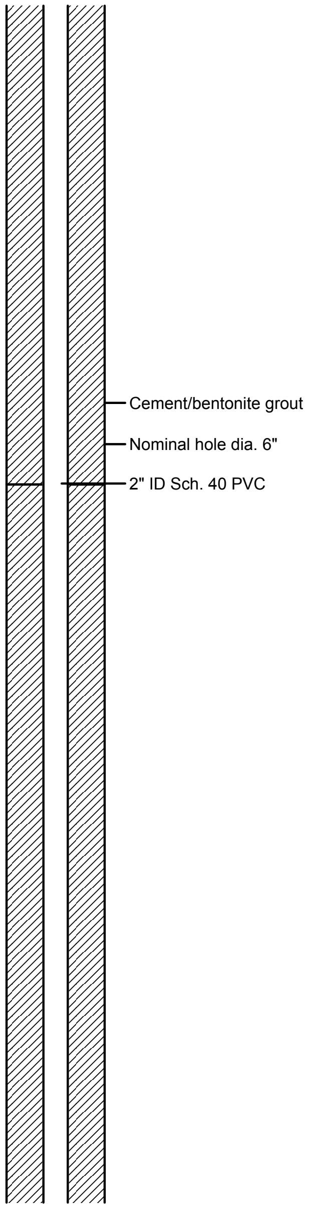
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/25/16	Ground Elevation	: 1009.13
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1468884.46	Northing	: 321494.03

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
200						Sst
					Sandstone, Limestone, Shale, purple/red, hard	Sst
210 220					Limestone green/gray with Claystones red, soft Strong HCL reaction At 214-215 Claystone red At 216-216.5 Claystone red	LS
230 240 250					Very fine Sandstone green/gray and Siltstone, hard No HCL reaction At 230 Hydrocarbon odor Below 235, more Shaley Increasing Sandstone with depth to 250	Sst



ATTACHMENT B

GW-23 Oil Fingerprinting Laboratory Report

FirstEnergy

BETA Laboratory
ISO 9001 Registered

File No. 17-95225

BETA Laboratory

Chemical Analysis
6670 Beta Dr., Mayfield Village OH 44143 (440)-604-9832

TO Edward Newbaker **MAIL STOP** G-CH

FROM J. L. Hirsch **DATE** 4/28/17
PHONE 824-9832 **MAIL STOP** BETA
SUBJECT Analysis of oil floating on a Pleasants GW-23-CCR water sample

Requisition No.: 170428008
LSN# AK06089

A water sample from the Pleasants Ground Water 23-CCR location was submitted for water analysis but when the container was opened an oil film was present on the water's surface. The oil was extracted off the water and analyzed using a FT Infrared Spectrometer.

Results:

1) The oil was identified and a straight chain hydrocarbon oil (mineral oil).

Discussion:

The oil was extracted off the surface of the water using a dropper and the water was removed from the residue. The oil was then analyzed on the FT Infrared Spectrometer. ATTACHMENT 1 shows the results.

The FT Infrared Spectrometer was calibrated with Standard Reference Material (SRM)1921b, which is a matte finish polystyrene film certified by the National Institute of Standards and Technology (NIST). There was no Sample Analysis Request / Chain of Custody submitted for this analysis.

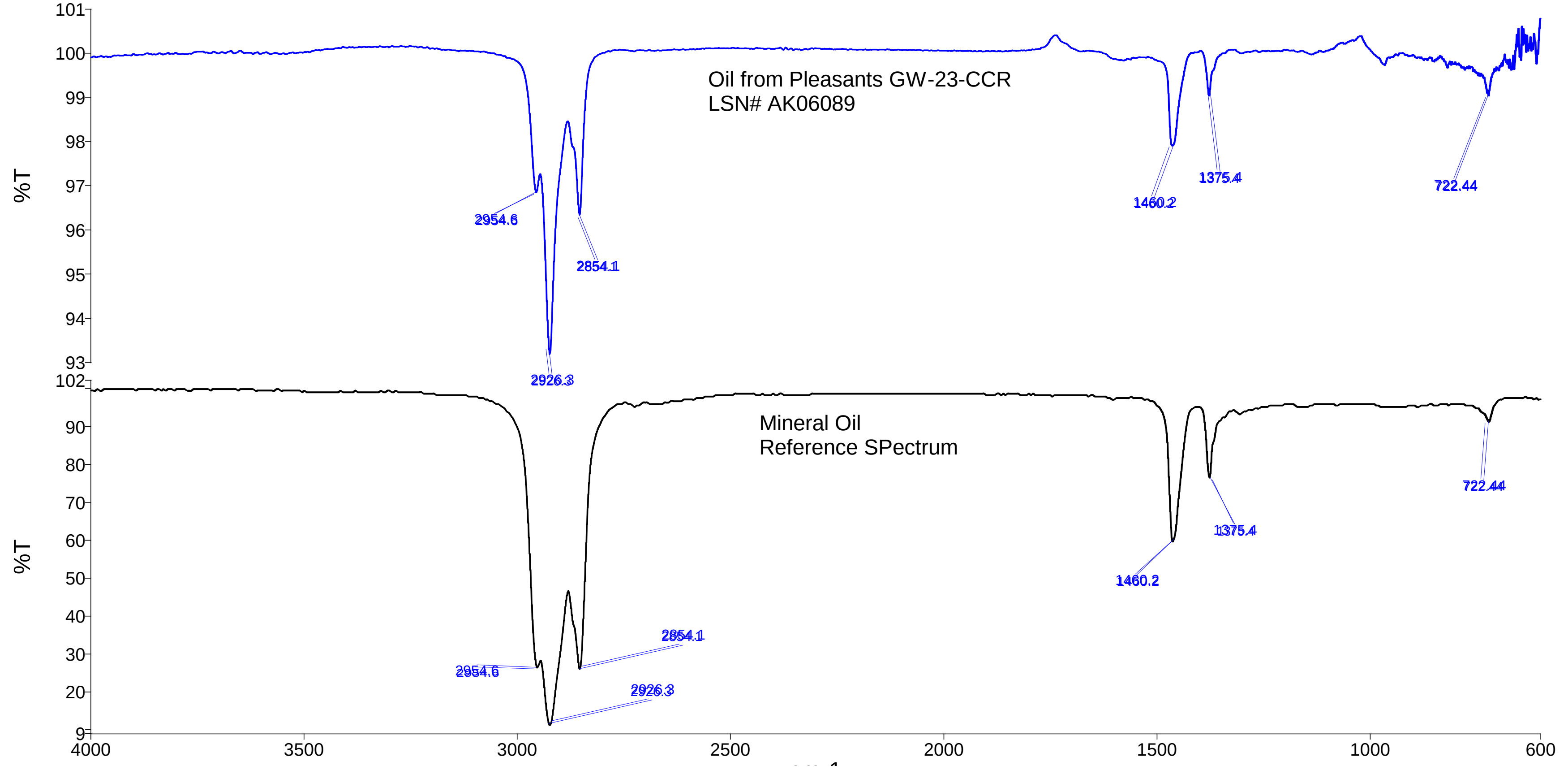
Material Test Equipment

Instrument Model: Perkin Elmer Frontier FT-IR Spectrometer, BETA 0755, Calibration Due: 5/4/17

Analysis Performed By J L Hirsch on 4/27/17

Reviewed By Zance Tery Date 4/28/17

ATTACHMENT 1: FTIR Spectrographic Analysis of the oil removed from the surface of the Pleasants GW-23-CCR water sample indicates the oil is a straight chain hydrocarbon mineral oil.
Instrument: Perkin Elmer Frontier FT-IR Spectrometer, BETA 0755, Calibration due 5/4/17
Performed by J. Hirsch on 4/27/17



ATTACHMENT 3-3

Assessment of Corrective Measures (ACM) Report

CCR RULE ASSESSMENT OF CORRECTIVE MEASURES (ACM) REPORT

COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY

Pleasants Power Station
Pleasants County, West Virginia

Prepared for:

FirstEnergy

800 Cabin Hill Drive
Greensburg, PA 15601

Prepared by:

Tetra Tech, Inc.

400 Penn Center Boulevard, Suite 200
Pittsburgh, PA 15235
Phone: (412) 829-3600
Fax: (412) 829-3260

Tetra Tech Project No. 212C-SW-00070

October 2019

CCR RULE ASSESSMENT OF CORRECTIVE MEASURES (ACM) REPORT

COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY

PLEASANTS POWER STATION
PLEASANTS COUNTY, WEST VIRGINIA

Prepared for:

FirstEnergy

800 Cabin Hill Drive
Greensburg, PA 15601

Prepared by:

Tetra Tech, Inc.
400 Penn Center Boulevard, Suite 200
Pittsburgh, PA 15235
Phone: (412) 829-3600
Fax: (412) 829-3260

Tetra Tech Project No. 212C-SW-00070

October 2019

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TABLES

FIGURES

APPENDICES

ACRONYMS/ABBREVIATIONS

ACM	Assessment of Corrective Measures
AGWMCA	Annual Groundwater Monitoring and Corrective Action
AM	Assessment Monitoring
ASD	Alternate Source Demonstration
bgs	Below ground surface
CCBDF	Coal Coombustion Byproduct Disposal Facility
CCBL	Coal Combustion Byproduct Landfill
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
CSM	Conceptual Site Model
DM	Detection Monitoring
FE	FirstEnergy Generation
gpm	Gallons Per Minute
GWPS	Groundwater Protection Standard
K	hydraulic conductivity
mg/L	milligrams per liter
MCL	Maximum Contaminant Level
MNA	Monitored Natural Attenuation
MW	Megawatt
msl	Mean sea level
N&E	Nature and Extent of Release
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and Maintenance
POC	Point of Compliance
psi	Pounds per Square Inch
PZ	Piezeometer
PRB	Permeable Reactive Barrier
SAP	Sampling and Analysis Plan
SoR	Selection of Remedy
SSI	Statistically Significant Increase
SSL	Statistically Significant Level
Station	Pleasants Power Station
TDS	total dissolved solids
Tetra Tech	Tetra Tech, Inc.
UPL	Upper Prediction Limit
USEPA	United States Environmental Protection Agency
WVDEP	West Virginia Department of Environmental Protection
ZVI	Zero Valent Iron

1.0 INTRODUCTION

This Assessment of Corrective Measures (ACM) Report was prepared by Tetra Tech, Inc. (Tetra Tech) on behalf of FirstEnergy Generation (FE) for the Coal Combustion Byproduct Disposal Facility (“CCBDF”, “CCR unit”, or “Site”) at the Pleasants Power Station (hereinafter referred to as the “Station”). The Station is located near the town of Belmont in Pleasants County, West Virginia. This report was developed to comply with pertinent requirements of the United States Environmental Protection Agency (USEPA) Coal Combustion Residuals (CCR) Rule, specifically the Assessment of Corrective Measures requirements per 40 CFR § 257.96.

As discussed further below, CCR Rule groundwater Assessment Monitoring (AM) conducted at the Site identified arsenic concentrations in certain downgradient CCR monitoring wells which were at Statistically Significant Levels (SSLs) that exceeded the Groundwater Protection Standard (GWPS) for arsenic, resulting in the need to conduct an Assessment of Corrective Measures per 40 CFR § 257.96.

1.1 PURPOSE

The purpose of this ACM Report is to provide the following: background on groundwater monitoring findings leading to the ACM; an overview of potential corrective measures which were evaluated; and a comparative evaluation of the corrective measures with regards to the pertinent CCR Rule criteria. In addition, the report specifies the path for meeting Selection of Remedy (SoR) requirements of the CCR Rule (per 40 CFR § 257.97). The assessment of corrective measures has included developing and evaluating new field and laboratory information and data as well as reviewing historical field and laboratory information and data developed by other professional engineers and geologists. In preparing this report, Tetra Tech has exercised its professional judgement in accordance with generally accepted engineering and geologic principles and practices to identify and assess the range of potential corrective measures described herein.

1.2 REGULATORY REQUIREMENTS

Initiating and Completing an Assessment of Corrective Measures

40 CFR§ 257.96(a) requires that within 90 days of finding that any constituent listed in Appendix IV has been detected at a SSL exceeding the GWPS or immediately upon detection of a release from a CCR unit, the owner or operator must initiate an assessment of corrective measures to prevent further releases, to remediate any releases, and to restore affected areas to original conditions. The assessment of corrective measures must be completed within 90 days, unless the owner or operator demonstrates the need for additional time to complete the assessment of corrective measures due to site-specific conditions or circumstances. The 90-day deadline to complete the assessment of corrective measures may be extended for no longer than 60 days.

Characterizing the Nature and Extent of Release

Following identification that one or more Appendix IV constituents has been detected at a SSL exceeding the GWPS, the owner or operator of the CCR unit must also:

(1) Characterize the nature and extent of the release (N&E) and any relevant site conditions that may affect the remedy ultimately selected. The characterization must be sufficient to support a complete and accurate assessment of the corrective measures necessary to effectively clean up all releases from the CCR unit pursuant to § 257.96. Characterization of the release includes the following minimum measures:

(i) Install additional monitoring wells as necessary to define the contaminant plume(s);

(ii) Collect data on the nature and estimated quantity of material released including specific information on the constituents listed in Appendix IV and the levels at which they are present in the material released;

(iii) Install at least one additional monitoring well at the facility boundary in the direction of contaminant migration and sample this well in accordance with 40 CFR 257.95(d)(1) ; and

(iv) Sample all wells in accordance with 40 CFR 257.95(d)(1) to characterize the nature and extent of the release.

The following summarizes the timeline pertaining to compliance at the Site with the above CCR Rule requirements:

- February 13, 2019 (Revised April 5, 2019) - Pursuant to 40 CFR 257.95(g) and 257.105(h)(8), FE provided notification in the Operating Record that the 2018 groundwater Assessment Monitoring (AM) program at the Site had identified arsenic, barium, fluoride, lithium, and radium concentrations detected at SSLs above their respective GWPSs established as per 40 CFR 257.95(h). Also, at that time, FE initiated activities to characterize the nature and extent of release. The notification was posted to the publicly accessible website on April 5, 2019.
- April 15, 2019 - Pursuant to 40 CFR 257.95(g)(3)(i) and 257.105(h)(9), FE provided notification in the Operating Record that an Assessment of Corrective Measures (ACM) had been initiated for the Site. The notification was posted to the publicly accessible website on May 22, 2019.
- July 15, 2019 - Pursuant to 40 CFR 257.96(a), FE provided in the Operating Record a demonstration that, based on hydraulic characteristics of the uppermost aquifer, an additional 60 days was required to complete the ACM.

This document was developed to meet requirements of 40 CFR § 257.96(c), which states the following:

“The assessment under paragraph (a) of this section must include an analysis of the effectiveness of potential corrective measures in meeting all of the requirements and objectives of the remedy as described under § 257.97 addressing at least the following:

(1) The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination;

(2) The time required to begin and complete the remedy;

(3) The institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy(s).”

1.3 SITE BACKGROUND

CCRs produced at the Station are placed in the facility’s captive CCBDF, which is located approximately one mile east-southeast of the Station. The facility consists of both a wet disposal area (impoundment) and dry disposal area (landfill) developed in the McElroy’s Run watershed. Taken together, the landfill and impoundment are regulated under West Virginia Department of Environmental Protection (WVDEP) Solid Waste/National Pollutant Discharge Elimination System (NPDES) Water Pollution Control Permit No. WV0079171. A WVDEP groundwater monitoring program for the landfill has been in effect since 1994 and a separate CCR Rule groundwater monitoring program has been in effect since 2017. As per the CCR Rule, the landfill and impoundment are considered two separate, existing CCR units that share a common boundary (the impoundment dam). As provided by the CCR Rule, a multi-unit groundwater monitoring system has been established for the CCBDF.

As shown on Figure 1-1, the impoundment is situated in the upper portion of the watershed and the landfill is situated in the lower portion of the watershed (adjacent to, and overlying, the impoundment dam). The impoundment is unlined and has been in continuous use since the late 1970s, while the landfill is lined and has been in continuous use since the early 1990s. At the current water level, the surface impoundment area is about 250 acres. The impoundment dam was constructed with a clay-filled cutoff trench at the upstream toe and a clay blanket on the upstream slope for a low permeability barrier. The downstream portion of the dam was constructed using compacted fly ash and periodic layers of bottom ash for blanket drains connected to sloping chimney drains that collect seepage to discharge pipes for monitoring. The downstream face of the dam is covered by the landfill facility which WVDEP considers to be a buttress to the dam. The landfill consists of three primary development stages (I, II, and III in the original permit drawings and now referred to as 1, 2, and 3) which are further subdivided into construction subareas (e.g., Stage 1G, 2A, etc.). At this time, development and disposal operations have only been performed in the Stage 1 and 2 areas while the Stage 3 area remains undeveloped. Up until 2009, all of the landfill subareas were constructed with a compacted clay liner system that included an underlying combined groundwater underdrain/leak detection system and overlying leachate collection system. However, since 2009 (in subareas 1G and 2B), a composite geosynthetic liner system (geosynthetic clay liner and geomembrane) has been utilized that also includes an underlying combined groundwater underdrain/leak detection system and overlying leachate collection system. For all portions of the landfill that overlie the downstream face of the impoundment dam, a bottom ash blanket drain layer has also been utilized under the liner system. Leachate and contact stormwater runoff from the Stage 1 and 2 disposal areas are managed in Sedimentation Pond Nos. 1 and 2, which are lined impoundments located immediately down-valley of the future Stage 3 landfill development area.

Groundwater in the CCBDF area occurs primarily within fractured bedrock and flow is controlled primarily by topography with limited, secondary control by orientation (strike and dip) of the rock units. The fractured bedrock of multiple sandstone units which have been collectively identified as the uppermost aquifer for CCR Rule groundwater monitoring for the combined landfill and impoundment units. Historic and recent groundwater level data indicate groundwater flows north from the topographically higher areas located to the south and southeast of the impoundment. West and northwest of the impoundment dam, topography may be the dominant influence on groundwater flow, as the multiple sandstone units underlying the site are eroded and discontinuous across the valley. Groundwater flow northwest of the dam and under the landfill is in the downstream direction of McElroy’s Run (toward the west). Flow in all of the rock units exhibit very little seasonal and temporal fluctuations. A representative set of water level data from the time period of this ACM (July 2019) were used for contouring groundwater elevations and identifying flow patterns at the Site (refer to Figure 1-2). These water levels were similar to historical levels across the Site. As such, separate mapping for other time periods was not necessary for this report. A more detailed discussion of the site’s geologic and hydrogeologic characteristics can be found in Section 4.0 of this report.

As detailed in the CCR unit’s most recent Annual CCR Groundwater Monitoring and Corrective Action Report (“2018 AGWMCA Report”, accessible at http://ccrdocs.firstenergycorp.com/), the certified CCR monitoring well network consists of three upgradient (background) wells (GW-7, -21, and -22), seven downgradient wells to monitor the northern side of the combined CCR units (GW-9, -19, -20, -23, -24, -25, and -26), and three downgradient wells to monitor the western side of the combined CCR units (GW-27, -28, and -29), as shown on Figure 1-1. It is noted there is also a groundwater monitoring well network at the Site associated with the state solid waste permit, and these wells are also shown on Figure 1-1. As discussed in Section 3.0, some of the state network wells were added to the monitoring program for the

N&E characterization since they were strategically located side-gradient and downgradient of the CCR waste boundary wells and are screened in the same monitored aquifer system.

1.4 OVERVIEW OF REPORT CONTENTS

Section 1.0 of this report provided an overview of the CCR ACM regulatory requirements and background on the CCR unit and CCR groundwater monitoring well network. Section 2.0 summarizes Detection and Assessment Monitoring results as well as the findings of the Appendix III ASD and Appendix IV ASD. Section 3.0 summarizes the Nature and Extent of Release Characterization. Section 4.0 presents the Conceptual Site Model (CSM). Section 5.0 provides the identification and screening of remediation technologies to address arsenic SSLs in groundwater, and Section 6.0 presents the assessment of corrective measures by comparing the candidate technologies to ACM criteria in 40 CFR § 257.96(c). Section 7.0 summarizes the Selection of Remedy (SoR) process. Section 8.0 provides references for documents cited in this report.

2.0 GROUNDWATER MONITORING RESULTS

This section summarizes the findings of the Site's CCR Rule Detection Monitoring (DM) program, the associated Appendix III ASD, and the subsequent AM program and Appendix IV ASD which, taken together, led to the requirement to conduct the ACM. Details on each phase of monitoring and the ASDs can be found in the referenced documents and the pertinent Annual Groundwater Monitoring and Corrective Action Reports.

2.1 DETECTION MONITORING & APPENDIX III ALTERNATE SOURCE DEMONSTRATION

2.1.1 Detection Monitoring Results

FE performed the first DM sampling event in September and October 2017. Following receipt of the validated analytical results, a statistical evaluation of the data was completed in January 2018 and the results indicated that there were statistically significant increases (SSIs) for boron, calcium, chloride, fluoride, pH, sulfate and total dissolved solids (TDS) in one or more well comparisons. The DM sampling, analysis, statistical evaluation, and findings were included in the 2018 CCR Annual Groundwater Monitoring and Corrective Action Report, which is available on the Site's publicly accessible CCR website (http://ccrdocs.firstenergycorp.com/).

2.1.2 Alternate Source Demonstration

Following the identification of SSIs in downgradient Site well samples for Appendix III parameters identified in Section 2.1.1, FE performed an ASD per 40 CFR § 257.94(e)(2). The ASD was performed by Tetra Tech, Inc. (Tetra Tech) to determine whether a source other than the CCR unit caused the SSIs or that the apparent SSIs resulted from errors in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The ASD scope and findings are presented in the Tetra Tech report entitled, "CCR Appendix III Alternative Source Demonstration Report - 2017 Detection Monitoring, McElroy's Run Coal Combustion Byproduct Disposal Facility, Pleasants Power Station," dated April 16, 2018. The subject report was placed in the facility's operating record in April 2018. The Appendix III ASD concluded that there are potential on-site sources which may have contributed to the SSIs for some constituents; however, it was not possible within the scope of work conducted to definitively confirm these sources resulted in all of the SSIs.

Since the ASD did not conclusively determine that all of the SSI constituents were related to sources or conditions other than the CCR unit, in accordance with 40 CFR 257.95(b), the Station transitioned from Detection Monitoring to Assessment Monitoring (discussed in the following section).

2.2 ASSESSMENT MONITORING & APPENDIX IV ALTERNATE SOURCE DEMONSTRATION

FE performed two rounds of Assessment Monitoring at the Site in May and August 2018 (events AM-1 and AM-2, respectively) in accordance with the facility's CCR groundwater monitoring plan. Following receipt of the validated analytical results, FE performed statistical evaluations of the 2018 AM data to determine whether there were any detected Appendix IV parameters with SSLs above the CCR Unit's established GWPSs. Arsenic, barium, fluoride, lithium, and radium were the only parameters detected at concentrations greater than their respective GWPS, as documented in the facility's Operating Record in February 2019. However, subsequent to the AM-1 and -2 statistical evaluations, groundwater level data collected at the Site necessitated a modified interpretation of current groundwater flow patterns along the northern boundary and an associated revision to the upgradient well comparisons in that area. The revised statistical evaluations determined that arsenic SSLs occurred in more wells than previously indicated but that fluoride was no longer an SSL for the single well (GW-20) in which the SSL was identified. As such, fluoride was no longer identified as an SSL and was not evaluated as part of the Appendix IV ASD nor evaluated in this ACM. Additional detail regarding the revised interpretation of groundwater flow patterns at the site and the associated impacts on statistical evaluations of AM data is provided in the Appendix IV ASD report included as Attachment A.

FE subsequently performed the first of the 2019 AM sampling events (AM-3) in February 2019, and the validated data was statistically evaluated in August 2019. The AM-3 results were consistent with the previous results with respect to having SSLs for arsenic, barium, lithium, and radium (SSL data from sampling events AM-1, -2, and -3 are also provided in the Appendix IV ASD report included as Attachment A). The second 2019 AM sampling event (AM-4) was performed by FE in July 2019, but the receipt and statistical evaluation of the validated data was not completed in time to be included with this ACM report. Those findings will be included as part of the CCR unit's 2019 AGWMCA Report. To date, no other Appendix IV constituents have been detected at SSLs above the their GWPS under the facility's AM program.

Pursuant to 40 CFR § 257.95(g)(3)(ii), Tetra Tech performed an ASD to assess if the Appendix IV SSLs determined for events AM-1, -2, and -3 were attributable to a release from the CCR unit or from a demonstrable alternative source(s). As part of the Appendix IV ASD, a single nature and extent of release characterization sampling event was performed in July 2019 that included wells from the state monitoring program (discussion in Section 3.2 below). The Appendix IV ASD determined that the barium and radium SSLs can be attributed to historical and current oil and gas exploration and production activities that have occurred at the Site; that the source of the lithium SSLs are currently indeterminate but there is a high potential they are also attributable to oil and gas impacts at the Site; and that the arsenic SSLs could not be attributed to sources other than the CCR unit. As such, a transition to N&E characterization and ACM for arsenic per § 257.96 of the CCR Rule commenced as discussed in the following sections.

3.0 NATURE AND EXTENT OF RELEASE CHARACTERIZATION

Pursuant to 40 CFR 257.95(g)(1), FE initiated an N&E of release characterization concurrent with performing the Appendix IV ASD. Following confirmation that the arsenic SSLs were not attributed to sources other than the CCR unit, N&E characterization continued and ACM commenced. This section summarizes the occurrence and fate and migration characteristics of arsenic, N&E activities conducted as part of the CCR Rule requirements, temporal changes in arsenic concentrations in Site leachate and groundwater as well as the extent of arsenic in Site groundwater as identified by the N&E activities.

3.1 NATURE OF ARSENIC

The following is an overview of arsenic sources, its key geochemical properties, and current regulatory concentration limits for health and environmental protection.

3.1.1 Arsenic Sources and Key Geochemical Properties

Arsenic in groundwater can be derived from various natural and anthropogenic sources including CCRs. It can occur in various forms and its concentration and migration characteristics in groundwater are controlled by the properties of aquifer materials and geochemical conditions (e.g., pH, oxidation-reduction potential, presence of competing anions which may inhibit sorption, etc.). A change in downgradient aquifer properties and geochemical conditions can result in potentially changing the mobility and concentration of arsenic. Therefore, the factors which control arsenic concentrations at a given site can be very complex. The following summarizes the occurrence of arsenic and key geochemical properties which affect its fate and migration characteristics that should be considered in site characterization and remediation strategies:

- Natural sources of arsenic are derived from a wide array of geologic materials, including igneous, metamorphic and sedimentary rocks. Arsenic may subsequently be accumulated during secondary mineral formation in overburden materials and soils. In contrast, anthropogenic sources are typically derived from the land application of arsenical pesticides and herbicides and from disposal of arsenic-bearing wastes generated during processing of ore materials for production of commercial products. (USEPA, October 2007).
- The median concentration of arsenic across all coal types is 7.7 mg/kg. Most arsenic associated with bituminous coal is associated with iron sulfides. While arsenic concentrations in coal ash can be in the range of those measured in background soils, typical arsenic levels in fly ash are higher than the typical levels in soils. (EPRI 2010).
- The most common forms of arsenic in groundwater are their oxy-anions, arsenite [As(III)] and arsenate [As(V)]. Under moderately reducing conditions, arsenite is the predominant species. In oxygenated water, arsenate is the predominant species. Both anions are capable of adsorbing to various subsurface materials, such as ferric oxides and clay particles. Ferric oxides are particularly important to arsenate fate and transport as ferric oxides are abundant in the subsurface and arsenate strongly adsorbs to these surfaces in slightly acidic to neutral waters (USEPA CLU-IN website).
- Arsenic mobility is lowest at pH 3 to 7 and increases at very acidic or alkaline pH (EPRI 2010). At higher alkaline pH, sorption still occurs, but to a lesser degree. Hence, under alkaline conditions, arsenate/arsenite can be expected to be more mobile. The arsenic oxy-anions are also sensitive to redox conditions, and the dominance of arsenate versus arsenite will change with this changing redox. Arsenic can also complex with organic compounds, which can affect its mobility.
- The extent to which inorganic arsenic will partition to mineral surfaces will also be affected by the competition of sorption sites with other anions in solution. There are several commonly occurring anions in natural waters (e.g., phosphate and sulfate) that can compete with arsenic sorption to mineral surfaces. These competitive sorption reactions will be active for all arsenic aqueous species in oxidized and reduced systems.

- Arsenic-bearing colloidal material may be mobilized either from changes in the surface charge on colloids or through deflocculation and suspension of colloidal material through dissolution of cementing agents within the aquifer matrix. Both processes would be facilitated in aquifers impacted by organic contaminants where microbial activity may be stimulated resulting in the generation of reducing conditions and/or the production of low molecular weight organic compounds that partition to fine-grained sediments. (USEPA, October 2007)

3.1.2 Regulatory Concentration Limits for Health and Environmental Protection

Research into state and federal drinking water, National Pollutant Discharge Elimination System (NPDES), and environmental standards by Tetra Tech found the following with respect to concentration limits:

- The federal Maximum Contaminant Level (MCL) for arsenic in drinking water was revised from 0.05 milligrams per liter (mg/L) to 0.01 mg/L, which is the GWPS in effect at the Site.
- For non-potable water sources, federal ambient water quality criteria (AWQC) have been developed that are protective of aquatic life. For arsenic, current statutes list both acute and chronic criteria for arsenic in fresh waters as 0.34 mg/L and 0.15 mg/L, respectively (USEPA, October 2007).
- West Virginia water quality criteria are determined by the state's water use category assigned to the receiving water which, for arsenic, varies from 0.01 mg/L (for public water supply or recreational water contact use) to 0.1 mg/L (for propagation and maintenance of fish and other aquatic life). In those instances where a receiving water does not have a use category assigned, the protective concentration limits for human contact and public water supply (0.01 mg/L) are used. There are also separate criteria for arsenite [As(III)] that apply to aquatic life only and vary between 0.15 mg/L (chronic limit) and 0.34 mg/L (acute limit), which align with the federal AWQC criteria noted above.

3.2 NATURE AND EXTENT OF RELEASE CHARACTERIZATION ACTIVITIES

In an effort to characterize the nature and extent of arsenic in groundwater at the Site and gather information which could be helpful in evaluating potential corrective measures, the following activities were conducted by Tetra Tech in 2019.

3.2.1 Additional Monitoring Points

As previously noted, there are several monitoring wells and piezometers present at the Site that are part of the WVDEP groundwater monitoring system but are not part of the CCR monitoring network (the basis for the CCR monitoring network development is presented in detail in Tetra Tech, 2017). The locations of these wells and piezometers are shown on Figure 1-1 and they either monitor stormwater and/or leachate ponds at the Site (these types of ponds are not required to be monitored by the CCR Rule), the landfill or the impoundment but are positioned too far from the waste boundary to meet the CCR Rule location criteria, or they are currently inactive because they're situated adjacent to the current waste boundary but slated for decommissioning during future permitted expansion of the waste boundary. Referring to Figure 1-1, these wells include GW-3, GW-4, GW-5, GW-8, GW-12, GW-17, MP-1B, MP-3, and MP-4, and the piezometers include P-96-1, -2, -4, and -5. Based on groundwater flow patterns at the Site and proximity to the facility boundary, it was determined that CCR downgradient monitoring wells GW-9, -19, -20, -23, -24, -25, and -26 fulfilled the requirement of 40 CFR § 257.95(g)(3)(iii) of having at least one monitoring well positioned at the facility boundary in the direction of contaminant migration (refer to Figure 1-2). As such, both the CCR and/or non-CCR monitoring wells and piezometers were used for N&E of release characterization and no additional monitoring wells have thus far been installed.

3.2.2 N&E Sampling and Analysis Program

As previously noted in Section 2.2, two rounds of regularly scheduled AM sampling (AM-3 and AM-4) were performed in 2019 for the CCR Rule monitoring network with the samples being analyzed for Appendix III parameters and all Appendix IV parameters. As also noted in Section 2.2, as part of the Appendix IV ASD work, a third sampling event, concurrent with the AM-4 event, was performed specifically for the N&E monitoring points described in Section 3.2.1 with the samples analyzed for Appendix III parameters and for arsenic, barium, fluoride, lithium, and radium. Laboratory analysis and data validation activities were completed for the AM-3 sample set in August 2019 but remain in progress for the AM-4 and N&E sampling event data sets. As such, the currently available findings (sampling events AM-1, -2, and -3) are presented in the following section; the AM-4 and N&E results were unable to be incorporated into this ACM, but preliminary review of the data indicates concentration trends similar to previous sampling events. The AM-4 and N&E sampling event findings will be included as part of the CCR unit's 2019 AGWMCA Report. To date, no other Appendix IV constituents have been detected at SSLs above the their GWPS under the facility's AM program.

3.3 EXTENT OF ARSENIC AND TRENDS IN CONCENTRATION

Figure 3-1 presents time series analysis showing total arsenic concentrations detected in groundwater from April 2005 to February 2019. Also shown for reference is a line indicating the 0.01 mg/L arsenic GWPS. As indicated, prior to adding groundwater monitoring wells as part of the CCR Rule compliance work in 2016, the wells with the highest concentrations were MP-1B, GW-3, and GW-4. Since implementation of groundwater monitoring as part of the CCR Rule compliance work in 2016 (including installing new monitoring wells GW-19 through GW-29), GW-19 and GW-22 have typically been the wells having the highest arsenic concentrations. Both of these wells show substantial seasonal fluctuations in arsenic concentrations over the monitoring period.

Figures 3-2 and 3-3 are iso-concentration maps representative of the areal distribution of total arsenic in groundwater in the monitored CCR aquifer for April 2017 and February 2019, respectively. Concentrations greater than the arsenic GWPS of 0.01 mg/L for the aquifer are shaded on the maps. It is noted that while arsenic concentration results are posted for each monitoring well, certain wells (specifically GW-5 and GW-20) which are not screened in the Grafton Sandstone or believed to be hydraulically connected to it, are excluded from contouring of arsenic values (these wells have much higher hydraulic heads than the nearby Grafton Sandstone wells). As discussed below in Section 4.1, the Grafton Sandstone is the monitored aquifer at the site. GW-5 and GW-20 are screened in intervals (Lower Connellsville Sandstone / Lower Clarksburg Redbeds) which are situated above the Grafton Sandstone. The wells were screened in these intervals because they are the shallowest aquifer units adjacent to the CCR unit in these areas. However, it is noted that neither GW-5 or GW-20 had reported concentrations above the GWPS during their May 2017 and April 2019 sampling events, which were close in time to the above-referenced April 2017 and February 2019 sampling events.

Based on interpolation of concentration gradients between the well measurements, both figures show elevated arsenic concentrations occurring through the impoundment and nearby adjacent areas, with the highest concentrations occurring at GW-19 (northwestern area) and GW-22 (southeastern area) for the April 2017 and February 2019 events. It is noted that there are no groundwater monitoring wells available in the central site area (i.e., beneath the impoundment) which precludes confirming the level of arsenic in the monitored aquifer throughout the central portion of the site. Based on the interpreted distribution in groundwater, arsenic concentrations above the GWPS occur beyond the property boundaries to the north and southeast. In response to these findings, additional N&E of release characterization work is recommended to determine the extent of arsenic concentrations above the GWPS off-site and to gather information to evaluate geochemical conditions to help model potential for natural attenuation to reduce arsenic concentrations in downgradient offsite areas. These and other additional data needs that are part of the final Selection of Remedy at the Site are discussed in Section 7.2 of this report.

4.0 CONCEPTUAL SITE MODEL

4.1 HYDROGEOLOGIC CHARACTERISTICS

This section provides an overview of hydrogeologic characteristics at the Site based on previous studies as well as more recent work completed under the CCR Rule monitoring program. A more detailed discussion of the site's geologic and hydrogeologic characteristics can be found in the "CCR Groundwater Monitoring System Evaluation Report, Harrison Power Station CCB Landfill", Tetra Tech, October 2017.

Groundwater at the Site is derived from precipitation infiltration, however, infiltration through the CCBDF itself is considered to be minimal to none. The entire landfill footprint is underlain with either a compacted clay or composite geosynthetic liner system, and leachate from the landfill is discharged to lined sedimentation ponds. For the disposal impoundment, the upstream face of the dam is clay-lined and keyed into bedrock and water from the impoundment is continuously discharged through an outflow tower and a siphon system. Leakage from the impoundment to groundwater has previously been interpreted to be negligible due primarily to the occurrence of low permeability redbed units present in the former stream valley floor, but sandstone unit outcrops are also present in the valley floor allowing for infiltration into (and/or out of) those units. Leakage from the impoundment may also be limited by the lacustrine deposition of the CCRs and their subsequent compression into a less permeable layer along the former valley bottom and lower sideslopes in the impoundment pool area.

Groundwater in the CCBDF area occurs primarily within the fractured bedrock of the Conemaugh Group, principally in the following sandstone units (in descending order): Morgantown Sandstone, Grafton Sandstone, Jane Lew Sandstone, and the Saltsburg Sandstone. Groundwater has also been identified in the Ames Limestone and Harlem Coal (in association with the Jane Lew sandstone), and, to a lesser extent, the redbed units at the site. Detailed review of occurrence of groundwater in the CCBDF area indicates that the Grafton Sandstone, often in combination with adjacent hydraulically connected stratigraphic units, is the primary aquifer monitored at the site as part of the CCR monitoring network. Groundwater flow at the CCBDF occurs primarily through networks of interconnected fractures formed through tectonic and stress relief processes. Generally, fine-grained rock units (e.g., redbeds) typically serve as aquitards to limit vertical groundwater migration, while coarser grained rock units (e.g., sandstones) typically have more well-developed and open fracture systems and are the primary conduits for groundwater migration. Infiltrated groundwater moves vertically until relatively low-permeability layers are encountered, where a perched water table forms. The perched groundwater flows laterally towards groundwater discharge points within the former stream valleys (manifested as springs or seeps). A portion of the groundwater also migrates through localized, vertically transmissive fractures that penetrate through the low permeability layers to underlying rock units.

Historic and recent groundwater level data indicate groundwater flows north from the topographically higher areas located to the south and southeast of the impoundment. West and northwest of the impoundment dam, topography may be the dominant influence on groundwater flow, as the multiple sandstone units underlying the site are eroded and discontinuous across the former valley. Groundwater flow northwest of the dam and under the landfill is in the downstream direction of McElroy's Run (toward the west). Flow in all of the rock units exhibit very little seasonal and temporal fluctuations. A representative set of water level data from the time period of this ACM (July 2019) were used for contouring groundwater elevations and identifying flow patterns at the Site (refer to Figure 1-2). These water levels were similar to historical levels across the Site. As such, separate mapping for other time periods was not necessary for this report. A more detailed discussion of the site's geologic and hydrogeologic characteristics can be found in Section 4.0 of this report.

Hydrogeologic properties for the CCBL area have been estimated as part of previous studies (referenced in Tetra Tech, October 2017). Estimates of hydraulic conductivity (K) are available for the landfill waste materials, natural soils, and bedrock. The estimates are based on limited testing data and should be considered generalized estimates only, particularly for the bedrock, as individual fractures in fractured rock groundwater flow systems typically vary widely in water-yielding capabilities. Estimated K values for landfill waste are in the range of 0.03 feet per day, while remolded K values for the natural soils present across the site (mostly silt/clay) range from 10^{-4} to 10^{-5} feet per day. Based on slug tests in well borings, bulk hydraulic conductivities of bedrock range from 0.5 feet per day (Pittsburgh Redbeds) to 255 feet per day (Morgantown and Saltsburg Sandstones). Slug tests measure the overall K of the tested portion of a boring, so it is likely that discrete fracture K values are much higher than the overall average. Historical packer tests and falling head tests yielded hydraulic conductivity values of 0.003 to 0.3 feet per day for the Saltsburg/Buffalo Sandstones.

Appendix B provides a generalized geologic cross-section completed as part of the solid waste permit application for the site. Cross-Section A-A' is a generally northwest-southeast section extending from the Ohio River to the facility boundary (near the location of CCR well GW-22). The section cuts through the landfill, dam, and impoundment areas and depicts the stratigraphic positioning of the Grafton and Saltsburg Sandstones, the Birmingham and Pittsburgh Redbeds, and the Ames Limestone.

4.2 POTENTIAL RECEPTORS

Based on information contained in the CCBL's recent state solid waste permit renewal applications, there are two downgradient water supply wells located within one mile of the landfill perimeter (this includes areas upgradient, side-gradient, and downgradient of the CCR unit). The study area and well locations are shown on attached Figure 4-1. Referring to this figure, the two wells are located approximately 1,500 to 2,000 feet northwest of the facility boundary and are situated close to the Ohio River. Given that there's a mix of arsenic concentrations at the closest downgradient facility boundary wells, with GW-9 being below the GWPS and GW-19 being above the GWPS, there is potential that attenuation of arsenic concentrations may occur over the relatively long flow path from the GW-9 area to the water supply wells. In addition, given the horizontal proximity of the two water supply wells to the Ohio River, it is likely that both wells draw their water from the Ohio River alluvial aquifer. This is a very high-yield aquifer that would significantly dilute any upland groundwater flows that discharge into it.

4.3 SUMMARY OF CSM

Figures 4-2 and 4-3 are generalized cross-sections presenting the Site CSM, with Figure 4-2 representing the portion of flow that branches off to the northwest and Figure 4-3 representing the portion of flow that branches off to the northeast. In summary, the CSM consists of arsenic leaching from the impounded CCRs at the Site and entering groundwater at the base of the former McElroy's Run valley. A significant volume of leachate and infiltration is removed from the groundwater system by the leachate collection and chimney drain systems present in the lined portions of the landfill and under the impoundment dam, respectively. These flows are collected and routed through the lined sedimentation ponds before being discharged off-site. As the remaining impacted groundwater flows downgradient of the CCR unit it is expected to undergo attenuation based on a combination of advection, dispersion, and, potentially natural dilution resulting in concentrations that are anticipated to be below the arsenic GWPS before flow reaches a potential receptor.

5.0 IDENTIFICATION AND SCREENING OF REMEDIATION TECHNOLOGIES

Technologies for the treatment of arsenic in groundwater are primarily based on ex-situ or in-situ approaches. Pump-and-treat technologies make use of processes common to water and wastewater treatment for removal of dissolved arsenic. In-situ treatment technologies are less common, but there is emerging research based on the application of permeable reactive barriers for arsenic removal from ground water. This technology is based on installation of reactive solid material into the subsurface to intercept and treat the contaminant plume (USEPA, October 2007). Monitored Natural Attenuation (MNA) may also be appropriate at some sites depending on aquifer properties and geochemical conditions. This section identifies the remediation technologies which were evaluated as part of this ACM and summarizes each technology including associated advantages and disadvantages. The technologies include those pertaining to source control and those addressing the impacted groundwater downgradient of the CCBDF.

5.1 SOURCE CONTROL

When remediating impacted groundwater, controlling on-site sources of historical, current, and future contamination to the aquifer are key components to the overall remediation plan. Source control includes a range of potential actions such as treatment in-place, removal, or containment, or some combination of these actions with the goal of reducing or eliminating, to the extent practicable, future releases. For each of the source control technologies below, the focus has been placed on the disposal impoundment as it’s an unlined CCR unit. The landfill is a lined CCR unit that includes a leachate collection system and an underlying combined leak detection/groundwater underdrain system and there have been no indications of any releases from the landfill since it was first developed.

5.1.1 Treatment in Place

For an unlined wet disposal impoundment like the existing CCR unit, options for in place source treatment would include amending the CCRs to reduce their permeability and/or chemically fixate the contaminants of concern and prevent them from leaching out. Amendment of the in-place CCRs would be accomplished by the use of drilled pressurized injection wells or deep auger mixing to introduce an amending agent slurry (e.g., Portland cement). Considering the surface area and volume of materials present in a large impoundment like the CCR unit, implementation of such treatment in-place technologies is impractical and has only been noted herein for completeness in presenting options.

5.1.2 Removal

Source removal for a wet disposal impoundment would require excavating, drying/stabilizing, loading and hauling all of the CCRs currently located in unlined areas and placing them in existing or new on-site or off-site lined disposal areas. In general, advantages of removal include:

- Effectively eliminates the potential for future contamination to occur; and
- Can oftentimes reduce the timeframe over which remediation goals can be attained.

In general, disadvantages include:

- An increased overall risk to cleanup workers, the surrounding community, and the environment due to factors such as fugitive dust generation and heavy construction equipment emissions;
- If off-site transport and disposal is required, an increased potential for severe cross-media environmental effects and safety hazards due to accidents; and
- For a large volume site, removal activities could take an unreasonable amount of time to complete and be financially infeasible.

Given the volume of materials present in a large impoundment like the CCR unit and the corresponding effects that the disadvantages noted above would entail for a facility of such size, implementation of CCR removal from unlined areas at the site is impractical and noted herein for completeness in presenting options.

5.1.3 Containment

Source containment approaches for a wet disposal impoundment would include the construction of a final cover (capping) system and/or the installation of a subsurface cutoff wall. Construction of a final cover system atop all exposed CCR surfaces would eliminate source material releases due to stormwater erosion or fugitive dust generation and would reduce leachate generation by minimizing the infiltration of storm water into the underlying CCRs. Installation of a low permeability upgradient groundwater cutoff wall by trench excavation and/or drilled high pressure injection grouting would minimize source contaminant mobilization by preventing groundwater flow into or through the landfilled CCRs.

In general, advantages include:

- Implementation can usually be completed in a relatively short period of time, depending on the dewatering characteristics of the CCRs and the size and depth of the impounded wastes;
- Final cover system design and construction have established processes;
- Can oftentimes reduce the timeframe over which remediation goals can be attained; and
- Effectively reduces the potential for future contamination to occur.

In general, disadvantages include:

- For cutoff walls, subsurface conditions must be favorable across the Site in order to construct an effective and reliable groundwater flow barrier (this is particularly difficult for controlling fractured bedrock flow);
- Depending on the impoundment size and material depths, final cover systems can be difficult to design with respect to tolerating settlement and maintaining reliable long-term stormwater collection and conveyance controls; and
- Final cover systems require routine monitoring, maintenance, and repair throughout their service life.

Given both the large size and the geologic and hydrogeologic characteristics of the Site, the installation of an effective groundwater cutoff wall is impractical and is noted herein for completeness in presenting options. However, construction of a final cover system (either a soil-only or typical regulatory composite cap) is a viable option for the CCR unit and is required under the solid waste permit issued by WVDEP for the Site after the impoundment reaches design capacity and is closed.

5.2 GROUNDWATER EXTRACTION AND TREATMENT

Groundwater extraction and treatment (also referred to as “pump and treat”) can be used as a containment strategy at or near the source of contamination or to reduce or eliminate the downgradient migration of a plume. The technology accomplishes a certain amount of mass removal from the plume. In its simplest form, extraction and treatment involves the installation and pumping of vertical extraction wells with the extracted water treated for the contaminant(s) of concern using methods appropriate for the type of contaminant (e.g., air stripping for volatile organic compounds, chemical precipitation for certain inorganic compounds, etc.). As with most remedial technologies it is most effective following source control. In most cases the groundwater treatment results in a need to manage residuals (e.g., sludges, filters, etc.) which may also act as a source of contamination if not properly managed. Extraction and treatment system application often has associated contaminant “rebound” effects related to desorption of additional contaminant mass from aquifer materials following the initial extraction phase. Groundwater extraction and treatment can also be accomplished via horizontal wells.

In general, advantages include:

- Accomplishes some contaminant mass removal; and
- Can help to protect receptors (e.g., drinking water wells) by preventing migration beyond the extraction wells.

In general, disadvantages include:

- Likely to have limited success under heterogenous or low permeability aquifer conditions;
- Often requires long term operation and maintenance and power usage;
- Results in treatment residuals which must subsequently be managed; and
- “Rebound” effects can inhibit the ability to achieve remedial goals.

For arsenic, treatment methods include coagulation (i.e., with ferric chloride or alum) and adsorption on packed bed media (e.g., granular ferric hydroxide or activated alumina). Particularly for aluminum-based coagulants and sorbents, the efficiency of arsenic removal can be dramatically enhanced by pre-oxidation of As(III) to As(V). With greensand filtration, the filter media itself is an oxidant and removal of arsenic, whether it occurs in the groundwater as either As(III) or As(V), is enhanced if the groundwater also contains elevated concentrations of Fe(II).

5.3 IN-SITU TECHNOLOGIES

As opposed to technologies such as groundwater extraction and treatment which involve mechanical systems that must be continually operated, “passive” in-situ technologies operate primarily by using a site’s natural characteristics (e.g., groundwater flow direction, aquifer geochemical conditions, etc.) to achieve remedial goals. As discussed in this section, in-situ technologies require a strong understanding of an impacted aquifer’s physical and geochemical characteristics, which can be “built upon” to achieve remedial goals through adding appropriate reagents to the subsurface environment to achieve contaminant reduction through processes such as adsorption, precipitation, etc.

5.3.1 Permeable Reactive Barriers (PRBs):

A permeable reactive barrier (PRB) typically involves digging a trench perpendicular to groundwater flow and of sufficient depth to intercept a groundwater plume, then placing a reagent in the trench which will react with the impacted groundwater flowing through it in order to reduce contaminant concentrations, primarily through adsorption or precipitation. A funnel and gate type approach can also be utilized for

PRBs where low permeability walls (the funnel) direct groundwater toward a permeable zone containing the reagent (the gate). Some gates are constructed to be readily accessible to facilitate the replacement of the reagent. The reagent is selected based on the constituent of concern and geochemical conditions of the aquifer (e.g. pH and redox conditions).

Certain contaminants are much more amenable to PRB treatment based on their physical and chemical properties. A commonly used reagent is Zero Valent Iron (ZVI) which can be used to convert certain contaminants to non-toxic or immobile species. ZVI has been shown to be effective in treating many halogenated hydrocarbons as well as removing hexavalent chromium, arsenic, and uranium ("Permeable Reactive Barriers, Permeable Treatment Zones and Application of Zero-Valent Iron", USEPA Clu-In Technologies website.) Both As(III) and As(V) can be removed from water by iron wire or filings in batch systems or columns, and this removal has been attributed to sorption and/or surface precipitation of As onto iron oxides (or rust) produced at the metal surface. However, ZVI has not yet been applied in a permeable reactive barrier system for in situ treatment of arsenic-contaminated groundwater. (SERDP, August 2008).

In general, advantages include:

- Essentially a passive type approach (i.e., no continuous operational oversight needed, maintenance is infrequent, etc.); and
- Can be very effective for certain types of contaminants and under the necessary hydrogeologic conditions.

In general, disadvantages include:

- Not suitable for bedrock aquifers;
- Limited by viable trenching depth;
- Suitable reagents have not been proven for all contaminant types (e.g., arsenic); and
- Reactive agent(s) must be replaced on a scheduled basis.

Application of PRB technology at the Site is not considered viable since the uppermost aquifer system occurs along the downgradient northwestern and northeastern flow paths at depths between approximately 100 and 375 feet and includes a fractured bedrock flow component. In addition, Tetra Tech is not aware of any current applications of PRB technology to remediate arsenic in groundwater at CCR sites. As such, it will not be considered in the evaluation of corrective measures discussion in Section 6.0 but could potentially be revisited should additional information about the viability of using this technology at the Site become available during SoR activities.

5.3.2 In-Situ Chemical Stabilization via Injection Wells

In-situ chemical stabilization involves injection into the subsurface via drilled wells a reagent that will result in the precipitation or adsorption of the constituent of concern, and thereby reduce its concentration in groundwater within and downgradient of the injection area. The type of reagent used will depend on the constituent and geochemical conditions within the aquifer including pH, redox conditions, types of natural clays which may be present, etc. It is critical that the aquifer characteristics, particularly permeability, lend themselves to suitable mixing of the reagent with impacted groundwater. Bench scale testing is typically performed to evaluate viability and, if found to be viable, to support design.

In general, advantages include:

- An overall passive approach with minimal disruption of the Site.

In general, disadvantages include:

- Proven reagents are not available for all CCR constituents;
- Changes in geochemistry or aquifer conditions outside of the injection interval may cause certain reactions to “reverse”;
- It can be difficult to achieve the desired mixing of the reagent with impacted groundwater under low permeability and/or heterogenous aquifer conditions (e.g., fractured bedrock); and
- The longevity of the reagents can be difficult to forecast.

5.4 MONITORED NATURAL ATTENUATION (MNA)

The following summary of MNA is based on USEPA Directive 9200.4 – 17P “Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites”, April 21, 1999.

> The term ‘monitored natural attenuation’… refers to the reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods. The “natural attenuation processes” that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants

The USEPA directive lists the following among the advantages and disadvantages of the MNA approach:

Potential advantages of MNA include:

- As with any in situ process, generation of lesser volume of remediation wastes, reduced potential for cross-media transfer of contaminants commonly associated with ex situ treatment, and reduced risk of human exposure to contaminants, contaminated media, and other hazards, and reduced disturbances to ecological receptors;
- Less intrusion as few surface structures are required;
- Potential for application to all or part of a given site, depending on site conditions and remediation objectives;
- Use in conjunction with, or as a follow-up to, other (active) remedial measures; and
- Potentially lower overall remediation costs than those associated with active remediation.

The potential disadvantages of MNA include:

- Longer time frames may be required to achieve remediation objectives, compared to active remediation measures at a given site;
- Site characterization can often be more complex and costly;
- Long-term performance monitoring will generally be more extensive and for a longer time;
- Institutional controls may be necessary to ensure long term protectiveness;
- Potential exists for continued contamination migration, and/or cross-media transfer of contaminants; and

- Hydrologic and geochemical conditions amenable to natural attenuation may change over time and could result in renewed mobility of previously stabilized contaminants (or naturally occurring metals), adversely impacting remedial effectiveness.

In addition to the above USEPA Directive, a companion Directive was also issued: “Use of Monitored Natural Attenuation for Inorganic Contaminants In Groundwater At Superfund Sites”, August 2015, USEPA. The Directive discusses a methodology for considering MNA as a remedial strategy for several inorganic constituents (including arsenic) and expands upon the Tiered Analysis Approach for Developing Multiple Lines of Evidence presented in the original 1999 Directive.

6.0 ASSESSMENT OF CORRECTIVE MEASURES

6.1 OBJECTIVE

The objective of this Assessment of Corrective Measures section is to provide a high-level evaluation of each of the viable remediation technologies presented in Section 5.0 with regards to the criteria identified in 40 CFR § 257.96(c) and previously presented in Section 1.2 of this report. These evaluations are summarized below and in Table 6-1. The criteria evaluated in Sections 6.2 through 6.5 are performance-related, so each of the technologies has been assigned a subjective rating of “Low”, “Medium”, or “High” based on how they are anticipated to satisfy each criterion. For the criteria evaluated in Sections 6.6 (time to begin and complete remedy) and 6.7 (institutional requirements), subjective ratings of “Short”, “Medium”, or “Long” and “Minimal”, “Moderate”, and “Extensive” have been assigned, respectively. As discussed in Section 5.3.1, the PRB technology was not considered viable due to both the aquifer depth and that the primary aquifer type is fractured bedrock; therefore, it is not included in the evaluations below. A more detailed evaluation of technologies leading to a final selection of remedy will be performed and reported during the Selection of Remedy phase as discussed in Section 7 of this report.

6.2 PERFORMANCE

This section discusses the anticipated performance of each technology relative to its ability to achieve remedial goals in consideration of the CSM. Technologies are ranked as “Low”, “Medium”, or “High” with regard to their effectiveness in reducing arsenic concentrations in groundwater.

6.2.1 Source Control

Containment using Final Cover System – Medium to High

As discussed in Section 5.1.3, constructing a final cover system atop all exposed CCR surfaces would minimize the infiltration of storm water into the underlying CCRs which would, in turn, reduce both the groundwater flow rates and the total contaminant loading on the monitored aquifer(s). The magnitude and extent of these reductions depend on the type of final cover system(s) utilized at the Site. As per the CCR unit’s current Closure Plan (available on the Site’s publicly accessible CCR website - http://ccrdocs.firstenergycorp.com/), the existing impoundment area will utilize a soil-only cover system once final closure of the unit is initiated. The soil-only cover system provides a medium level of containment performance while a composite cover system, should the design be revised to utilize one, would provide a high level of containment performance.

6.2.2 Groundwater Extraction and Treatment

Low. It is anticipated that the performance of a groundwater extraction and treatment system would be poor due to the anisotropic nature and overall low permeability of the aquifer. It is also noted that the cross-sectional area through the groundwater flow path downgradient of the landfill is wide. Given that and the fact that groundwater flow at the Site is primarily occurring through bedrock fractures, it is likely many extraction wells would be necessary to ensure that all groundwater flow paths were being captured.

6.2.3 In-Situ Technologies

Chemical Stabilization via Injection Wells – Low

The anisotropic nature and relatively low permeability of the monitored aquifer would make in-situ treatment by injection wells difficult from the standpoint of achieving adequate contact and reagent mixing with the impacted groundwater.

6.2.4 Monitored Natural Attenuation (MNA)

Medium to High. As discussed in Sections 3.3 and 4.2, it's believed that attenuation of the arsenic levels down to the GWPS is occurring near the downgradient facility boundary based on interpolation of the measured concentration gradients. In addition, the nearest water supply users in the downgradient flow path are located approximately 1,500 to 2,000 feet from the facility boundary and are likely drawing from the Ohio River alluvial aquifer. Taken together, the anticipated ongoing performance of MNA would be medium when combined with the eventual installation of a soil-only final cover system, but high if it is combined with the eventual installation of a composite final cover system.

6.3 RELIABILITY

Reliability is the anticipated consistency of a technology to function as designed/expected under variable site-specific conditions. Factors which affect reliability can include aquifer variability (e.g., groundwater geochemistry and flow changes) and equipment performance (e.g., power outages and frequency of maintenance activities). Technologies are ranked as “Low”, “Medium”, or “High” with regard to their effectiveness in consistently reducing arsenic concentrations in groundwater.

6.3.1 Source Control

Containment Using Final Cover System - High

The soil-only cover system that is proposed for use during final closure will be designed and constructed in accordance with well-established practices. The design could also be modified to use a composite final cover system that incorporates a geomembrane and an upper layer of vegetated cover soil that's comparable to the soil-only cover system. Both systems are expected to be highly reliable as long as they are properly monitored and maintained, which FE will do for the remainder of the landfill's operating life and for the duration of the landfill's post-closure period as required by the state Solid Waste Permit.

6.3.2 Groundwater Extraction and Treatment

Medium to High. Extraction and treatment would require proper operation and maintenance (O&M) of extraction well (e.g., pumps) and treatment system equipment in order to maintain reliability. The aquifer system would also need to be evaluated for the presence of high iron and manganese concentrations as these constituents require measures to be taken to prevent fouling and deterioration of pumps and treatment equipment as well as any connecting piping.

6.3.3 In-Situ Technologies

Chemical Stabilization via Injection Wells – Low to Medium

It is anticipated that since in-situ chemical stabilization of arsenic in a low yield, fractured bedrock aquifer system via injection wells does not seem to be proven, that reliability would be questionable. Beyond concept reliability, the injection system itself would require proper O&M of the well equipment (e.g., pumps) and the surface batching and feed systems in order to maintain operational reliability.

6.3.4 Monitored Natural Attenuation

Medium to High. Based on the factors previously discussed in Section 6.2.4, it is anticipated that reductions in arsenic concentrations would be reliable going forward provided it is combined with the eventual installation of either a soil-only or a composite final cover system and confirmation of geochemical conditions which may affect attenuation.

6.4 EASE OF IMPLEMENTATION

Ease of implementation relates to how challenging the technology installation will be considering site-specific conditions (e.g., degree of aquifer heterogeneity), the complexity of the design effort (e.g., modeling, bench scale and pilot testing, etc.), and the availability of suitable equipment. Technologies are ranked as “Low”, “Medium”, or “High” with regard to their ease in being installed to begin reducing arsenic concentrations in groundwater.

6.4.1 Source Control

Containment using Final Cover System – Medium to Low

Either the currently proposed soil-only cover system or a composite cover system would require the development of construction-level drawings and specifications and then have to proceed through the Station’s procurement process before construction could commence. Construction would first require dewatering (and possibly treatment) of all free liquids and sufficient pore water to stabilize the impounded CCRs so they could be graded to receive the cover system and to provide positive drainage. Construction of the cover system would then entail the use of commonly accepted materials but non-standard means and methods due to the physical nature and engineering characteristics of partially and completely saturated CCRs. The ease of completion would also depend heavily on the size of the area(s) being covered and seasonal weather constraints. Because of these factors, ease of installation for either final cover system is considered medium to low.

6.4.2 Groundwater Extraction and Treatment

Low. Based on the anisotropic and low permeability nature of the monitored aquifer, it is likely that many groundwater extraction wells would be needed to attempt to capture impacted groundwater. Given both the topography and the number of below and above ground oil and gas conveyance lines in the targeted intercept areas and the interferences they would present, siting the wells in the desired locations would prove extremely difficult. Bench scale testing would also need to be conducted to identify the best reagent(s) for use in removing the arsenic from solution. Such a bench scale testing program would be expected to go through multiple iterations before establishing the treatment program needs. Because of these factors, ease of installation for this system is considered low.

6.4.3 In-Situ Technologies

Chemical Stabilization via Injection Wells – Low

Implementation would likely be very challenging due to identifying the appropriate reagent(s) and "dosing" strategy to effectively and efficiently treat the aquifer due to the anisotropic conditions. It is likely that various phases of bench scale and field pilot testing would be necessary to support the design.

6.4.4 Monitored Natural Attenuation

Medium to High. No additional equipment would be necessary for a natural attenuation remedy. There would likely be a need to add a limited number of properly constructed monitoring wells in the downgradient areas along the northern facility boundary to evaluate the program’s performance, and this could present significant difficulties due to the topography of this area and the potential need to negotiate monitoring well easements with downgradient property owners.

6.5 POTENTIAL IMPACTS OF APPROPRIATE REMEDIES (SAFETY, CROSS-MEDIA AND CONTROL OF EXPOSURE)

Potential impacts of technologies were evaluated considering the following:

- Safety: The likelihood that illness, injury, or death directly related to the technology would occur during construction or operations. In general, “active” technologies and those requiring significant construction effort were considered higher risk than “passive” technologies and those not requiring significant construction effort.
- Cross-Media: The likelihood that the technology will result in a transfer of contaminants to the air, surface water, or soil, either from a direct discharge or from management of treatment residuals.
- Control of Exposure: The likelihood that that the technology will result in exposure of contaminants to human or environmental receptors either from a direct discharge or from management of treatment residuals.

Technologies are ranked as “Low”, “Medium”, or “High” with regard to how likely they are to have negative effects for Safety and Cross-Media, and with regard to how well they avoid negative effects for Control of Exposure.

6.5.1 Source Control

Containment using Final Cover System

Safety Impacts: **Medium to High**. Construction of either a soil-only or composite final cover system would involve both typical and atypical construction risks, both on-site and off-site. Typical risks would include material deliveries and heavy equipment operations, while atypical risks would include excessive settlement and low shear strengths, both of which are commonly associated with dewatered impoundment CCRs. However, after construction is completed, the final cover system would present little to no implementation-related safety impacts.

Cross-Media Impacts: **Low**. Construction of either a soil-only or a composite final cover system atop all exposed CCR surfaces would eliminate source material releases and potential cross-media impacts to the air, ground surface, or surface water due to stormwater erosion or fugitive dust generation.

Control of Exposure: **High**. Construction of either a soil-only or a composite final cover system atop all exposed CCR surfaces would eliminate direct and indirect exposure to the disposed CCRs.

6.5.2 Groundwater Extraction and Treatment

Safety Impacts: **Medium**. Safety risks associated with drilling extraction wells and construction of a treatment facility would exist but could be minimized through implementation of an appropriate health and safety plan. Likewise, some safety risks would be associated with the operation of the treatment system;

however, such risks could be minimized through proper O&M procedures and through implementation of an appropriate health and safety plan.

Cross-Media Impacts: **Medium**. Treatment residuals would need to be managed. In addition, the potential exists for releases from well connections, valves, system piping, and tanks that could impact site soils and potentially groundwater and surface water.

Control of Exposure: **Medium**. Treatment residuals would need to be properly managed to minimize exposure. In addition, the potential exists for exposure to workers and other on-site personnel from any releases which may occur at the well heads, piping, and any storage tanks that are part of the extraction and treatment system.

6.5.3 In-Situ Technologies

Chemical Stabilization via Injection Wells

Safety Impacts: **Medium** – There would be safety risks associated with drilling injection wells and handling reagent.

Cross-Media Impacts: **Low to Medium** – Would need to confirm that selected reagent would not have negative impacts associated with downgradient groundwater discharge to surface water.

Control of Exposure: **Medium to High** – Will require proper handling procedures for the selected reagent.

6.5.4 Monitored Natural Attenuation

Safety Impacts: **Medium** - Some additional construction or well installation would be necessary under the MNA remedy; there would be safety risks associated with possibly installing a limited number of properly constructed monitoring wells in the downgradient areas along the northern facility boundary to evaluate the program's performance, but this would not present significant safety impacts.

Cross-Media Impacts: **Low to Medium** – As noted in Section 4.3, the Site CSM indicates groundwater from the monitored aquifer flows to the northwest and the northeast. The nearest drainage feature to the northwest appears to be the Ohio River, which is located approximately ½-mile from the facility boundary. Based on a review of aerial imagery, there does not appear to be a downgradient drainage feature that would intercept the Grafton sandstone within one mile of the facility boundary. However, for flow in both directions, it's believed that attenuation of the arsenic levels down to the GWPS is occurring near the northwestern facility boundary based on interpolation of the measured concentration gradients. In addition, the arsenic levels measured in the Site wells are either below or near the state and federal aquatic water quality criteria presented in Section 3.1.2, which would apply to the Ohio River.

Control of Exposure: **High** - No contamination residuals will be generated. As stated in Section 4.2, the closest downgradient water supply users are located approximately 1,500 to 2,000 feet from the facility boundary.

6.6 TIME REQUIRED TO BEGIN AND COMPLETE REMEDY

The anticipated time required to begin and compete a remedy considers factors such as the complexity of the design, construction, and permitting efforts, as well as forecasting how efficient the technology is expected to be in achieving remedial goals in a timely manner. Technologies are ranked as "Short", "Medium", or "Long" with regard to their anticipated time to reduce arsenic concentrations in groundwater.

6.6.1 Source Control

Containment using Final Cover System

Time to Begin Remedy: **Medium.** It is anticipated that preparation of engineering and construction drawings and documents and contractor procurement would take approximately two years.

Time to Complete Remedy: **Medium to Long.** As previously noted, construction would first require dewatering operations which would then be followed by installation of the final cover system. All of this work would need to be performed using a phased construction approach that would include seasonal (winter) shutdowns, with the total time to complete construction being approximately five to ten years.

6.6.2 Groundwater Extraction and Treatment

Time to Begin Remedy: **Medium.** It is anticipated that one to two years would be required to initiate a groundwater extraction and treatment remedy in order to allow time for modeling to select well locations; to complete well, pipeline and treatment system design and permitting, and to construct the extraction and treatment systems (medium).

Time to Complete Remedy: **Currently Unknown**. Extraction and treatment, while effective at containment in some settings, is often not successful in achieving remedial goals due to "rebound" effects and other field variables that become more defined during system startup and operation.

6.6.3 In-Situ Technologies

Chemical Stabilization via Injection Wells

Time to Begin Remedy: **Medium.** Two to three years are estimated for bench scale testing in order to select the treatment reagent(s), perform modeling to identify injection well locations, complete well and injection system design and permitting, and to install the injection wells and construct the injection system (medium).

Time to Complete Remedy: **Currently Unknown**. The time required to complete the remedy will depend on the duration of leaching of arsenic into the aquifer, which is expected to decrease as the CCR unit is covered/capped. The duration of treatment required is difficult to estimate until at least bench scale testing is performed on the selected reagent.

6.6.4 Monitored Natural Attenuation

Time to Begin Remedy: **Short**. As previously noted, it’s believed that attenuation of the arsenic levels down to the GWPS is occurring near the northwestern facility boundary based on interpolation of the measured concentration gradients.

Time to Complete Remedy: **Long**. Additional monitoring and the installation of additional monitoring well locations would be necessary to confirm that the GWPS is being attained near the facility boundary. Ongoing monitoring to confirm the remedy continues to be effective would also be proposed with the duration to be determined as part of the Selection of Remedy process discussed in Section 7.0 of this report.

6.7 INSTITUTIONAL REQUIREMENTS (STATE AND LOCAL PERMITS AND OTHER APPROVALS)

Institutional requirements pertain to the anticipated state and local permits and other approvals needed to construct and operate the remedial technology. These can include programs already in-place for a given CCR unit (e.g., solid waste permit) that will need to be modified to accommodate a potential technology, or new programs that may result from a potential technology (e.g., NPDES permit). FE will continue to provide CCR Rule program notifications to WVDEP as required by 40 CFR § 257.106 and will also consult with WVDEP to confirm anticipated permitting requirements that would be associated with the selected remedy. As mentioned in Section 1.3, the CCBDF is permitted under the WVDEP solid waste regulations; therefore, consultation with the agency will be required to support remedy selection, design, and implementation. The following summarizes the expected permits/approvals which may be required by WVDEP or local authorities for each technology and associated rankings of “Minimal”, “Moderate”, and “Extensive” with regard to the anticipated level of effort that will be needed to obtain them.

6.7.1 Source Control

Containment using Final Cover System – Minimal to Moderate

Both the existing soil-only cover system and a potential composite final cover system would be regulated under the state-issued Solid Waste Permit. The use of the soil-only cover system in its current operating capacity would only require minimal modifications to the Solid Waste Permit, while the use of a composite cover system would require moderate modifications to the Solid Waste permit.

6.7.2 Groundwater Extraction and Treatment

It is anticipated that either an amendment to the facility’s combined Solid Waste/NPDES permit or a new individual NPDES permit will be required for construction and operation of a treatment system. This would likely constitute a moderate to extensive effort. Well locations, piping, and any excavation related to the treatment system would also need to undergo utility clearances.

6.7.3 In-Situ Technologies

Chemical Stabilization via Injection Wells - Moderate

It is anticipated that only an amendment to the facility’s Solid Waste Permit would be required for construction and operation of an injection system.

6.7.4 Monitored Natural Attenuation

No new or amended permits and/or approvals are anticipated from state or local agencies and authorities for an MNA remedy. The implementation of an MNA remedy would only require the regular renewal of the Solid Waste Permit, which would likely constitute a minimal effort.

6.8 COMPARATIVE ANALYSIS OF CORRECTIVE MEASURES ALTERNATIVES

Based on the evaluation of viable remediation technologies presented in Sections 6.1 through 6.7, MNA, combined with source control by the eventual installation of a final cover system, ranks highest among the evaluated options. It ranks medium to high in performance, reliability, ease of implementation, potential safety impacts and potential for residual contamination impacts. Also, additional monitoring of the groundwater network should be conducted to confirm that there are not trend changes that could impact effectiveness. These and other additional data needs that are part of the final Selection of Remedy at the Site are discussed in Section 7.2. It is also noted that it is anticipated that the installation of a final cover system should accelerate the effectiveness of whichever associated corrective measure is selected.

7.0 PROCESS FOR SELECTION OF REMEDY

7.1 SELECTION CRITERIA AND SCHEDULE

As required by 40 CFR § 257.97(a), FE will, as soon as feasible after completion of this ACM, select a remedy that, at a minimum, meets the performance standards listed in 40 CFR 257.97(b) and the evaluation factors listed in 40 CFR 257.97(c). As required by 40 CFR § 257.97(d), FE will specify as part of the selected remedy a schedule(s) for implementing and completing remedial activities. The schedule will require the completion of remedial activities within a reasonable period of time taking into consideration the factors set forth in 40 CFR § 257.97(d)(1) through (d)(6),

7.2 ADDITIONAL DATA NEEDS

In order to select a remedy that is both effective and implementable, additional data collection and analyses will be required as summarized below:

- Installation of additional monitoring wells downgradient of the northwestern and northeastern flow paths to confirm attenuation of arsenic is occurring near the facility boundary, gather geochemical information pertinent to evaluating arsenic natural attenuation, and to monitor the continued effectiveness of the attenuation mechanisms.
- Modeling of the monitored aquifer to further evaluate the MNA alternative to assist in forecasting likely long-term effectiveness and to estimate timeframes for completing remedial activities.
- Additional research into potential reagents for chemical stabilization of arsenic via injection wells as presented in Section 5.3.2.

7.3 REMEDY SELECTION PROGRESS REPORTING

As required by 40 CFR § 257.97(a), FE will prepare a semi-annual report describing the progress in selecting and designing the remedy. One of the semi-annual reports will be included in the forthcoming 2019 Annual Groundwater Monitoring and Corrective Action Report, which will be completed in January 2020.

7.4 PUBLIC MEETING

As required by 40 CFR § 257.96(e), FE will discuss the results of the corrective measures assessment at least 30 days prior to the selection of remedy, in a public meeting with interested and affected parties.

7.5 FINAL REMEDY SELECTION

Upon selection of a remedy, FE will prepare a final report describing the selected remedy and how it meets the standards outlined in Section 7.1. The final report will include a certification from a qualified professional engineer that the remedy selected meets the requirements of the selection criteria and the final report will be placed in the Station's operating record as required by § 257.105(h)(12).

8.0 REFERENCES

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USEPA, 2015. Use Of Monitored Natural Attenuation For Inorganic Contaminants In Groundwater At Superfund Sites. August 2015.

TABLES

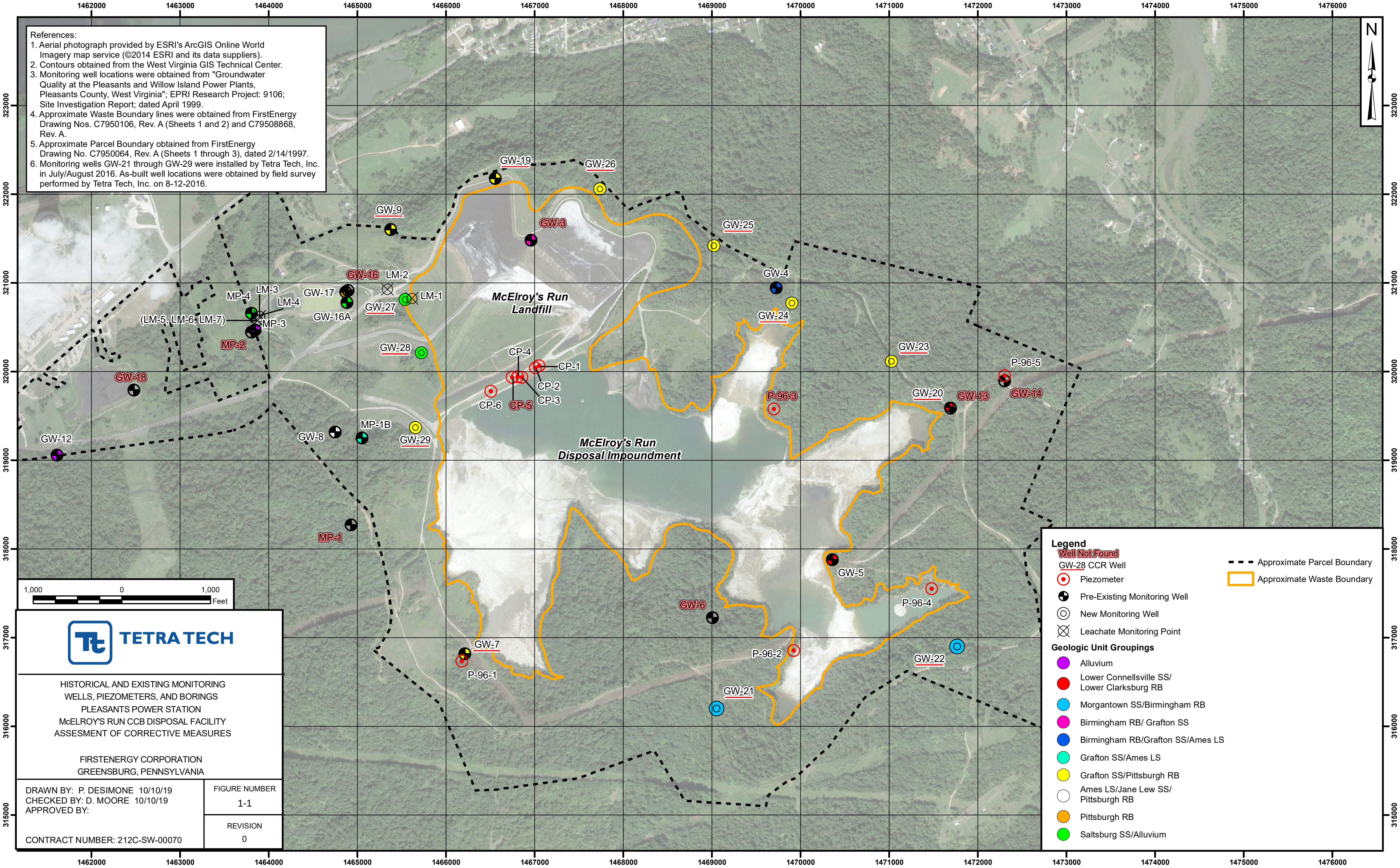
Table 6-1. Screening of Potential Corrective Measures Summary
CCR Rule ACM Report
FirstEnergy - Pleasants

	Potential Corrective Measures			
	Source Control	**Groundwater Extraction and Treatment**	**In-Situ Chemical Stabilization via Injeciton Wells**	**Monitored Natural Attenuation**
Evaluation Criteria [per 257.96(c)]	**Containment Using Final Cover System**			
Performance[1] [257.96(c)(1)]	Medium to High	Low	Low	Medium to High
Reliability[1] [257.96(c)(1)]	High	Medium to High	Low to Medium	Medium to High
Ease of Implementation[1] [257.96(c)(1)]	Medium to Low	Low	Low	Medium to High
Potential Impacts of Appropriate Remedies[1] - Safety [257.96(c)(1)]	Medium to High	Medium	Medium	Medium
Potential Impacts of Appropriate Remedies[1] - Cross-Media [257.96(c)(1)]	Low	Medium	Low to Medium	Low to Medium
Potential Impacts of Appropriate Remedies Control of Exposure to Residual Contamination[1] [257.96(c)(1)]	High	Medium	Medium to High	High
Time Required to Begin Remedy[2] [257.96(c)(2)]	Medium	Medium (~ 1 to 2 years)	Medium (~ 2 to 3 years)	Short
Time Required to Complete Remedy[2] [257.96(c)(2)]	Medium to Long (~5 to 10 years)	Currently Unknown	Currently Unknown	Long - Additional monitoring and wells would be necessary to confirm that the GWPS is not being exceeded.
Institutional Requirements (State and Local Permits and Other Approvals)[3] [257.96(c)(3)]	Minimal to Moderate	Moderate to Extensive	Moderate	Minimal

Notes:

1. Subjective ratings of "Low", "Medium", or "High" assigned based on how the potential corrective measures are anticipated to satisfy each evaluation criterion:
   Performance: Effectiveness in reducing arsenic concentrations in groundwater.
   Reliability: Effectiveness in consistently reducing arsenic concentrations in groundwater.
   Ease of Implementation: Ease in being installed to begin reducing arsenic concentrations in groundwater.
   Safty Impacts: Likelihood that illness, injury, or death directly related to the potential corrective measure would occur during construction or operations.
   Cross-Media Impacts: Likelihood that the potential corrective measure will result in a transfer of contaminants to the air, surface water, or soil, either from a direct discharge or from management of treatment residuals.
   Control of Exposure: Likelihood that that the potential corrective measure will result in exposure of contaminants to human or environmental receptors either from a direct discharge or from management of treatment residuals.
2. Subjective ratings of "Short", "Medium", or "Long" assigned with regard to the anticipated time for each potential corrective measure to reduce arsenic concentrations in groundwater, accounting for factors such as the complexity of the design, construction, and permitting efforts, as well as forecasting how efficient the technology is expected to be in
3. Subjective ratings of "Minimal", "Moderate", and "Extensive" assigned with regard to the anticipated level of effort that will be needed to obtain the permits/approvals which may be required by WVDEP or local authorities for each potential corrective measure.

FIGURES



References:
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4. Approximate Waste Boundary lines were obtained from FirstEnergy Drawing Nos. C7950106, Rev. A (Sheets 1 and 2) and C79508868, Rev. A.
5. Approximate Parcel Boundary obtained from FirstEnergy Drawing No. C7950064, Rev. A (Sheets 1 through 3), dated 2/14/1997.
6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

TETRA TECH

HISTORICAL AND EXISTING MONITORING
WELLS, PIEZOMETERS, AND BORINGS
PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY
ASSESMENT OF CORRECTIVE MEASURES

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 10/10/19
CHECKED BY: D. MOORE 10/10/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
1-1

REVISION
0

Legend

Well Not Found
GW-28 CCR Well
⊙ Piezometer
◐ Pre-Existing Monitoring Well
○ New Monitoring Well
⊗ Leachate Monitoring Point

- - - Approximate Parcel Boundary
▭ Approximate Waste Boundary

Geologic Unit Groupings
● Alluvium
● Lower Connellsville SS/ Lower Clarksburg RB
● Morgantown SS/Birmingham RB
● Birmingham RB/ Grafton SS
● Birmingham RB/Grafton SS/Ames LS
● Grafton SS/Ames LS
● Grafton SS/Pittsburgh RB
○ Ames LS/Jane Lew SS/ Pittsburgh RB
● Pittsburgh RB
● Saltsburg SS/Alluvium

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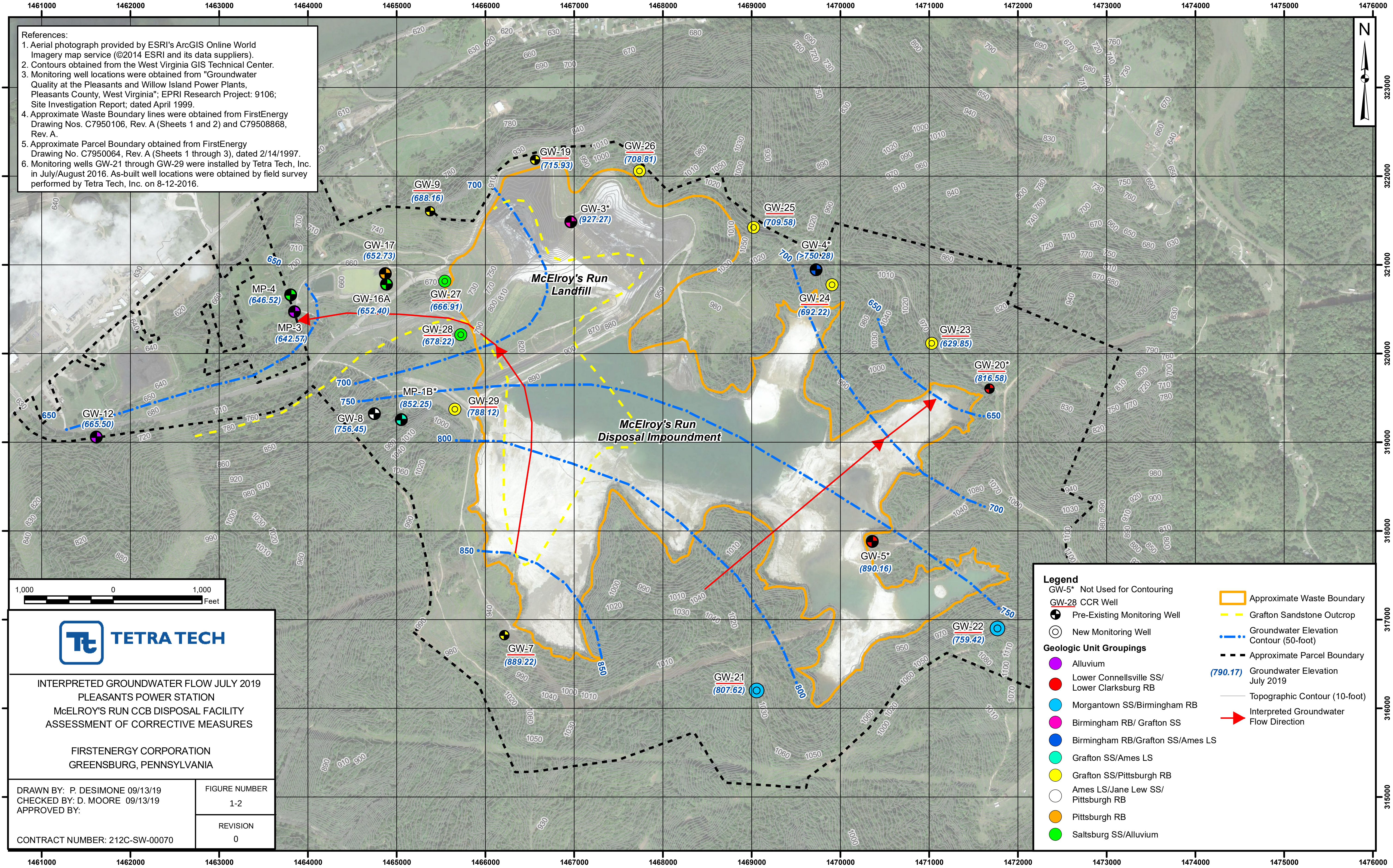

References:
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6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

Legend

GW-5* Not Used for Contouring
GW-28 CCR Well
Pre-Existing Monitoring Well
New Monitoring Well

Geologic Unit Groupings

- ● Alluvium
- ● Lower Connellsville SS/ Lower Clarksburg RB
- ● Morgantown SS/Birmingham RB
- ● Birmingham RB/ Grafton SS
- ● Birmingham RB/Grafton SS/Ames LS
- ● Grafton SS/Ames LS
- ● Grafton SS/Pittsburgh RB
- ○ Ames LS/Jane Lew SS/ Pittsburgh RB
- ● Pittsburgh RB
- ● Saltsburg SS/Alluvium

Approximate Waste Boundary
Grafton Sandstone Outcrop
Groundwater Elevation Contour (50-foot)
Approximate Parcel Boundary
(790.17) Groundwater Elevation July 2019
Topographic Contour (10-foot)
Interpreted Groundwater Flow Direction

TETRA TECH

INTERPRETED GROUNDWATER FLOW JULY 2019
PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY
ASSESSMENT OF CORRECTIVE MEASURES

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 09/13/19
CHECKED BY: D. MOORE 09/13/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
1-2

REVISION
0

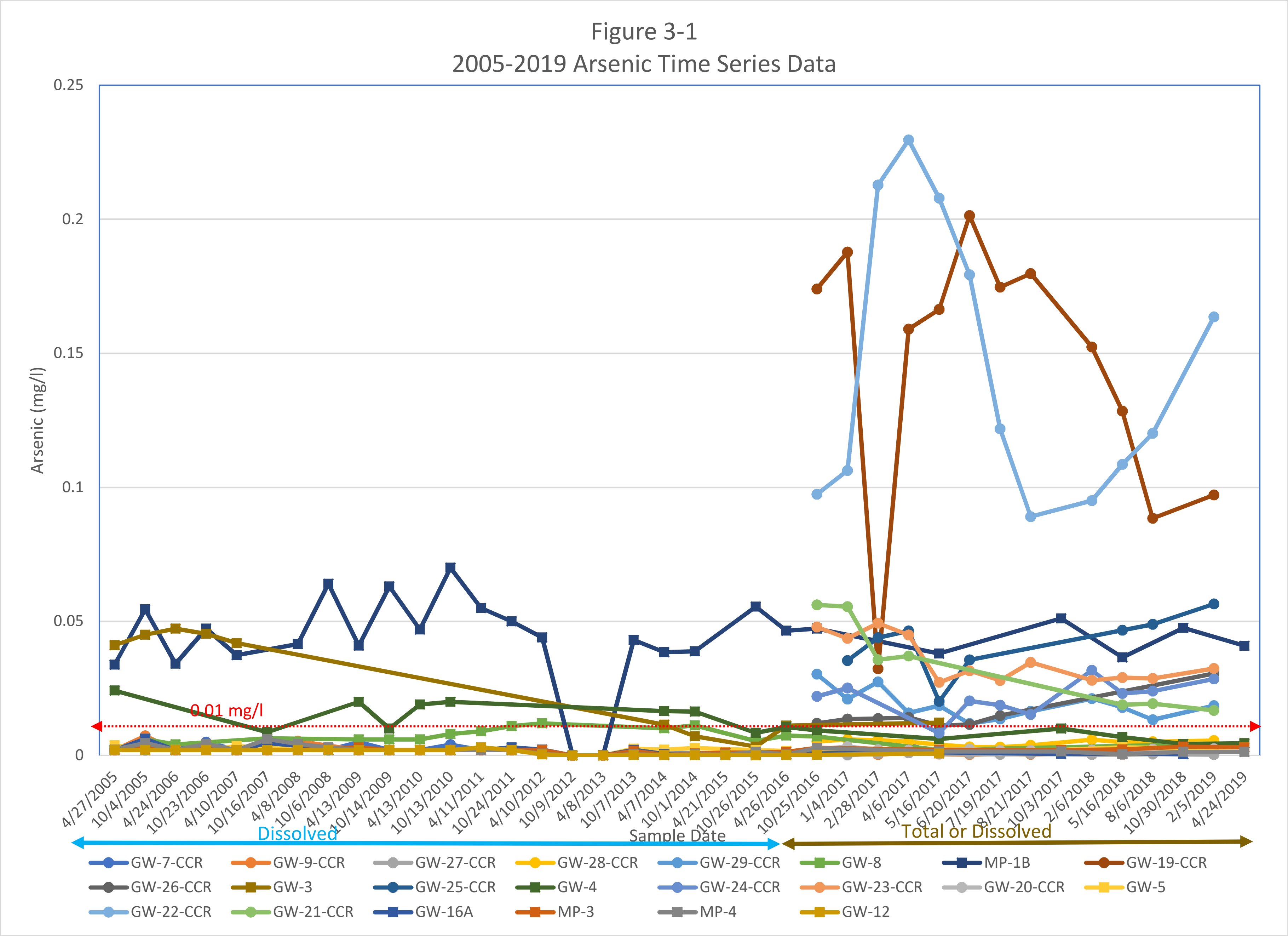

Figure 3-1

2005-2019 Arsenic Time Series Data

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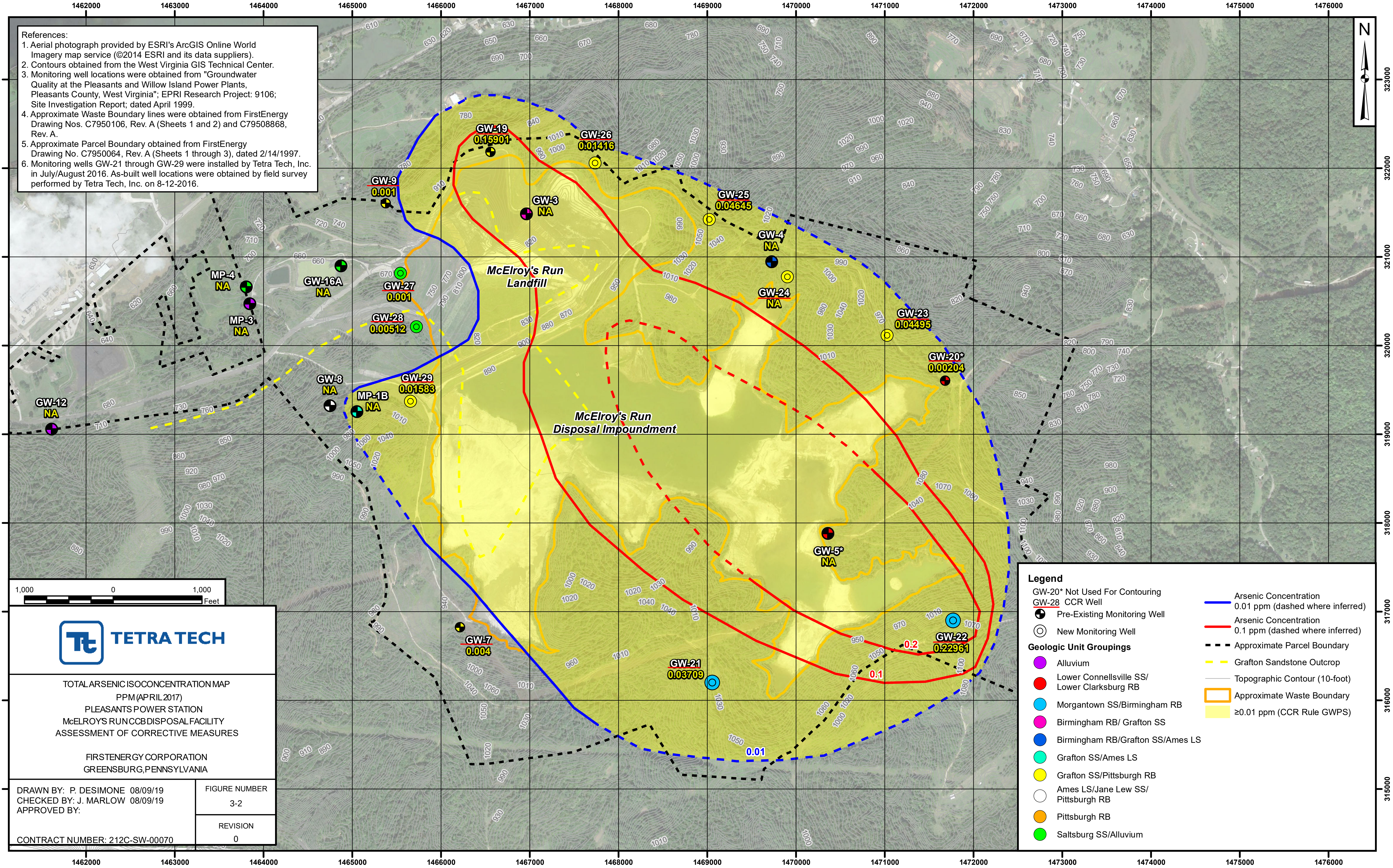

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6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

TETRA TECH

TOTAL ARSENIC ISOCONCENTRATION MAP
PPM (APRIL 2017)
PLEASANTS POWER STATION
McELROYS RUN CCB DISPOSAL FACILITY
ASSESSMENT OF CORRECTIVE MEASURES

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 08/09/19
CHECKED BY: J. MARLOW 08/09/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
3-2

REVISION
0

Legend

GW-20* Not Used For Contouring
GW-28 CCR Well
⊕ Pre-Existing Monitoring Well
◎ New Monitoring Well

Geologic Unit Groupings

- ● Alluvium
- ● Lower Connellsville SS/ Lower Clarksburg RB
- ● Morgantown SS/Birmingham RB
- ● Birmingham RB/ Grafton SS
- ● Birmingham RB/Grafton SS/Ames LS
- ● Grafton SS/Ames LS
- ● Grafton SS/Pittsburgh RB
- ○ Ames LS/Jane Lew SS/ Pittsburgh RB
- ● Pittsburgh RB
- ● Saltsburg SS/Alluvium

Arsenic Concentration 0.01 ppm (dashed where inferred)
Arsenic Concentration 0.1 ppm (dashed where inferred)
Approximate Parcel Boundary
Grafton Sandstone Outcrop
Topographic Contour (10-foot)
Approximate Waste Boundary
≥0.01 ppm (CCR Rule GWPS)

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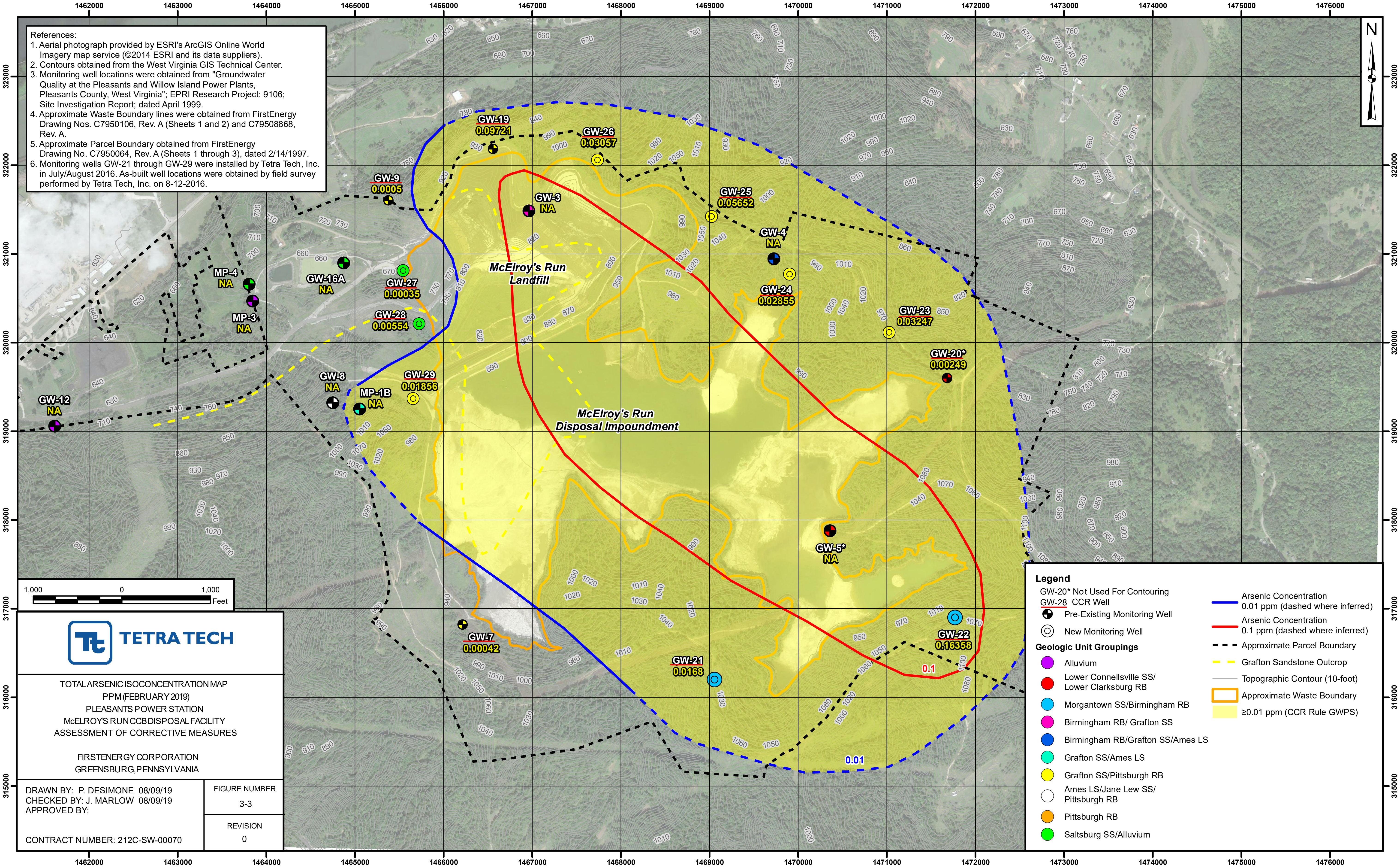

References:

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3. Monitoring well locations were obtained from "Groundwater Quality at the Pleasants and Willow Island Power Plants, Pleasants County, West Virginia"; EPRI Research Project: 9106; Site Investigation Report; dated April 1999.
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6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

Legend

GW-20* Not Used For Contouring
GW-28 CCR Well
⊕ Pre-Existing Monitoring Well
◎ New Monitoring Well

Geologic Unit Groupings

- ● Alluvium
- ● Lower Connellsville SS/ Lower Clarksburg RB
- ● Morgantown SS/Birmingham RB
- ● Birmingham RB/ Grafton SS
- ● Birmingham RB/Grafton SS/Ames LS
- ● Grafton SS/Ames LS
- ● Grafton SS/Pittsburgh RB
- ○ Ames LS/Jane Lew SS/ Pittsburgh RB
- ● Pittsburgh RB
- ● Saltsburg SS/Alluvium

— Arsenic Concentration 0.01 ppm (dashed where inferred)
— Arsenic Concentration 0.1 ppm (dashed where inferred)
- - - Approximate Parcel Boundary
- - - Grafton Sandstone Outcrop
— Topographic Contour (10-foot)
▭ Approximate Waste Boundary
▨ ≥0.01 ppm (CCR Rule GWPS)

TETRA TECH

TOTAL ARSENIC ISOCONCENTRATION MAP
PPM (FEBRUARY 2019)
PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY
ASSESSMENT OF CORRECTIVE MEASURES

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 08/09/19
CHECKED BY: J. MARLOW 08/09/19
APPROVED BY:

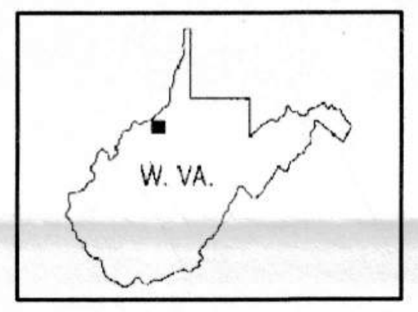
CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
3-3

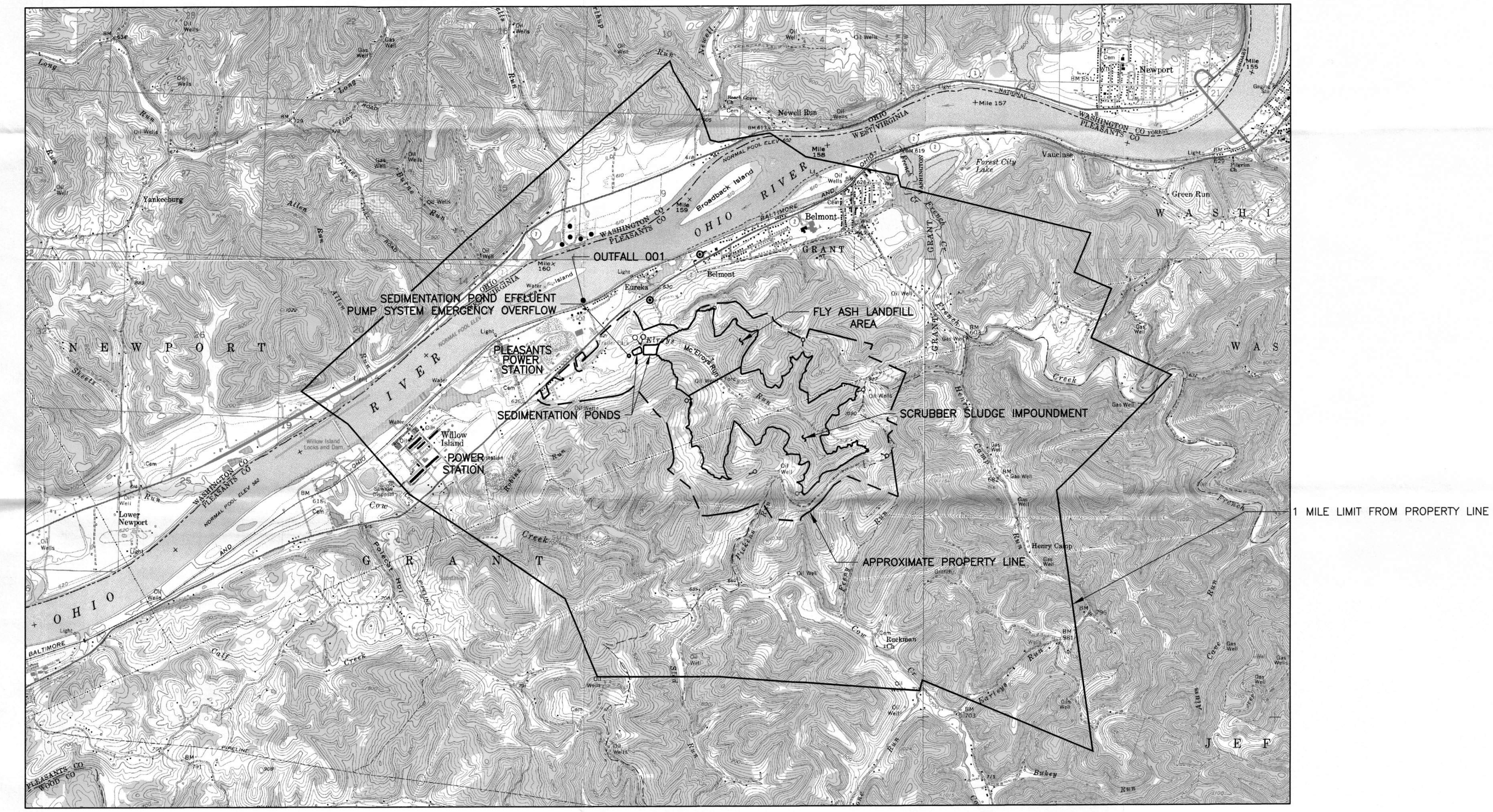
REVISION
0

TETRA TECH

FIGURE 4-1 (GROUNDWATER DRINKING WATER SUPPLY WELLS MAP)
PLEASANTS CCBDF - ASSESSMENT OF CORRECTIVE MEASURES



VICINITY MAP
N.T.S.



ONE MILE LIMIT MAP

SCALE 1"=2000'

SCALE: 1" = 2000'
2000' 0 2000' 4000'

LEGEND

— — —	PROPERTY LINE (APPROXIMATE)
⊙	APPROXIMATE LOCATION OF PRIVATE WATER WELL
♀	APPROXIMATE LOCATION OF SPRING

MAP REFERENCES:

U.S.G.S. 7.5 MINUTE SERIES (TOPOGRAPHIC)
BELMONT, WV–OH 1969, PHOTOREV. 1976
WILLOW ISLAND, WV–OH 1957, PHOTOREV. 1976
RAVEN ROCK, WV–OH 1961, PHOTOREV. 1989
SCHULTZ, WV 1961, PHOTOREV. 1975

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NO.	DATE	DWN	CHKD	APPVD	DESCRIPTION
B	1/10/2014	EJM	JLM	JMJ	UPDATED FOR 2014 PERMIT RENEWAL

REVISIONS

PLEASANTS POWER STATION
McELROY'S RUN DISPOSAL SITE
VICINITY MAP AND ONE MILE LIMIT MAP

ALLEGHENY ENERGY SUPPLY COMPANY, LLC
GREENSBURG, PENNSYLVANIA

GAI CONSULTANTS

DRAWN MAS
CHECKED
APPROVED
DATE 11/12/02
SCALE: AS SHOWN
DRAWING NUMBER C7950107
SHT. NO. 1 OF 1
REV B

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Pittsburgh, PA Orlando, FL • Boone, NC • Charleston, WV • Ft. Wayne, IN

GAI DWG.

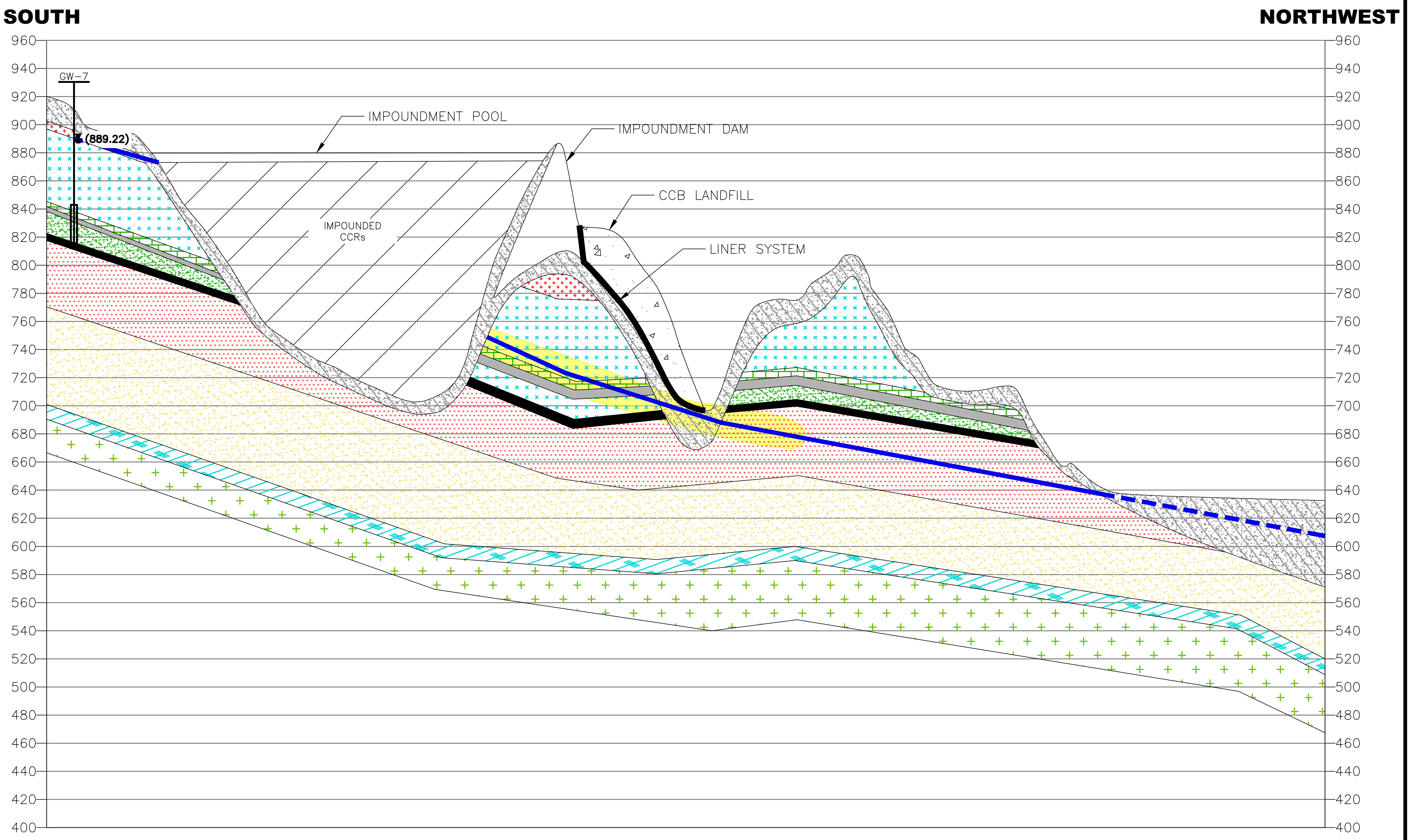
GAI CAD FILE: 99-170-E1001.DWG 1/4/02

NOTES

1. JULY 2019 GROUNDWATER ELEVATIONS SHOWN.

LEGEND

- ▬ UPPERMOST AQUIFER
- ▬ LANDFILL LINER SYSTEM
- 🟨 GWPS EXCEEDANCE FOR ARSENIC
- ☐ CCB LANDFILL
- ▨ ALLUVIUM
- ▦ GRAFTON SANDSTONE
- ▦ BIRMINGHAM RED BEDS
- 🟩 AMES LIMESTONE
- ■ HARLEM COAL
- ■ JANE LEW SANDSTONE
- ■ LOWER HARLEM COAL
- ▦ PITTSBURGH RE[redacted] BEDS
- ▦ SALTSBURG SANDSTONE
- ▨ CAMBRIDGE LIMESTONE
- ▦ BUFFALO SANDSTONE



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TETRA TECH

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661 ANDERSEN DRIVE - SUITE 200
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T: (412) 921-7090 | F: (412) 921-4040

FIRST ENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

PLEASANTS CCB LANDFILL ASSESSMENT OF CORRECTIVE MEASURES

PLEASANTS COUNTY, WEST VIRGINIA

CONCEPTUAL SITE MODEL (CSM) NORTHWEST FLOW PATH

NOT TO SCALE

DATE: 10/15/19
PROJECT NO.:212C-SW-00070
DESIGNED BY: DS
DRAWN BY: NN
CHECKED BY: DS

FIGURE 4-2

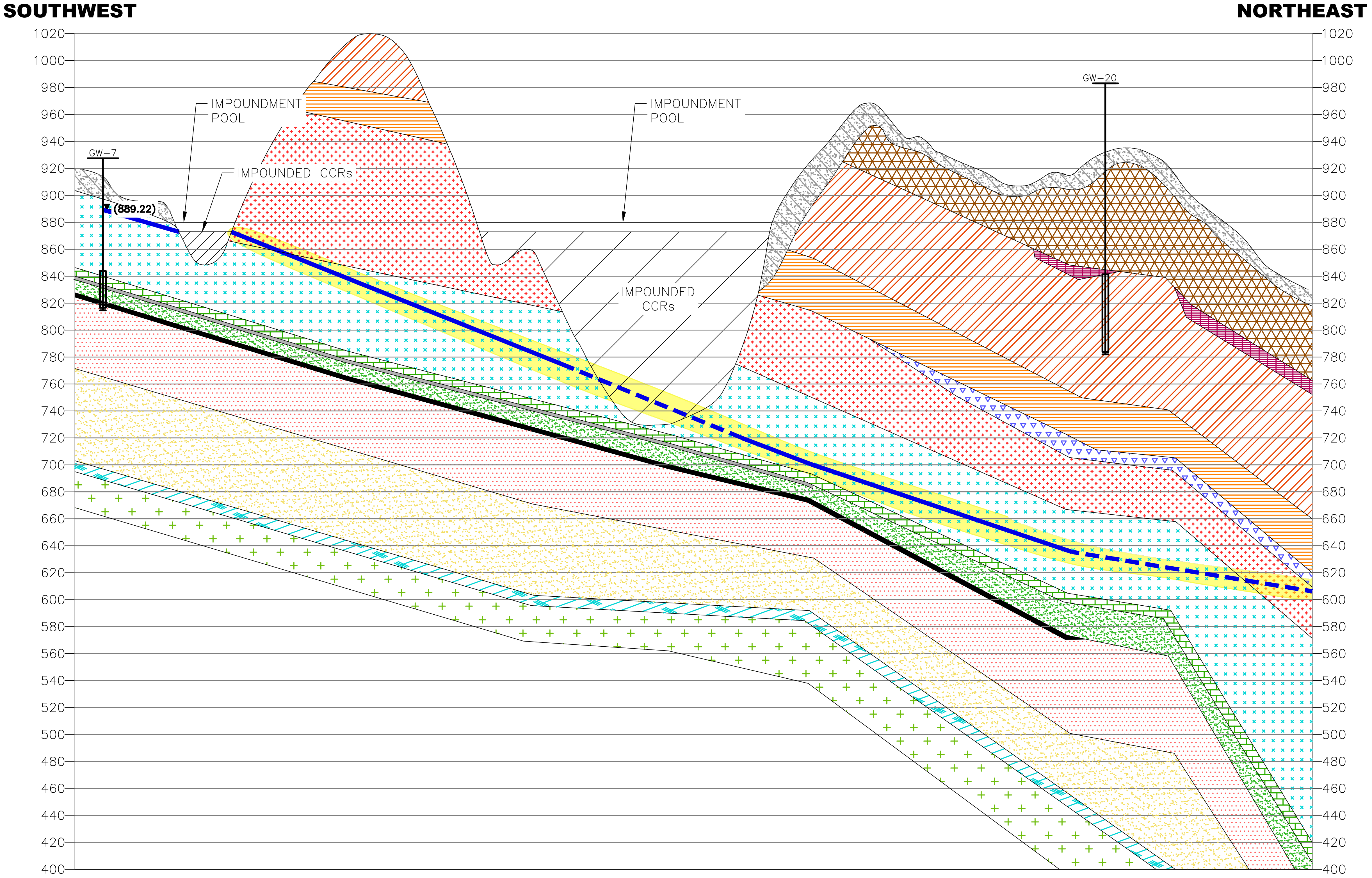
SHEET 1 OF 1

NOTES

1. JULY 2019 GROUNDWATER ELEVATIONS SHOWN.

LEGEND

- ▬ UPPERMOST AQUIFER
- 🟨 GWPS EXCEEDANCE FOR ARSENIC
- ▨ CLAYEY SILT TRACE ROCK FRAGMENTS
- ▨ LOWER CONNELLSVILLE SANDSTONE
- ▨ MONA LIMESTONE
- ▨ LOWER CLARKSBURG REDBED
- ▨ MORGANTOWN SANDSTONE
- ▨ ELK LICK LIMESTONE
- ▨ BIRMINGHAM RED BED
- ▨ GRAFTON SANDSTONE
- ▨ AMES LIMESTONE
- ■ HARLEM COAL
- ■ JANE LEW SANDSTONE
- ■ LOWER HARLEM COAL
- ▨ PITTSBURGH RE[redacted] BEDS
- ▨ SALTSBURG SANDSTONE
- ▨ CAMBRIDGE LIMESTONE
- ▨ BUFFALO SANDSTONE



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FIRST ENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

PLEASANTS CCB LANDFILL
ASSESSMENT OF CORRECTIVE MEASURES

PLEASANTS COUNTY, WEST VIRGINIA

CONCEPTUAL SITE MODEL (CSM)
NORTHEAST FLOW PATH

NOT TO SCALE

DATE:	10/15/19
PROJECT NO.:212C-SW-00070	
DESIGNED BY:	DS
DRAWN BY:	NN
CHECKED BY:	DS

FIGURE 4-3

SHEET 1 OF 1

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APPENDIX A

Appendix IV Alternative Source Demonstration Report – 2018/2019 Assessment Monitoring

CCR Rule Appendix IV Alternative Source Demonstration Report – 2018/2019 Assessment Monitoring

McElroy's Run Coal Combustion Byproduct Disposal Facility

Pleasants Power Station
Pleasants County, West Virginia

Prepared for:

FirstEnergy

800 Cabin Hill Drive
Greensburg, PA 15601

Prepared by:

Tetra Tech, Inc.

400 Penn Center Boulevard, Suite 200
Pittsburgh, PA 15235
Phone: (412) 829-3600
Fax: (412) 829-3260

Tetra Tech Project No. 212C-SW-00070

October 2019

CCR RULE APPENDIX IV ALTERNATIVE SOURCE DEMONSTRATION REPORT
2018/2019 ASSESSMENT MONITORING

McELROY'S RUN COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY

PLEASANTS POWER STATION
PLEASANTS COUNTY, WEST VIRGINIA

Prepared for:

FirstEnergy

800 Cabin Hill Drive
Greensburg, PA 15601

Prepared by:

Tetra Tech, Inc.
400 Penn Center Boulevard, Suite 200
Pittsburgh, PA 15235
Phone: (412) 829-3600
Fax: (412) 829-3260

Tetra Tech Project No. 212C-SW-00070

October 2019

TABLE OF CONTENTS

TABLES

FIGURES

ATTACHMENTS

1.0 INTRODUCTION/BACKGROUND

FirstEnergy (FE) owns and operates the coal-fired Pleasants Power Station (hereinafter referred to as the “Station”) located in Pleasants County, West Virginia. Coal Combustion Residuals (CCRs) produced at the Station are placed in the facility’s Coal Combustion Byproduct Disposal Facility (CCBDF or “CCR unit”), which is located approximately one mile east-southeast of the Station (see Figure 1). The facility consists of both a wet disposal area (impoundment) and dry disposal area (landfill) developed in the McElroy’s Run watershed. Taken together, the landfill and impoundment are regulated under West Virginia Department of Environmental Protection (WVDEP) Solid Waste/National Pollutant Discharge Elimination System (NPDES) Water Pollution Control Permit No. WV0079171, and the United States Environmental Protection Agency (USEPA) Disposal of Coal Combustion Residuals from Electric Utilities rule (40 CFR Part 257, hereinafter referred to as the “CCR Rule” or “Rule”). As per the CCR Rule, the landfill and impoundment are considered two separate, existing CCR units that share a common boundary (the impoundment dam). As provided by the CCR Rule, a multiunit groundwater monitoring system has been established for the CCBDF.

In accordance with § 257.94 of the Rule, the initial Detection Monitoring (DM) sampling and analysis event for the CCR unit was completed in October 2017, and the statistical evaluation of the resulting data was completed in January 2018. As required by § 257.90(e), the results and findings from the 2017 groundwater monitoring program were documented in the 2017 Annual Groundwater Monitoring and Corrective Action Report (AGWMCA Report) that was posted in both the CCR unit’s operating record and on its publicly accessible website in January 2018 (Tetra Tech, 2018). In that report, Statistically Significant Increases (SSIs) for boron, calcium, chloride, fluoride, pH, sulfate, and total dissolved solids (TDS) were determined in several downgradient monitoring wells. Based on the various parameters for which SSIs were identified, an Appendix III Alternative Source Demonstration (ASD) was undertaken as discussed in the 2018 AGWMCA Report (Tetra Tech, 2019). However, all of the Appendix III SSIs that were identified for DM-1 could not be attributed to alternative sources.

During the transition period between completing the statistical evaluation of the DM-1 data and performing the Appendix III ASD, FE performed another round of DM sampling (event DM-2) in order to have data available should the ASD prove to be successful and the facility remained in the DM program. DM-2 sampling occurred in February 2018, with laboratory analysis and data validation completed by April 2018. However, before statistical evaluation of the DM-2 data commenced, it was determined that a transition to Assessment Monitoring (AM) was required which precluded the need to statistically evaluate the DM-2 data. As such, a transition to the applicable requirements of AM per § 257.95 of the CCR Rule commenced.

In accordance with 40 CFR § 257.95(b) and (d)(1), two AM sampling events (AM-1 and AM-2) were performed in May and August 2018. Pursuant to §§ 257.94(e)(3), 257.105(h)(5), and 257.106(h)(4), a notice was posted to the facility's Operating Record and issued to the WVDEP in August 2018, to provide notification that a groundwater Assessment Monitoring program for the CCR unit had been established. Pursuant to § 257.107(h)(4), the subject notice was posted to the facility's publicly accessible website in September 2018. Analytical data summary tables and a description of the 2018 AM program results can be found in the 2018 AGWMCA Report (Tetra Tech, 2019). Once initiated, the AM program continued in 2019 with two additional sampling events performed in February (AM-3) and July (AM-4).

Statistical evaluation of the AM sampling events was completed in January 2019 for AM-1 and -2 and in August 2019 for AM-3 (validated AM-4 results were not available in time to be included in this report). The statistical evaluations indicated Appendix IV constituent concentrations in downgradient wells at Statistically Significant Levels (SSLs) above applicable Groundwater Protection Standards (GWPS). In accordance with 40 CFR § 257.106(h)(6), a notice was prepared and posted to the facility's Operating Record, issued to the WVDEP, and then posted on the facility's publicly accessible website in April 2019, to provide notification of the SSLs for arsenic, barium, fluoride, lithium, and radium at the CCR unit.

During this same notification period and in accordance with 40 CFR § 257.95(g)(3)(ii), an Appendix IV ASD was initiated to assess if the SSLs determined for the AM-1, AM-2, and AM-3 events were attributable to a release from the CCR unit, from a demonstrable alternative source(s), or if they resulted from errors in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. Pursuant to § 257.95(g)(4), if a successful ASD has not been completed within 90 days from the date of determining that an SSL has occurred, the CCR unit owner or operator must initiate an Assessment of Corrective Measures (ACM) in accordance with 40 CFR § 257.96. Due to the additional monitoring points, sampling events, laboratory analyses, and evaluations needed to complete a successful ASD, the work to complete the ASD had to be extended. Therefore, and in accordance with 40 CFR § 257.106(h)(7), a separate notice was prepared and posted to the facility's Operating Record, issued to the WVDEP, and then posted on the facility's publicly accessible website in April 2019, to provide notification of the initiation of the assessment of corrective measures for arsenic, barium, fluoride, lithium, and radium at the Site.

Subsequent to the above-referenced AM notifications, additional rounds of groundwater level data were collected and evaluated which resulted in a modified interpretation of current groundwater flow patterns along the northern boundary of the Site than were described in the *CCR Rule Groundwater Monitoring System Evaluation Report for the Pleasants Power Station* (Tetra Tech, 2017). In the subject report there were two, separate upgradient/background wells identified for the western and northern boundaries of the CCR unit. The current understanding of groundwater flow based on the additional rounds of groundwater level measurements is such that one upgradient well, GW-7, is now considered the upgradient/background well for both the western and northern boundaries of the CCR unit (Figure 2). This change in groundwater flow pattern is likely attributable to the low permeability of the formation and long stabilization period required for the wells installed along the northern boundary. As such, the AM statistical evaluations that have recently been conducted have incorporated upper prediction limits (UPLs) associated with GW-7 for both boundaries.

The table shown on the following page summarizes the results of the statistical evaluation of the CCR Rule Appendix IV parameters based upon utilizing the updated groundwater flow interpretation (i.e., utilizing the GW-7 UPL for comparison with downgradient constituent concentrations) and lists which wells (labeled “GW-#”) have parameters that were determined to be above their GWPS. The revised statistical evaluation based on the updated understanding of groundwater flow patterns determined that arsenic SSLs occurred in more wells than previously indicated (due to the lower arsenic GWPS for MW-7), but that fluoride was no longer an SSL in the single well it was previously found in (GW-20) due to the higher fluoride GWPS for MW-7. As such, fluoride is no longer considered an SSL and was not evaluated in this ASD. A detailed discussion of the revised interpretation of groundwater flow patterns at the site and the associated impacts on statistical evaluations of AM data will be provided in the forthcoming 2019 AGMCA Report that will be issued in January 2020.

After initiating the ACM in April 2019, the ongoing ASD activities were continued as they indicated a strong possibility that the barium, lithium, and radium SSLs were attributable to demonstrable alternative source(s). As such, this ASD report has been prepared to document the evaluation of the AM-1, -2, and -3 Appendix IV SSLs and to incorporate the findings into the CCR unit’s ACM.

	Northern Boundary (Upgradient Well GW-7)					Western Boundary (Upgradient Well GW-7)
Appendix IV Parameters [GWPS]	**GW-19**	**GW-23**	**GW-24**	**GW-25**	**GW-26**	**GW-29**
Arsenic (As) [0.01 mg/L]	**SSL**	**SSL**	**SSL**	**SSL**	**SSL**	**SSL**
AM-1	0.1285	0.0290	0.0231	0.0467	n/s	0.0179
AM-2	0.0885	0.0288	0.0240	0.0489	n/s	0.0134
AM-3	0.0972	0.0325	0.0286	0.0565	0.0306	0.0186
Barium (Ba) [2 mg/L]		**SSL**	**SSL**	**SSL**	**SSL**	
AM-1	<GWPS	10.41	8.53	6.69	n/s	<GWPS
AM-2	<GWPS	10.51	10.28	7.03	n/s	<GWPS
AM-3	<GWPS	9.76	9.25	7.63	0.53473	<GWPS
Lithium (Li) [0.04 mg/L]		**SSL**	**SSL**			
AM-1	<GWPS	0.1054	<GWPS	<GWPS	n/s	<GWPS
AM-2	<GWPS	0.1131	<GWPS	<GWPS	n/s	<GWPS
AM-3	<GWPS	0.1502	0.0451	<GWPS	<GWPS	<GWPS
Radium (Ra 226 + 228) [5 pCi/L]		**SSL**	**SSL**	**SSL**		
AM-1	<GWPS	86.5	49.3	24.2	n/s	<GWPS
AM-2	<GWPS	85.6	38.8	28.4	n/s	<GWPS
AM-3	<GWPS	83.4	46.1	30.5	<GWPS	<GWPS

Note: Downgradient well GW-26 was not sampled (n/s) during the AM-1 and AM-2 events due to insufficient available water.

2.0 APPROACH

For this ASD, a multiple Line of Evidence (LOE) approach as presented in *Guidance for Development of Alternative Source Demonstrations at Coal Combustion Residual Sites* (EPRI, 2017) was followed. This approach divides LOEs into five separate ASD categories (types):

- Sampling causes (ASD Type I);
- Laboratory causes (ASD Type II);
- Statistical evaluation causes (ASD Type III);
- Natural variation not accounted for in the basic DM statistics (ASD Type IV); and
- Potential natural or anthropogenic sources (ASD Type V).

EPRI (2017) includes detailed checklists that provide a standardized, incremental approach that is followed to determine whether additional LOE evaluations are warranted or not. These checklists include:

- Checklist 1: Sampling, Laboratory, or Statistical Causes (ASD Types I, II, and III);
- Checklist 2: LOEs Associated with the CCR Unit (ASD Type IV); and
- Checklist 3: LOEs Associated with Alternative Natural or Anthropogenic Sources (ASD Type V).

For this ASD all three Checklists were completed and are attached as Tables 1, 2, and 3. Based on indications from these checklists as well as the CCR unit's topographic and geologic setting, development and operational history, and currently available information and data, it was determined that additional evaluations of the following site-specific LOEs were warranted:

- Regional groundwater chemistry studies/reports; and
- Potential existing and historic oil and/or gas production well effects.

The findings from the checklist completion activities and site-specific LOE evaluations are summarized in Section 3.0.

3.0 SUMMARY OF FINDINGS

3.1 ASD CHECKLIST 1

ASD Checklist 1 is attached as Table 1 of this report. The checklist evaluations were performed by re-reviewing the CCR groundwater monitoring program's field sampling notes and chain-of-custody forms, laboratory data validation (Level 2) reports, statistical evaluation spreadsheets, and results from field-filtered duplicate samples that were obtained during events where turbid unfiltered samples had been obtained. As indicated in Table 1, for many potential sampling, laboratory, or statistical evaluation causes, no instances/issues/indications were identified. Sample contamination with petroleum and/or brine from on-site oil and gas exploration and production activities could be a contributing factor for the SSIs and SSLs for barium, lithium, and radium in GW-23, -24, and -25 (as discussed in Section 3.5 of this report, barium, lithium, and radium have been documented as being associated with oil and gas well brines). For other potential causes where some issues were identified, it was determined that they most likely did not contribute to the Appendix IV SSLs.

Based on these LOE findings, laboratory analysis and statistical evaluations are not demonstrable alternative sources of all the Appendix IV SSLs determined for the AM-1, -2, and -3 events, while sample turbidity and contamination are potential sources of the SSIs and SSLs determined for barium, lithium, and radium in some of the downgradient monitoring wells.

3.2 ASD CHECKLIST 2

ASD Checklist 2 is attached as Table 2 of this report. The checklist evaluations were performed by re-reviewing the groundwater analytical results (background, DM, and AM) for both Appendix III and IV parameters, leachate data for the CCR unit (specifically for arsenic, barium, lithium, and radium) provided by FE, and hydrogeologic and design information and data included in *CCR Rule Groundwater Monitoring System Evaluation Report for the Pleasants Power Station* (Tetra Tech, 2017). For the LOEs in Checklist 2, the following evaluation criteria were used:

- Primary Indicators – As per Table A-1 in EPRI (2017), primary indicator constituents for CCRs include the CCR Rule parameters Boron (Appendix III), Calcium (Appendix III), Chloride (Appendix III), Fluoride (Appendix III and IV), Lithium (Appendix IV), Molybdenum (Appendix IV), and Sulfate (Appendix III), as well as Bromide, Potassium, and Sodium, which are parameters that are not listed in the CCR Rule.

- Secondary Indicators – For this ASD, secondary indicator constituents for CCRs include those Appendix III and IV constituents that are not considered primary indicators.
- Leachate Data – Analytical results from five leachate sampling events performed at the CCR unit between October 2017 and July 2019 at three locations (LM1, LM5, and LM7) were used for comparison to the February 2019 AM-3 groundwater results, as shown in Table 4. The comparison of data for barium and radium indicates that barium is found at higher concentrations in groundwater in both the upgradient well and in all the downgradient wells than in leachate, whereas radium is found at higher concentrations in only the downgradient wells than in leachate, indicating a localized, non-CCR source exists along the northern boundary of the CCR unit. Alternatively, concentrations of arsenic and lithium in the leachate samples are several times higher than those of the upgradient well and the downgradient wells, indicating that the arsenic and lithium SSLs in groundwater are likely attributable to a release from the CCR unit.
- Site Hydrogeology - As discussed in the *CCR Rule Groundwater Monitoring System Evaluation Report* (Tetra Tech, 2017), groundwater in the CCBDF area occurs primarily within the fractured bedrock of multiple Conemaugh Group sandstone units including the Morgantown, Grafton, Jane Lew, and Saltsburg, which have been collectively identified as the uppermost aquifer for CCR Rule groundwater monitoring for the combined landfill and impoundment units. The CCR groundwater monitoring well network at the site is shown on Figure 1 and consists of three upgradient (background) wells (GW-7, -21, and -22), six downgradient wells to monitor the northern side of the combined CCR units (GW-19, -20, -23, -24, -25, and -26), and four downgradient wells to monitor the western side of the combined CCR units (GW-9, -27, -28, and -29). Historic and recent groundwater level data indicate groundwater flow at the site as flowing north from the topographically higher areas located to the south and southeast of the impoundment. Groundwater flow northwest of the dam and under the landfill is in the downstream direction of McElroy's Run toward the west. Flow in all of the rock units exhibit little seasonal and temporal fluctuations.

  Having sufficient recoverable volumes of groundwater from one of the upgradient (GW-21) and three of the downgradient wells (GW-23, -24, and -25) was found to be problematic during both the background and initial DM sampling events. These four wells were noted to have low to very low yields during their installation and development which was anticipated given that historical well borings drilled at the site under the WVDEP groundwater monitoring program were abandoned over time due to a lack of water in the same rock units. During the initial DM sampling event, sufficient recoverable groundwater volumes were found to be available in GW-23 and -24 but not in GW-21, -25, or in an additional downgradient well, GW-26. Geologic and hydrogeologic characteristics of the site, the monitoring well network, and the initial DM results are discussed in greater detail in both Tetra Tech 2017 and 2018.

It was originally intended that upgradient wells GW-21 and GW-22, which are both screened in the Morgantown sandstone, would be grouped for statistical evaluation purposes. However, after both the background and the initial DM sampling events were completed, it was determined that the two wells did not have the level of statistical similarity needed for grouping and that the availability of sufficient volumes of recoverable water was a recurring problem for GW-21. As such, it was decided that only GW-22 would be used to establish background chemistry for the northern side of the CCR units since it exhibited lower concentrations of all the Appendix III parameters than those measured in GW-21 and it also provided a reliable water yield while GW-21 did not. GW-21 was left in place (i.e., it was not abandoned) and it has been sampled when sufficient volumes of recoverable water were available. GW-21's water levels have also continued to be used to verify groundwater flow patterns at the site. FE intends is to keep GW-21 as a part of the CCR monitoring network until a sufficiently-sized data set can be compiled and used to determine whether or not it's statistically appropriate to group its results with the data set for GW-22. As discussed in Section 1.0, recent groundwater elevation measurements and mapping of the potentiometric surface indicate that GW-7, instead of a combination of GW-7 and GW-22 for the western and northern boundaries, respectively, acts as the upgradient well for the CCR network for both the western and northern boundary CCR wells as shown on Figure 2.

- CCR Unit Design - As shown on Figure 1, the CCR unit consists of two conterminous disposal areas, an impoundment and a landfill, that share a common boundary (the impoundment dam). The majority of the CCR material that has been disposed of at the site is managed in an unlined impoundment formed by a dam constructed across McElroy's Run. The dam was constructed with a clay-filled cutoff trench at the upstream toe and a clay blanket on the upstream face to function as a low permeability barrier. The downstream portion of the dam was constructed using compacted fly ash and periodic layers of bottom ash for blanket drains connected to sloping chimney drains that collect seepage to discharge pipes for monitoring. The downstream face of the dam is covered by the landfill facility which WVDEP considers to be a buttress to the dam.

The landfill consists of three primary development stages which are further subdivided into construction subareas. At this time, development and disposal operations have only been performed in Stages 1 and 2 and the Stage 3 area remains undeveloped. Up until 2009 all of the landfill subareas were constructed with a compacted clay liner system that included an underlying combined groundwater underdrain/leak detection system and an overlying leachate collection system. Since 2009 a composite geosynthetic liner system (geosynthetic clay liner and geomembrane) has been utilized which also includes an underlying combined groundwater underdrain/leak detection system and an overlying leachate collection system. For all portions of the landfill that overlie the downstream face of the impoundment dam, a bottom ash blanket drain layer has also been utilized. Leachate and contact stormwater runoff from the landfill disposal areas are managed in Sedimentation Pond Nos. 1 and 2, which are lined impoundments located immediately down-valley of the future Stage 3 landfill development area. These impoundments also accept flows from the groundwater underdrain/leak detection zones and stormwater runoff from portions of the landfill's South Haul Road. Discharges from Sedimentation Pond Nos. 1 and 2 are pumped up to the CCR disposal impoundment and, ultimately, routed through the impoundment's dewatering system.

Based on the various LOE findings presented in Table 2, arsenic and possibly lithium SSLs determined for the AM-1, -2, and -3 events can most likely be attributed to a release from the CCR unit. However, the comparison of leachate data to upgradient and downgradient wells indicates that a source other than the CCR unit may be contributing to the occurrence of barium and radium in groundwater.

3.3 ASD CHECKLIST 3

ASD Checklist 3 is attached as Table 3 of this report. The checklist evaluations were performed similar to those of ASD Checklist 2 by re-reviewing the groundwater analytical results (background, DM, and AM) for both Appendix III and IV parameters, leachate data for the CCR unit (specifically for barium, lithium, and radium) provided by FE, and hydrogeologic and design information and data included in *CCR Rule Groundwater Monitoring System Evaluation Report for The Pleasants Power Station* (Tetra Tech, 2017). For the LOEs in Checklist 3, the following evaluation criteria were used in addition to those used for ASD Checklist 2:

- Results of AM/Nature and Extent of Release (N&E) groundwater sampling conducted in February and July 2019 indicate that an alternate source of barium, lithium, and radium appears to exist along the northern boundary as shown on Figures 3, 4, and 5, respectively. Isoconcentration contour lines located around these northern boundary wells indicate a localized source of all three parameters in this area. Historical and current oil and gas exploration and production activities have occurred in this area and are documented sources of barium, radium, and lithium that could be the source of the SSLs in the northern boundary wells. These results and associated comparisons are discussed in greater detail in Section 3.5 of this report.
- Review of site-wide boring logs for observations of potential oil and gas well impacts to groundwater during previous investigations identified several wells in which oil and gas impacts were noted. Observations of petroleum/hydrocarbon odor, sheen, and/or crude oil product were noted for the following wells at the time of their installation (copies of the relevant pages from each log are included as Attachment A of this report):
    - GW-3 – light hydrocarbon odor
    - GW-4 – oil odor
    - GW-5 – oil odor and sheen
    - GW-6 – black crude in rock cuttings
    - GW-7 – hydrocarbon odor, black crude in rock cuttings
    - P-96-4 – oil odor
    - P-96-5 – crude oil odor
    - N-3 – oil odor
    - GW-13 – crude oil in sandstone, visual staining
    - GW-15 – 0.32 feet of crude oil-fingerprinted product
    - GW-19 – crude oil odor
    - GW-24 – petroleum hydrocarbon odor
    - GW-25 – petroleum hydrocarbon odor

Based on the LOE findings presented in Table 3 and the discussion above, the barium, radium, and lithium SSLs determined for the AM-1, -2, and -3 events can most likely be attributed to historical and current oil and gas exploration and production activities. While lithium has also been shown to be a component of oil and gas well brine, the relatively high concentrations of lithium in the leachate is an indication that the CCR unit may be the source of the lithium SSLs.

3.4 REGIONAL GROUNDWATER STUDY

In an effort to evaluate the natural variation in groundwater quality in the various water producing units of the Conemaugh Group (e.g., Morgantown, Grafton, Jane Lew, and Saltsburg sandstones) which comprise the CCR Rule uppermost aquifer, *Ground-Water Hydrology of the Minor Tributary Basins of the Ohio River, West Virginia* (USGS, 1984) was reviewed. The report review did not yield any specific information regarding natural variation of arsenic, barium, lithium, or radium in regional groundwater. However, the following table presents the range and mean concentrations reported for Appendix III constituents with SSIs in the Conemaugh Group wells which can be compared with CCR unit well data that point to oil and gas exploration activities as an alternative source:

	Dissolved Chloride (mg/L)	Dissolved Sulfate (mg/L)	TDS (mg/L)
No. of Wells	6	6	6
Range	2.6 - 130	10 - 88	241 - 589
Mean	31	37	371

Based on these reported values, the following observations were made:

- **Chloride -** The reported mean concentration of 31 mg/L is below the UPL for upgradient well GW-7 (104 mg/L), and the reported maximum concentration of 130 mg/L is slightly higher than the GW-7 UPL. With respect to downgradient wells along the northern boundary with Appendix IV SSLs, the reported maximum chloride concentration of 130 mg/L is well below the concentrations of chloride in GW-23 (12,900 mg/L), GW-24 (8,520 mg/L), and GW-25 (7,110 mg/L).
- **Sulfate** – Sulfate concentrations tend to have an inverse relationship with other parameters typically present in groundwater impacted by oil and gas activities. Accordingly, the reported minimum concentration of 10 mg/L is significantly higher than both the GW-7 UPL of 0.5 mg/L and the sulfate concentrations in downgradient wellsGW-23 (0.2664 mg/L), GW-24 (<0.0386 mg/L), and GW-25 (0.618 mg/L).
- **TDS** – The reported mean concentration of 371 mg/L is well below the UPL for GW-7 (1,260 mg/L). The reported maximum TDS concentration of 589 mg/L is also well below

the GW-7 UPL. With respect to downgradient wells with Appendix IV SSLs, the reported maximum TDS concentration of 589 mg/L is well below the concentrations of TDS for GW-23 (68,500 mg/L), GW-24 (42,400 mg/L), and GW-25 (35,900).

The comparisons noted above indicate that upgradient chloride and TDS concentrations (all indicators of oil and gas brine) at the site appear to be higher than the concentrations measured in regional Conemaugh Group groundwater during the USGS study period, while upgradient sulfate concentrations appear to be within the range of or below the concentrations measured in the study. However, comparing the maximum reported study results to the results for the corresponding downgradient wells with Appendix IV SSL concentrations indicates that all of the wells exhibit chloride and TDS concentrations that are higher to much higher than those for regional groundwater. Reduced sulfate, elevated chloride and, to a lesser extent, elevated TDS concentrations are typically observed with oil and gas exploration and production activities as discussed in the following section.

3.5 POTENTIAL FOR OIL AND GAS WELL IMPACTS

In an effort to evaluate the potential for oil and gas well development on and near the site to have impacted groundwater for the SSL constituents, particularly barium, lithium, and radium, and to substantiate the results of Checklist 3, several lines of evidence related to oil and gas impacts were evaluated including a review of nearby oil and gas wells and their completion records, historical research related to oil and gas exploration activities near the site, research related to the occurrence of the site's SSL constituents in oil and gas activities, and historical investigations and studies performed at the site regarding oil and gas impacts.

3.5.1 Nearby Oil and Gas Well Locations and Completion Information

The locations of oil and gas wells and basic information on the wells (e.g., total depth, date drilled, status, etc.) were obtained from the West Virginia Geologic and Economic Survey (WVGES) online oil and gas well database (http://ims.wvgs.wvnet.edu/WVOG/viewer.htm). Figure 6 presents the locations of these wells relative to the CCR monitoring well network and includes field observations of existing on-site oil and gas wells and associated infrastructure as well as groundwater sampling field notes that indicate oil and gas well-related impacts (e.g., sheen, odor, free product). A total of more than 100 existing or plugged/abandoned oil and gas wells were identified as shown on Figure 6. The table below summarizes key information for these wells obtained from the online database records:

API #	Completion Year	Well Type	Operator	Total Depth (ft)	Deepest Formation
4707300005		Oil	Oper in Min.owner fld,no code assgn(Orphan well proj)	1052	Undiff Price below Big Injun
4707300008		Oil	Oper in Min.owner fld,no code assgn(Orphan well proj)	512	Undetermined unit
4707300043	1935	Dry w/ Oil Show	All In One Producing & Refining Co., The	71	Big Injun (Price & equivs)
4707300069	1936	Oil w/ Gas Show	Feeney Oil & Gas	1600	Squaw
4707300069	1941	Dry w/ O&G Show	Feeney Oil & Gas	3379	Berea Sandstone
4707300073		Dry	Love, C. E.	1903	
4707300124	1939	Oil w/ Gas Show	Columbian Carbon Co.	5311	Oriskany Sandstone
4707300170	1940	Oil w/ Gas Show	Columbian Carbon Co.	2280	Up Devonian undiff:Berea to Lo Huron
4707300179	1940	Dry w/ Gas Show	Columbian Carbon Co.	2930	Berea Sandstone
4707300183	1940	Dry	Columbian Carbon Co.	2930	Berea Sandstone
4707300192	1941	Dry w/ Oil Show	Faith Oil Co.	430	Buffalo Ss (Lit Dunkard)/1st Cow Run
4707300578	1959	Dry w/ O&G Show	Smellie & Myers	2527	Up Devonian undiff:Berea to Lo Huron
4707300588	1960	Dry	Daugherty, John	1217	Maxton
4707300611	1962	Dry w/ O&G Show	Quaker State Oil Refining Co.	1727	Berea Sandstone
4707300646	1968	Dry	Holton, Harry A.	5684	Salina
4707300682	1974	Gas	McDuff, Inc.	3297	Up Devonian undiff:Berea to Lo Huron
4707300684	1974	Gas	McDuff, Inc.	3179	Up Devonian undiff:Berea to Lo Huron
4707300913	1980	Oil and Gas	Haught, Inc.	3911	Lower Huron (undifferentiated)
4707300914	1980	Oil and Gas	Haught, Inc.	4011	Lower Huron (undifferentiated)
4707300915	1980	Oil and Gas	Haught, Inc.	4286	Lower Huron (undifferentiated)
4707300975	1980	Oil and Gas	Prior, Ferrell L.	3906	Java Formation
4707300976	1980	Oil and Gas	Prior, Ferrell L.	3646	Java Formation
4707300976	1989	Gas w/ Oil Show	Dupke, Roger	3646	Lower Huron (undifferentiated)
4707300996	1980	Oil and Gas	Prior, Ferrell L.	4129	Java Formation
4707301025	1980	Oil and Gas	Prior, Ferrell L.	3100	Lower Huron (undifferentiated)
4707301026	1981	Oil and Gas	Prior, Ferrell L.	3557	Lower Huron (undifferentiated)
4707301033	1980	Oil and Gas	Haught, Inc.	3990	Angola Formation
4707301087	1981	Oil and Gas	Prior, Ferrell L.	4050	Java Formation
4707301368	1981	Gas	Shafer Oil & Gas Corp.	4350	Rhinestreet Shale
4707301594	1983	Gas w/ Oil Show	Jenkins Energy Corp. & H. Davis Jenkins	4761	Rhinestreet Shale
4707301595	1983	Gas w/ Oil Show	Jenkins Energy Corp. & H. Davis Jenkins	4940	Rhinestreet Shale
4707301595	2011	not available	Ritchie Petroleum Corp., Inc.		
4707301596	1983	Gas w/ Oil Show	Jenkins Energy Corp. & H. Davis Jenkins	4769	Rhinestreet Shale

API #	Completion Year	Well Type	Operator	Total Depth (ft)	Deepest Formation
4707301597	1984	Dry w/ O&G Show	Stalnaker, Gene, Inc.	5059	Angola Formation
4707301604	1983	Oil and Gas	Jenkins Energy Corp. & H. Davis Jenkins	2038	Up Devonian undiff:Berea to Lo Huron
4707301630	1983	Dry w/ O&G Show	Stalnaker, Gene, Inc.	5050	Rhinestreet Shale
4707301635	1983	Dry w/ O&G Show	Stalnaker, Gene, Inc.	5060	Middlesex Shale
4707302514	2009	Gas w/ Oil Show	Patchwork Oil & Gas, LLC	2514	Up Devonian undiff:Berea to Lo Huron
4707302514	2009	Dry w/ Oil Show	Patchwork Oil & Gas, LLC	2125	Up Devonian undiff:Berea to Lo Huron
4707330089		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330090		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330113		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330115		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330127		not available	Faith Oil Co.		
4707330196		not available	Delong, J. R.		
4707330250		Oil and Gas	Oper in Min.owner fld,no code assgn(Orphan well proj)	884	Big Injun (undifferentiated)
4707330251		Oil and Gas	Oper in Min.owner fld,no code assgn(Orphan well proj)	820	Maxton
4707330258		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330270		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330271		not available	Oper in Min.owner fld,no code assgn(Orphan well proj)		
4707330593		not available	Dinsmoor & Co.		
4707330596		not available	Dinsmoor & Co.		
4707330597		not available	Dinsmoor & Co.		
4707330831		not available	Daugherty, John		
4707330885		not available	Daugherty, John		
4707331095		not available	WV Department of Mines, Oil & Gas Division		
4707331114		not available	Monongahela Power Company		
4707331115		not available	Monongahela Power Company		
4707331116		not available	Monongahela Power Company		
4707331117		not available	Monongahela Power Company		
4707331118		not available	Monongahela Power Company		
4707331119		not available	Monongahela Power Company		
4707331120		not available	Monongahela Power Company		
4707331121		not available	Monongahela Power Company		
4707331122		not available	Monongahela Power Company		
4707331123		not available	Monongahela Power Company		
4707331124		not available	Monongahela Power Company		

API #	Completion Year	Well Type	Operator	Total Depth (ft)	Deepest Formation
4707331125		not available	Monongahela Power Company		
4707331126		not available	Monongahela Power Company		
4707331127		not available	Monongahela Power Company		
4707331128		not available	Monongahela Power Company		
4707331129		not available	Monongahela Power Company		
4707331130		not available	Monongahela Power Company		
4707331131		not available	Monongahela Power Company		
4707331132		not available	Monongahela Power Company		
4707331133		not available	Monongahela Power Company		
4707331135		not available	Monongahela Power Company		
4707331136		not available	Monongahela Power Company		
4707331137		not available	Monongahela Power Company		
4707331138		not available	Monongahela Power Company		
4707331139		not available	Monongahela Power Company		
4707331141		not available	Lauderman Oil & Gas Drilling		
4707370016		not available	---------- unknown ----------		
4707370048		not available	Jennings Brothers, E. H., Company		
4707301119	1981	Dry w/ Gas Show	Vessel Resources Corp.	4000	Lower Huron (undifferentiated)
4707301606	1983	Gas w/ Oil Show	Beacon Resources Corp.	4110	Lower Huron (undifferentiated)
4707302524	2010		WVDEP Office Of Oil & Gas		
4707390126					
4707391316					

Note: Wells having API #s from 4707390041 through 4707390140 are also listed but have no associated information.

The completion dates for most of the wells are unknown, implying they were drilled as part of historic oil and gas well exploration in the area and potentially could have been drilled in the early 1900s or possibly in the late 1800s. A review of data for the other wells indicates they were drilled between 1935 and 2011. The total depths of the wells range from 71 ft to 5,684 ft and they've produced from formations including undifferentiated Upper Devonian Sandstone units. Many of the wells are reported as orphan wells and some have little or no information provided. As indicated on Figure 6, the wells are distributed across much of the site and adjoining areas. Considering the age of the wells there would seem to be potential for groundwater impacts from corroded/damaged well casing, degraded seals, etc., which could result in out-of-interval migration of oil and gas and formation brine. Any leaking oil and gas gathering lines/pipelines and wellhead brine storage tanks at currently producing locations could be another potential source of releases. As discussed further below, potential constituents known to be associated with oil and gas wells include barium, radium, chloride, sodium, lithium, and elevated TDS levels.

3.5.2 Occurrence of SSL Constituents in Oil and Gas Brines

It is noted in the "Chemistry and Origin of Oil and Gas Well Brines in Western Pennsylvania," (Dresel, P.E., and Rose, A.W., 2010) that brine samples collected from oil and gas operations indicate "…radium shows a general correlation with barium and strontium and an inverse correlation with sulfate." The data presented in Section 3.4, in which sulfate concentrations are inversely low compared to barium concentrations, supports this conclusion. The following table presents the range and mean concentrations reported in Dresel and Rose (2010) for applicable Appendix III/IV constituents in western Pennsylvania brines (assumed to be similar to those in West Virginia based on age and depositional environment):

	Dissolved Barium (mg/L)	Dissolved Chloride (mg/L)	Dissolved Lithium (mg/L)	Radium 226 (pCi/L)
No. of Brine Samples	33	40	33	6
Range	0.80 – 4,370	5,760 – 207,000	0.30 - 315	0 – 5,300
Mean	877.37	104,544	61	2,150

Based on these reported values, the following observations were made:

- **Barium -** The reported mean concentration of 877.37 mg/L is well above the UPL for upgradient well GW-7 (0.0934 mg/L). With respect to downgradient wells with SSLs for barium, the reported mean concentration of 877.37 mg/L is also well above the concentrations of barium in GW-23 (9.76212 mg/L), GW-24 (9.25331 mg/L), and GW-25 (7.62675 mg/L). However, brine impacts to those wells would be expected to be diluted by groundwater and, hence, a potential reason they are lower.
- **Chloride -** The reported mean concentration of 104,544 mg/L is three orders of magnitude greater than the UPL for upgradient well GW-7 (104 mg/L), and the reported minimum concentration of 5,760 mg/L is also higher than the GW-7 UPL. With respect to downgradient wells along the northern boundary with Appendix IV SSLs, the reported minimum chloride concentration in brines of 5,760 mg/L is below the concentrations of chloride in GW-23 (12,900 mg/L), GW-24 (8,520 mg/L), and GW-25 (7,110 mg/L)

indicating the groundwater in those wells is within the range of the minimum and maximum concentrations of chloride found in brine.

- **Lithium** – The reported mean concentration of 61 mg/L is significantly higher than the GW-7 UPL of 0.023374 mg/L. With respect to the downgradient well with an SSL for lithium, the reported mean concentration of 61 mg/L is higher than the concentration of lithium in GW-23 (0.150178 mg/L). However, brine impacts to GW-23 would also be expected to be diluted by groundwater and, hence, a potential reason they are lower.
- **Radium 226** – The reported mean concentration of 2,150 pCi/L is significantly higher than the GW-7 UPL of 0.58 pCi/L for the sum of both radium-226 and radium-228. With respect to downgradient wells with Appendix IV SSLs, the reported mean radium-226 concentration of 2,150 pCi/L in brine is higher than the concentration of radium-226 in GW-23 (23.6 pCi/L), GW-24 (12.7 pCi/L), and GW-25 (13.2 pCi/L). However, brine impacts to GW-23, GW-24, and GW-25 would also be expected to be diluted by groundwater and, hence, a potential reason they are lower.

An additional study regarding the occurrence of radium with oil and gas produced waters conducted by the USGS identified median radium concentrations of 2,460 pCi/L and 734 pCi/L, for Marcellus Shale and non-Marcellus Shale produced water samples, respectively (USGS, 2011). An increase in concentration of radium was directly correlated with increases in TDS and salinity of the produced water.

3.5.3 Previous Oil and Gas Impact Studies at the Site

In March 2004, Hydrosystems Management, Inc. (HMI) prepared a report for Allegheny Power Supply Company (a predecessor company of FirstEnergy) which evaluated increased barium concentrations in groundwater samples from monitoring well GW-4. GW-4 is part of the state Solid Waste/NPDES groundwater monitoring system, is located in the north-northeastern portion of the site (as shown on Figure 1), and has a total depth of 255 feet and a screen length of 55 feet. Barium concentrations in the well consistently exceeded the Ground-Water Quality Standard (GWQS) established in the facility's Solid Waste/NPDES permit. The HMI report concluded that leakage of brine from surrounding oil and gas wells was the most probable cause of the barium GWQS exceedances. GW-4 also showed increases in sodium and chloride levels. The HMI report indicated two known oil and gas wells were within 1,000 feet of GW-4 and referenced the existence of numerous orphaned wells in the area. As noted in Section 3.3 of this report, the boring log for GW-4 indicated oil and gas odors at the time of drilling; additionally, some oil associated with groundwater and oil sheen were both present during well installation and development.

In 2017, oil observed in GW-23 sample water was submitted for fingerprinting laboratory analysis to determine the exact oil type. Results of that fingerprinting analysis indicated that the oil from GW-23 was representative of a straight chain hydrocarbon mineral oil. This oil is likely a result of historical oil and gas exploration activities that have occurred in the area over the past 150 years. A copy of the fingerprinting analysis results is provided as Attachment B.

3.5.4 Historical Oil and Gas Activities in the Surrounding Area

Historical references regarding local oil and gas exploration activities in the Pleasants County area were also reviewed. In “A History of Pleasants County, West Virginia,” (Pemberton, 1929) the Burning Springs-Eureka anticline is noted as having its “ridge” eroded and exposing lower (older) strata with oil-bearing rocks located at or near the surface. Additionally, the First Cow Run sand mentioned in the text (from which oil and gas have been produced) is also known as the Saltsburg Sandstone, the formation in which numerous on-site wells have penetrated. Bearing more relevance to the site is the following anecdote:

> “Brown and Company of New York drilled in a well on McElroy Run back of Eureka on the Giles Hammett farm, which came to be known as the ‘Burnt Well,’ heretofore mentioned. At a depth of 1,100 feet a copious quantity of oil was found filling the hole to a depth of 100 feet. This was on April 27, 1886. A few days later the well was shot, and for a time flowed at a rate of forty barrels a day. Unfortunately, the rig caught fire, the cable was burned, and the heavy tools fell into the hole, where they remained about a year.”

The 1974 Environmental Impact Statement (EIS) (U.S. Army Engineer District, 1974) completed for the Pleasants Power Station noted that several oil and gas wells were drilled in 1958 and 1959 in the vicinity of the plant with one drilled to 740 feet producing 11 barrels of oil the first day. Four additional wells drilled to depths between 1,600 and 2,527 feet produced similar quantities of oil. It was stated in the EIS that “…it is presumed locally that these oil wells are those which have contaminated the water wells in the site area.”

In summary, the potential for impacts to groundwater by oil and gas wells on the site and in nearby upgradient areas appears to be significant, particularly in light of the historical and well-documented oil and gas well impacts in many of the groundwater monitoring wells located on-site. The data presented in this section indicate that the Appendix IV parameters barium and radium are likely attributable to oil and gas (brine) impacts. Lithium, which was reported at very high concentrations in oil and gas well brines for formations present at the site, may also be related to oil and gas brines, but since it is also present in site leachate at concentrations well above concentrations reported in the upgradient and downgradient CCR monitoring wells, it is not possible to clearly differentiate the source of lithium SSLs. However, as indicated by comparing the radium and barium isoconcentration maps (Figures 3 and 4, respectively) with the lithium isoconcentration map (Figure 5), the location of the highest concentrations for all three of these constituents occurs at GW-23, located along the northern property boundary, suggesting that lithium may exhibit a potential relationship with the barium and radium impacts from oil and gas well activities. Additionally, wells immediately downgradient of the leachate collection system along the western boundary (GW-27, GW-28, and GW-29) do not exhibit elevated concentrations of lithium, barium or radium, indicating that the presence of the three constituents in concentrations greater than their respective GWPS along the northern boundary are likely correlated and associated with oil and gas well impacts.

4.0 CERTIFICATION STATEMENT

In accordance with § 257.95(g)(3)(ii) of the CCR Rule, an ASD for Appendix IV constituents was undertaken for the CCR unit identified herein. Based on the information and data that were available for review, the following determinations have been made with respect to the AM-1, -2, and -3 events:

- The barium and radium SSLs can be attributed to historical and current oil and gas exploration and production activities that have occurred on-site. As such, in accordance with the applicable requirements of § 257.95 of the CCR rule, no corrective measures are required for these parameters and assessment monitoring for barium and radium will continue.
- The lithium SSLs are currently considered indeterminate based on the LOE's presented herein, but the available evidence indicates a high potential for the elevated lithium concentrations to also be attributable to oil and gas impacts at the site based on the occurrence of the barium, radium, and lithium concentrations above the GWPS occurring in the northern boundary in which extensive oil and gas activities have occurred historically. To resolve this uncertainty, the applicability of leachate and groundwater lithium isotopic analysis at the site will be evaluated and lithium sampling of brine from on-site production equipment will be considered. Pending completion of that work and for the purposes of this ASD, lithium has not been categorized as attributable to either the CCR unit or to an alternate source. It will continue to be analyzed as part of the assessment monitoring program and will transition to the applicable requirements of assessment of corrective measures per § 257.96 of the CCR Rule, should isotopic analysis and/or brine sampling indicate the CCR unit is the likely source of the lithium exceedances.
- The arsenic SSLs could not be attributed to sources other than the CCR unit, to errors in sampling, analysis, or statistical evaluation, or from natural variation in groundwater quality. As such, a transition to the applicable requirements of assessment of corrective measures for arsenic per § 257.96 of the CCR Rule appears to be warranted and assessment monitoring of this parameter will also continue.

5.0 REFERENCES

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TABLES

Table 1 - ASD Checklist 1: Sampling, Laboratory, or Statistical Causes

ASD Type	Potential Cause	Evaluation Summary
Sampling Causes (ASD Type I)	Sample mislabeling	No mislabeling found by comparing all COCs and lab data identifiers.
	Contamination	Field notes identified sheens and petroleum odors in GW-23 for Events 4 through 13, GW-24 for Events 6 through 13, and GW-25 for Events 4 through 6 (well was dry and not sampled in Events 7 through 10) and had odor in Events 11-13 when sampled again. Petroleum contamination could be a contributing factor for SSIs in these wells for Ba and Ra226 and 228.
	Sampling technique	HydraSleeves™ used instead of bladder pumps on some dates in wells GW-21 (upgradient), -23, -24, -25, and -26 due to limited available water.
	Turbidity	High turbidity (>10 NTU) in GW-19 (Events 1 and 2), GW-20 (Events 1, 4 through 11, and 13), GW-22 (Events 1 and 8 through 13), GW-24 (Event 12), GW-26 (Events 1 through 7), GW-28 (Event 1), and GW-29 (Event 1). When HydraSleeves™ used, turbidity not always reported. Turbidity may be a contributing factor to SSIs in GW-20.
	Sampling anomalies	Insufficient water for sampling in GW-21 (upgradient) for Events 5 through 10, GW-24 for Events 3 and 4, GW-25 for Events 1 and 7 through 10, and GW-26 for Events 8 through 12.
Laboratory Causes (ASD Type II)	Calibration	No comments on lab calibration in Data Validation Reports for Appendix IV parameters As, Ba, Li, or Ra226/228..
	Contamination	Barium detected in lab blank in Event 1, so GW-22 qualified "J" and in Event 8, but results >10X blank so no action taken. Arsenic detected in lab blank in Event 3, but all results >10X blank so no action taken. In Event 10, Ba was outside recovery range, so GW-27, -28, and -29 were qualified "J". Arsenic detected in lab blank in Event 4, so GW-7, -9, and -27 qualified "U. In Event 7, Ra226 and 228 detected in lab blank, so GW-9, -19, and -26, GW-9 qualified "U". In Event 8, Ra226 detected in lab blank, so GW-7 and its duplicate, GW-27, -28, and -29 qualified "U". In Event 11, Ra228 detected in lab blank, but results for GW-23 and -24 were >10X blank or were non-detect. In Event 12, Ra226 detected in lab blank, so GW-7, -9, -20, -21 and its duplicate, GW-27, -28, and -29 qualified "U" but no action taken for GW-23, -24 and -25, since results were >10X blank; Ra228 also detected in lab blank, so GW-21 and its duplicate, and GW-27 qualified "U". In Event 5 for Li, GW-24 qualified "J" due to conflicting directional bias. In Event 6, GW-27 was qualified "J" for Ra228 due to field imprecision.
	Digestion methods	No differences for Appendix IV parameters As, Ba, Li, and Ra226/228.
	Dilution corrections	Dilution factors in some events different for As and Ba between wells in the same event and for As for the same well in different events. Dilution factors high for As and Ba in some events in wells GW-7, -23, -24, and -25.
	Interference	Possible interference was noted in Data Validation Reports for Ra226 and 228 in Events 10 & 11. Barium carrier gas had radiation counts > limit, so Ra226 and 228 in GW-23 qualified "J" in Events 8, 10, 11, 12 and 13 and in Event 11, GW-24 also qualified "J".
	Analytical methods	Methods same as in CCR GW Monitoring Plan for As, Ba, Li, and Ra226/228.
	Laboratory technique / qualifier flags	Had high recovery for MS/MSD for Ba in Event 1 (GW-20, -26, -27, and -29 and its duplicate). Had high recovery for MS/MSD for As in Event 4 (GW-23 and -22 and its duplicate). Had low recovery for MS/MSD for Li in Event 5 (GW-24). Had high recovery for LCS for Ra228 in Event 12 (GW-9 and -22). In Event 11, had low recoveries for MS/MSD for As with GW-19, -21, -24, -27 and its duplicate, GW-28, and -29) qualified "J" due to directional bias. Qualifier flags added appropriately.
	Transcription error(s)	None identified.
Statistical Evaluation Causes (ASD Type III)	Lack of statistical independence	Sampling interval was at least 4-5 weeks in upgradient wells GW-7 and -22 which are 2.5-inch and 4-inch diameter, respectively, wells in fractured bedrock, so not likely to be a concern. GW-7 was used as upgradient comparison well.
	Outliers	Possible outlier for Li identified in GW-23.
	False positives	In general, for the case of small sample sizes (e.g., n < 10-20), there is no mathematical algorithm to statistically prove a false positive result without resampling.
	Non-detect processing	Appendix IV parameters were non-detect in upgradient well GW-7 except for As, Ba, Li, and Ra226/228. In downgradient wells used for AM-1, AM-2 and AM-3, As, Ba, Li, and Ra226/228 detected in wells GW-9, -19, -20, -23, -24, -25, -26, -27, -28, and -29.
	Background data / change in normality	No new background data used for Assessment Monitoring (Events 11, 12, and 13).

Table 2 - ASD Checklist 2: Lines of Evidence Associated with the CCR Unit

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Primary CCR Indicators						
1a	If the CCR unit contains fly ash, is there an SSI/SSL for boron and sulfate?	Yes	CCR Release	Key	Monitoring Point	Northern Boundary: Boron SSIs in GW-19, -20, and -24; No Sulfate SSIs. Western Boundary: No Boron SSIs; Sulfate SSIs in GW-9, -27, and -29.
1b	If the CCR unit contains FGD gypsum (only) is there an SSI/SSL for sulfate?	Yes	CCR Release	Key	Monitoring Point	Northern Boundary: No. Western Boundary: Sulfate SSIs in GW-9, -27, and -29.
1c	Are there other constituents in the groundwater that represent primary indicators? List the applicable constituents.	Yes	CCR Release	Supporting	Monitoring Point	Northern Boundary: Calcium, Chloride, Fluoride, Lithium, and Molybdenum are all found at detectible levels in multiple downgradient monitoring wells. Western Boundary: Calcium, Chloride, Fluoride, Lithium, and Molybdenum are all found at detectible levels in multiple downgradient monitoring wells.
1d	Is there an SSI/SSL for any of the other primary indicators?	Yes	CCR Release	Key if No	Monitoring Point	Northern Boundary: Calcium (GW-23 and -24), Chloride (GW-19, -20, -23, and -24), Fluoride (GW-20), and Molybdenum (Gw-20, ,-24, and -25) have exhibited SSIs. Lithium is an SSI in GW-24 and an SSL in GW-23. Western Boundary: Calcium (GW-27, -28, and -29) and Chloride (GW-27, -28, and -29) have exhibited SSIs. Lithium has exhibited SSIs in GW-29; Molybdenum has exhibited SSIs in (GW-28).
1e	Is the leachate concentration for any of the primary indicators (including boron and sulfate) with an SSI/SSL statistically higher than background? List the applicable constituents.	Yes	CCR Release	Key if No	Constituent	Northern Boundary: Boron, Calcium, and Chloride – Yes; Fluoride - No. It is noted that statistical analysis has not been performed on leachate results; evaluation is based on four leachate sampling events conducted between October 2017 and April 2019. Western Boundary: Calcium, Chloride, and Sulfate – Yes. It is noted that statistical analysis has not been performed on leachate results; evaluation is based on four leachate sampling events conducted between October 2017 and April 2019.
1f	Are concentrations for the primary indicators increasing?	No	Uncertain	Supporting	Monitoring Point	Northern Boundary: No. It should be noted that the CCR dataset covers a very limited time range (~1.5 year) for trend analysis. Western Boundary: No. It should be noted that the CCR dataset covers a very limited time range (~1.5 year) for trend analysis.
Secondary Indicators						
2a	Are there other SSI(s) or SSL(s) of Appendix III or IV parameters?	Yes	CCR Release	Supporting	Monitoring Point	Northern Boundary: SSIs for pH (GW-23 and -24), TDS (GW-19, -20, -23, and -24), Barium (GW-19 and GW-20), Chromium (GW-20), Radium 226+228 (GW-9 and -19), and Selenium (GW-20); SSLs for Arsenic (GW-19, -23, -24, and -25), Barium (GW-23, -24, and -25), and Radium 226+228 (GW-9 and -19).

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Secondary Indicators (Continued)						
2a (con't)	(These are potential secondary indicators. List the applicable constituents.)					Western Boundary: SSIs for pH (GW-27, -28, and -29), TDS (GW-28 and -29), Barium (GW-27, -28, and -29), and Radium 226+228 (GW-27, -28, and -29); SSLs for Arsenic (GW-29).
2b	Are the constituents identified in 2a present in leachate in concentrations statistically higher than background?	Yes / No	Uncertain	Key if No	Constituent	Northern Boundary: pH, TDS, and Arsenic – Yes; Barium – No; Radium 226+228 not historically analyzed in leachate sampling program, but sampled once in July 2019 for this ASD. Statistical analysis has not been performed on leachate results; evaluation based on four sampling events conducted between October 2017 and April 2019 plus July 2019 sampling for Radium 226+228. Western Boundary: pH, TDS, and Arsenic – Yes; Barium – No; Radium 226+228 not historically analyzed in leachate sampling program, but sampled once in July 2019 for this ASD. Statistical analysis has not been performed on leachate results; evaluation based on four sampling events conducted between October 2017 and April 2019 plus July 2019 sampling for Radium 226+228.
2c	Are concentrations for any of the secondary indicators increasing? List the applicable constituents.	No	Uncertain	Supporting	Monitoring Point	Northern Boundary: No. It should be noted that the CCR dataset covers a very limited time range (~1.5 years) for trend analysis. Western Boundary: No. It should be noted that the CCR dataset covers a very limited time range (~1.5 years) for trend analysis.
Other Chemistry						
3a	Are organic constituents present in concentrations statistically higher than background?	N/A	-----	Supporting	Monitoring Point	Organics not analyzed as part of groundwater testing program at site.
3b	Is major ion chemistry similar to leachate?	ND	-----	Key	Monitoring Point	Based on primary and secondary indicator LOE's listed above, major chemistry analysis was not performed as part of Appendix IV ASD.
3c	Does major ion chemistry suggest a mixture of leachate and background groundwater?	ND	-----			Based on primary and secondary indicator LOE's listed above, major chemistry analysis was not performed as part of Appendix IV ASD.
3d	Does tritium age dating indicate that the groundwater was recharged after the facility was first used?	N/A	-----	Key if No	Monitoring Point	Disposal site development initiated in the late 1970's.
3e	Does isotopic analysis show evidence of mixing with CCR leachate?	ND	-----	Key	Monitoring Point	Based on primary and secondary indicator LOE's listed above, isotopic analysis was not performed as part of Appendix IV ASD.
Hydrogeology						
4a	Is the monitoring well with an SSI/SSL downgradient from CCR unit at any point during year?	Yes	CCR Release	Key if No	Monitoring Point	Multiple SSIs and SSLs were identified in the downgradient wells, all of which are positioned downgradient of the disposal site during all times of the year.

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Hydrogeology (Continued)						
4b	Review the Hydrogeological vs Leachate Scenario Table (EPRI, Table A-2) and identify the most representative scenario for each SSI or SSL case. List cases and scenario numbers.	-----	-----	Key	Monitoring Point	**Northern Boundary** Boron - CCR Leachate Release (Row c) Calcium - CCR Leachate Release + Possible Alternative Source (Row b) Chloride - CCR Leachate Release + Possible Alternative Source (Row c) Fluoride – Alternative Source Release (Row b) pH – Alternative Source Release (Row a) TDS - CCR Leachate Release + Possible Alternative Source (Row b) Arsenic – CCR Leachate Release (Row c) Barium – Alternative Source Release (Row a) Chromium – Leachate data not available for comparison Lithium – CCR Leachate Release + Possible Alternative Source (Row c) Molybdenum – Leachate data not available for comparison Radium 226+228 - Alternative Source Release (Row a) Selenium – Leachate data not available for comparison **Western Boundary** Calcium - CCR Leachate Release (Row a) Chloride - CCR Leachate Release + Possible Alternative Source (Row b) pH – CCR Leachate Release (Row a) Sulfate - CCR Leachate Release (Row a) TDS - CCR Leachate Release (Row a) Arsenic – CCR Leachate Release (Row c) Barium – Alternative Source Release (Row a) Lithium – CCR Leachate Release + Possible Alternative Source (Row c) Molybdenum – Leachate data not available for comparison Radium 226+228 - Alternative Source Release (Row a)
4c	Is the CCR unit immediately underlain by clay, shale, or other geologic media with low hydraulic conductivity?	Varies	Uncertain	Supporting	Unit	Some areas of site are underlain by clayey colluvial soils, mostly along what were the lower portions of tributary valleys.
4d	Is the monitoring point distant from the facility AND does the constituent with an SSI/SSL have low mobility in groundwater given the hydrogeologic environment at the monitoring location (EPRI, Table A-3)?	No	CCR Release	Supporting	Case	All downgradient monitoring wells are located at the waste boundary except for GW-23 (Northern Boundary) and GW-9 (Western Boundary).

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Hydrogeology (Continued)						
4e	Are the background monitoring wells screened in the same hydrostratigraphic unit, and along the same groundwater flow path, as the monitoring location with the SSI?	No / Yes	CCR Release	Supporting	Monitoring Point	The CCR Rule-defined uppermost aquifer at the site is comprised of multiple water-bearing strata that are hydraulically connected. The site's upgradient well (GW-7) is located along the appropriate groundwater flow path to its corresponding downgradient wells, however, it is are also positioned stratigraphically higher than some of the downgradient wells.
CCR Unit Design						
5a	Does the entire footprint of the monitored CCR unit have a liner?	Yes / No	Potential Alternate Source / CCR Release	Supporting	Unit	The landfill area does have a liner system while the impoundment area (including the dam) does not.
5b	If the facility is lined, is it a composite liner?	Yes / No	Potential Alternate Source / CCR Release	Supporting	Unit	A portion of the landfill area is lined with only 24-inches of compacted clay, while the remainder utilizes a composite system comprised of a geosynthetic clay liner (GCL) overlain by a high density polyethylene (HDPE) geomembrane.
5c	Does the entire footprint of the CCR unit have a leachate collection system?	Yes / No	Potential Alternate Source / CCR Release	Supporting	Unit	The entire footprint of the landfill area does have a leachate collection system. The impoundment area does not have a leachate collection system, but the dam does include a blanket drain/chimney drain system.
5d	If the CCR unit is unlined, is it known to have or is it likely to have groundwater intersecting the CCR?	Yes	CCR Release	Supporting	Unit	Both the landfill and impoundment areas are situated within a valley (the impoundment at the head and the landfill at the mouth) and the CCR Rule-defined uppermost aquifer at the site is comprised of multiple water-bearing strata that are hydraulically connected. Most of the uppermost aquifer rock strata all outcropped within the valley before the disposal site was developed so it is very likely that groundwater intersects the CCRs, particularly in the impoundment area.

Table Notes:

[1] ND (not determined) indicates that this line of evidence was not tested or there are insufficient data to make a determination; N/A means lines of evidence not applicable to the CCR unit.

[2] Line of Evidence (LOE) Types:
Key lines of evidence are based on relationships that must be observed in order for an SSI/SSL to be due to a release from a CCR unit. If these relationships are not observed, then they are critical to establishing an ASD. It is difficult to build a strong ASD without any key lines of evidence. It may be possible to build an ASD with a single key line of evidence, but the ASD will be stronger with additional key or supporting lines of evidence.
Supporting lines of evidence provide additional information that supports the ASD. Supporting lines of evidence are generally not sufficient to build an ASD unless there is at least one key line of evidence, although it may be possible if there are many supporting lines of evidence.

[3] This LOE applies to:
Constituent: An SSI/SSL for that constituent at any monitoring point
Monitoring Point: All SSIs/SSLs at a specific monitoring point
Case: An SSI/SSL for a specific constituent at a specific monitoring point
Unit: All SSIs/SSLs at the monitored unit

Table 3 - ASD Checklist 3: Lines of Evidence Associated with Alternative Natural and Anthropogenic Sources

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
General						
6a	Are there any known alternative sources for any of the constituents of concern on-site or off-site?	Yes	Potential Alternate Source	Supporting	Unit	Historical and current oil and gas exploration and production activities have the potential to cause brine water and associated constituents of concern to migrate into the monitored aquifer. Several hundred oil and gas wells dating back as far back as the late 1880s have the potential to have been improperly drilled, plugged, or produced, resulting in releases to the environment.
6b	Are any current or former potential alternative sources upgradient of the monitoring location?	Yes	Potential Alternate Source	Supporting	Monitoring Point	Historical and current oil and gas exploration and production activities have occurred in all areas surrounding the CCR unit, including areas upgradient/background of the monitoring locations.
6c	Do monitoring locations between a potential upgradient source and CCR unit have concentrations at SSI/SSL levels?	N/A	N/A	Supporting	Constituent	There are currently no monitoring locations situated between the potential upgradient sources and the CCR unit.
On-Site Alternative Source						
7a	Is the monitoring point downgradient of or near a coal pile, or coal pile runoff, or coal pile leachate management area?	No	No Alternate Source	Supporting	Monitoring Point	There are no coal pile, coal pile runoff, or coal pile leachate management areas near the downgradient monitoring points.
7b	Are there former coal mines, mine spoil, or conveyers near the CCR unit or upgradient from the facility?	No	No Alternate Source	Supporting	Unit	There are no known coal mining operations that have occurred on-site or in the surrounding area.
7c	Does the site have other CCR units that are upgradient or side gradient of the affected monitoring location?	No	No Alternate Source	Supporting	Monitoring Point	There are no other CCR units located upgradient or side gradient of the affected monitoring locations.
7d	Is the CCR unit built on top of a former CCR disposal area (i.e., has a lined impoundment been built on top of a former unlined impoundment, or has a lined landfill been built on top of a portion of an unlined impoundment)?	No	No Alternate Source	Supporting	Unit	The landfill area is lined (refer to Table 2, LOE 5b) and constructed atop the downstream face of the unlined impoundment's dam. However, the two disposal areas share a multi-unit groundwater monitoring network that does not allow for differentiation of impacts from one area or the other.

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
On-Site Alternative Source (Continued)						
7e	Do the CCR unit or adjacent units have an active underdrain piping system or groundwater pumping system, or are there any groundwater pumping activities nearby, that could have localized influence on groundwater flow and quality?	Yes/No	No Alternate Source	Supporting	Unit	The entire footprint of the landfill area does have a combined groundwater underdrain/leak detection system and the impoundment dam has a blanket drain/chimney drain system. However, the impoundment area does not have any type of groundwater control system. As such, the landfill system is not expected to have a measurable localized influence on groundwater flow and quality.
7f	Is there evidence that water used for dust suppression on uncovered CCR or coal piles flowed off the footprint of the liner or runoff containment system near the monitoring point?	No	No Alternate Source	Supporting	Monitoring Point	There is no evidence of dust suppression water to have flowed off the footprint of the landfill liner or runoff containment systems and near the monitoring points.
7g	Is leachate or sluice water used for dust control close to the monitoring location?	No	No Alternate Source	Supporting	Monitoring Point	Dust control water is obtained from non-potable sources from the power station.
7h	Is the monitoring point downgradient of or near a CCR handling area (silo, storage area, dewatering bin, sump, truck loading/unloading or washing area, etc.) or haul road?	No/Yes	No Alternate Source/Potential Alternate Source	Supporting	Monitoring Point	Northern Boundary: No. Western Boundary: GW-27 and -28 are located near the CCR landfill haul road.
7i	Is the monitoring point downgradient of or near sluice water lines, handling equipment, or storage areas?	No/Yes	No Alternate Source/Potential Alternate Source	Supporting	Monitoring Point	Northern Boundary: No. Western Boundary: GW-27, -28, and -29 are positioned downgradient of the impoundment influent sluice line and effluent siphon line.
7j	Is the monitoring point downgradient of or close to a leachate collection pipeline or leachate storage structure?	No/Yes		Supporting	Monitoring Point	Northern Boundary: No. Western Boundary: GW-27 is located near the landfill's leachate collection and detection discharge lines.
7k	Have there been any documented spills of CCR or leachate or sluice water in upgradient or nearby locations?	No	No Alternate Source	Supporting	Monitoring Point	There are no known spills of CCRs, leachate, or sluice water in upgradient or nearby locations.

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
On-Site Alternative Source (Continued)						
7l	Were CCRs ever drained or stockpiled in unlined areas and/or without run-off/leachate control in upgradient or nearby areas?	No	No Alternate Source	Supporting	Monitoring Point	All known CCR management activities at the site have been performed in the landfill or impoundment disposal areas..
7m	Is there any history of on-site or upgradient oil or chemical spills or leaking underground storage tanks?	Yes	Potential Alternate Source	Supporting	Monitoring Point	There are numerous historical and current oil and gas tank batteries and underground pipelines on the site with at least one known release from an oil pipeline that occurred near GW-7 approximately 15 years ago.
7n	Does a significant amount of road salting occur on-site? (also see 9b)	No	No Alternate Source	Supporting	Monitoring Point	The portion of the site access road that is paved and salted is located downgradient of the CCR unit monitoring wells.
7o	Are fertilizers being used on-site for cap vegetation or other uses?	Yes	Potential Alternate Source	Supporting	Monitoring Point	Fertilizers are used in the hydroseeding of all disturbed areas at the site (capped areas, borrow areas, etc.)
7p	Is there any history of on-site or background ash utilization (structural fill, landfill, road base, berm construction, soil stabilization, etc.)?	Yes	Potential Alternate Source	Supporting	Monitoring Point	The downstream portion of the impoundment dam is constructed of compacted fly ash and includes blanket and chimney drains that are constructed of bottom ash.
7q	Was the power plant site subgrade prepared with CCR, dredge spoils, incinerator residue, construction debris, industrial waste, or non-native soils?	N/A	N/A	Supporting	Monitoring Point	The Power Plant is located downgradient and distant from the CCR unit.
Natural Variation						
8a	Are background wells screened in the same geomedia as the monitoring point?	Yes/No	Potential Alternate Source/No Alternate Source	Supporting	Monitoring Point	The CCR Rule-defined uppermost aquifer at the site is comprised of multiple water-bearing strata that are hydraulically connected. The site's upgradient well (GW-7) and other background wells (GW-21 and -22) are located along the appropriate groundwater flow paths to the downgradient wells, however, it they are also positioned stratigraphically higher than some of the downgradient wells.
8b	Is the aquifer comprised of poorly buffered media such as sand and gravel?	No	No Alternate Source	Supporting	Unit	The aquifer is comprised of cyclic sequences of sandstone, shale, claystone, coal, and limestone and is not considered to be poorly buffered.
8c	Is the pH at the monitoring point similar to the background pH?	Varies	Uncertain	Supporting	Monitoring Point	The pH of the background well is typically moderately higher than the downgradient monitoring points.
8d	Is the monitoring point near a river?	No	No Alternate Source	Supporting	Monitoring Point	The Ohio River is located approximately 2000 feet downgradient of the closed CCR monitoring points (GW-9 and -19).

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Natural Variation (Continued)						
8e	Is the constituent chemically reactive in groundwater, such that dissolution or desorption is possible (EPRI, Table A-3)?	Yes/No	Potential Alternate Source/No Alternate Source	Supporting	Constituent	Arsenic: Reactive and influenced by pH and redox; sorption usually decreases with pH. Barium: Reactive; has limited solubility and is usually sorbed to clay, soils, and sediment. Lithium: Non-reactive. Radium: Reactive; subject to cation exchange.
8f	Is there a difference in redox indicators between background and compliance monitoring data?	ND	ND	Supporting	Monitoring Point	Redox parameters were not analyzed as part of the Appendix IV ASD.
8g	Has there been a recent flood, recharge event, or dry period that caused groundwater elevation to rise or fall to elevations higher or lower than observed during the background monitoring period?	No	No Alternate Source	Supporting	Unit	Groundwater conditions have generally remained consistent with changes not being attributable to flooding and drought conditions.
8h	Does the aquifer contain saline water at depth?	No	No Alternate Source	Supporting	Unit	Saline conditions are not observed in Site groundwater.
8i	Was the direction of groundwater flow prior to or during the sample event different than observed during the background prior?	No	No Alternate Source	Supporting	Monitoring Point	Groundwater flow has consistently been to the north and west and to the northeast for the western and northern boundaries, respectively.
Off-Site Anthropogenic						
9a	Are there former coal mines, mine spoil, or conveyers near the CCR unit or upgradient from the facility (also consider under "On-site")?	No	Uncertain	Supporting	Unit	There are no former coal mine, mine spoil, or conveyor systems upgradient of or near the CCR unit.
9b	Does a significant amount of road salting occur off-site?	N/A	N/A	Supporting	Unit	CCR unit is a captive site situated above the surrounding off-site roadways that are typically salted.
9c	Does the surrounding land use include agriculture (crops)?	Yes/No	No Alternate Source	Supporting	Unit	The neighboring properties appear to have limited agricultural uses (crops) which are determined to present little to no impacts to groundwater as it relates to the CCR unit.
9d	Does the surrounding land use include agriculture (animal)?	Yes/No	No Alternate Source	Supporting	Unit	The neighboring properties appear to have limited agricultural uses (animal) which are determined to present little to no impacts to groundwater as it relates to the CCR unit.

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Off-Site Anthropogenic (Continued)						
9e	Are there current or former underground or aboveground storage tanks that have had a release? (Consider gas stations and surrounding industrial activities.)	Yes	Potential Alternate Source	Supporting	Unit	There are numerous historical and current oil and gas production tank batteries surrounding the CCR unit. Documented spills from those tanks were not identified, but given the age of the tanks there is the potential that leaks and spills have resulted in impacts to groundwater.
9f	Are there, or were there, oil and gas production wells in the vicinity of the site?	Yes	Potential Alternate Source	Supporting	Unit	There are several hundred historical and existing oil and gas exploration and production wells on and in the vicinity of the site. Observations of oil and gas impacts to groundwater have been noted during the installation of several groundwater monitoring wells at the site and during groundwater sampling activities.
9g	Are there existing or historical commercial and/or industrial sources of impacts, such as metal manufacturing, mining, landfills, Superfund or brownfield sites, wood treatment, etc.?	No	No Alternate Source	Supporting	Unit	Other than the oil and gas activities discussed in LOE 9f, there are no other known historical off-site commercial and/or industrial sources.
9h	Could any potential anthropogenic sources be causing changes to groundwater chemistry that would result in release of the constituent of concern through changes to pH, redox, etc.?	Yes	Potential Alternate Source	Supporting	Unit	Historical and current oil and gas exploration and production activities have likely allowed for the migration of brine water and other constituents of interest in the overlying aquifer of the CCR unit that could be affecting groundwater geochemistry.
Time-of-Travel Analysis						
10	Has groundwater flowing beneath potential sources had enough time to migrate to the affected monitoring well location?	Yes	Potential Alternate Source	Supporting	Monitoring Point	Given the age of the CCR unit and history of disposal activities dating back to the late 1970s, there has been enough time for potentially impacted groundwater to flow to the affected monitoring wells.

Table Notes:

[1] ND (not determined) indicates that this line of evidence was not tested or there are insufficient data to make a determination; N/A means line of evidence not applicable to the CCR unit.

[2] Line of Evidence (LOE) Types:
Key lines of evidence are based on relationships that must be observed in order for an SSI/SSL to be due to a release from a CCR unit. If these relationships are not observed, then they are critical to establishing an ASD. It is difficult to build a strong ASD without any key lines of evidence. It may be possible to build an ASD with a single key line of evidence, but the ASD will be stronger with additional key or supporting lines of evidence.
Supporting lines of evidence provide additional information that supports the ASD. Supporting lines of evidence are generally not sufficient to build an ASD unless there is at least one key line of evidence, although it may be possible if there are many supporting lines of evidence.

[3] This LOE applies to:
Constituent: An SSI/SSL for that constituent at any monitoring point
Monitoring Point: All SSIs/SSLs at a specific monitoring point
Case: An SSI/SSL for a specific constituent at a specific monitoring point
Unit: All SSIs/SSLs at the monitored unit

Table 4 - Leachate Data Summary

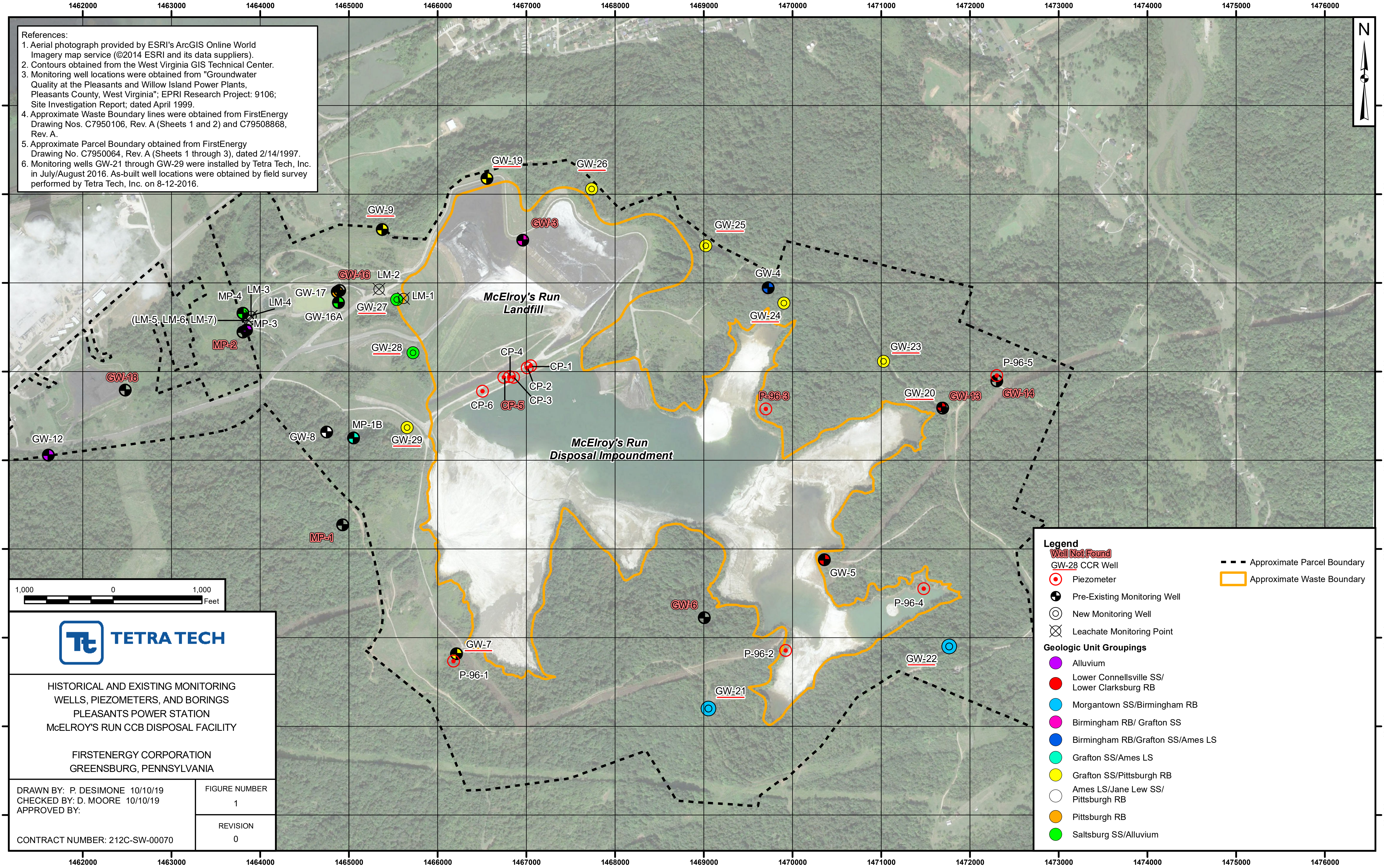
	Leachate Concentrations (mg/L)				GW Concentrations (mg/L) Northern Boundary															
Parameters	**LM1 Average**	**LM5 Average**	**LM7 Average**	**Leachate Avg.**	**UG UPL (GW-7)**	**GW-9**	**GW-19**	**GW-20**	**GW-23**	**GW-24**	**GW-25**	**GW-26**	**DG Avg.**	**Leachate Avg. > UG UPL?**	**DG Avg. > UG UPL?**	**GW-9 < Leachate Avg.?**	**GW-19 < Leachate Avg.?**	**GW-20 < Leachate Avg.?**	**GW-23 < Leachate Avg.?**	**GW-24 < Leachate Avg.?**
Arsenic	0.055321	0.1667684	1.133410	0.451833	0.00682	0.00050	0.09721	0.00250	0.03248	0.02855	0.05652	0.03058	0.03548	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Barium	0.0204316	0.0233133	0.0344573	0.026067	0.0934	0.062755	1.10111	0.240567	9.76212	9.25331	7.62675	0.534738	4.08305	No	Yes	No	No	No	No	No
Lithium	3.29002	6.35006	4.26817	4.636083	0.023374	0.017431	0.014145	0.01607	0.150178	0.045126	0.030696	0.038631	0.04461	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Radium (226+228) (pCi/L)	0.5	1.81	0.0748	0.7949	0.58	ND	2.44	0.505	83.4	46.1	30.5	1.92	27.478	Yes	Yes	No	No	Yes	No	No

	Leachate Concentrations (mg/L)				GW Concentrations (mg/L) Western Boundary															
Parameters	**LM1 Average**	**LM5 Average**	**LM7 Average**	**Leachate Avg.**	**UG UPL (GW-7)**	**GW-27**	**GW-28**	**GW-29**					**DG Avg.**	**Leachate Avg. > UG UPL?**	**DG Avg. > UG UPL?**	**GW-27 < Leachate Avg.?**	**GW-28 < Leachate Avg.?**	**GW-29 < Leachate Avg.?**		
Arsenic	0.055321	0.1667684	1.133410	0.451833	0.00682	0.000352	0.005549	0.018564					0.00816	Yes	Yes	Yes	Yes	Yes		
Barium	0.020432	0.023313	0.034457	0.026067	0.0934	0.914027	0.249275	1.05644					0.73991	No	Yes	No	No	No		
Lithium	3.29002	6.35006	4.26817	4.636083	0.023374	0.013196	0.016578	0.033673					0.02115	Yes	No	Yes	Yes	Yes		
Radium (226+228) (pCi/L)	0.5	1.81	0.0748	0.7949	0.58	1.3	0.466	1.27					1.012	Yes	Yes	No	Yes	No		

Notes: DG -Downgradient; GW - Groundwater; UG - Upgradient; UPL - Upper Prediction Limit
Leachate Concentrations averaged from 5 sampling events performed between October 2017 and July 2019, except for Lithium and Radium which was from one event in July 2019.
GW Concentrations of App. III parameters from sampling and analysis completed in February 2019.
GW Concentrations of App. IV parameters from sampling and analysis completed in February 2019.
UG UPL's based on 8 baseline sampling events.

LM1 - Leachate Collection from Dam Blanket/Chimney Drains
LM5 - Stage 1G LCS
LM7 - Stage 2B LCS

FIGURES



References:
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5. Approximate Parcel Boundary obtained from FirstEnergy Drawing No. C7950064, Rev. A (Sheets 1 through 3), dated 2/14/1997.
6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

Legend

Well Not Found
GW-28 CCR Well
◉ Piezometer
● Pre-Existing Monitoring Well
◎ New Monitoring Well
⊗ Leachate Monitoring Point
- - - Approximate Parcel Boundary
▭ Approximate Waste Boundary

Geologic Unit Groupings

● Alluvium
● Lower Connellsville SS/ Lower Clarksburg RB
● Morgantown SS/Birmingham RB
● Birmingham RB/ Grafton SS
● Birmingham RB/Grafton SS/Ames LS
● Grafton SS/Ames LS
● Grafton SS/Pittsburgh RB
○ Ames LS/Jane Lew SS/ Pittsburgh RB
● Pittsburgh RB
● Saltsburg SS/Alluvium

TETRA TECH

HISTORICAL AND EXISTING MONITORING
WELLS, PIEZOMETERS, AND BORINGS
PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 10/10/19
CHECKED BY: D. MOORE 10/10/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER	1
REVISION	0

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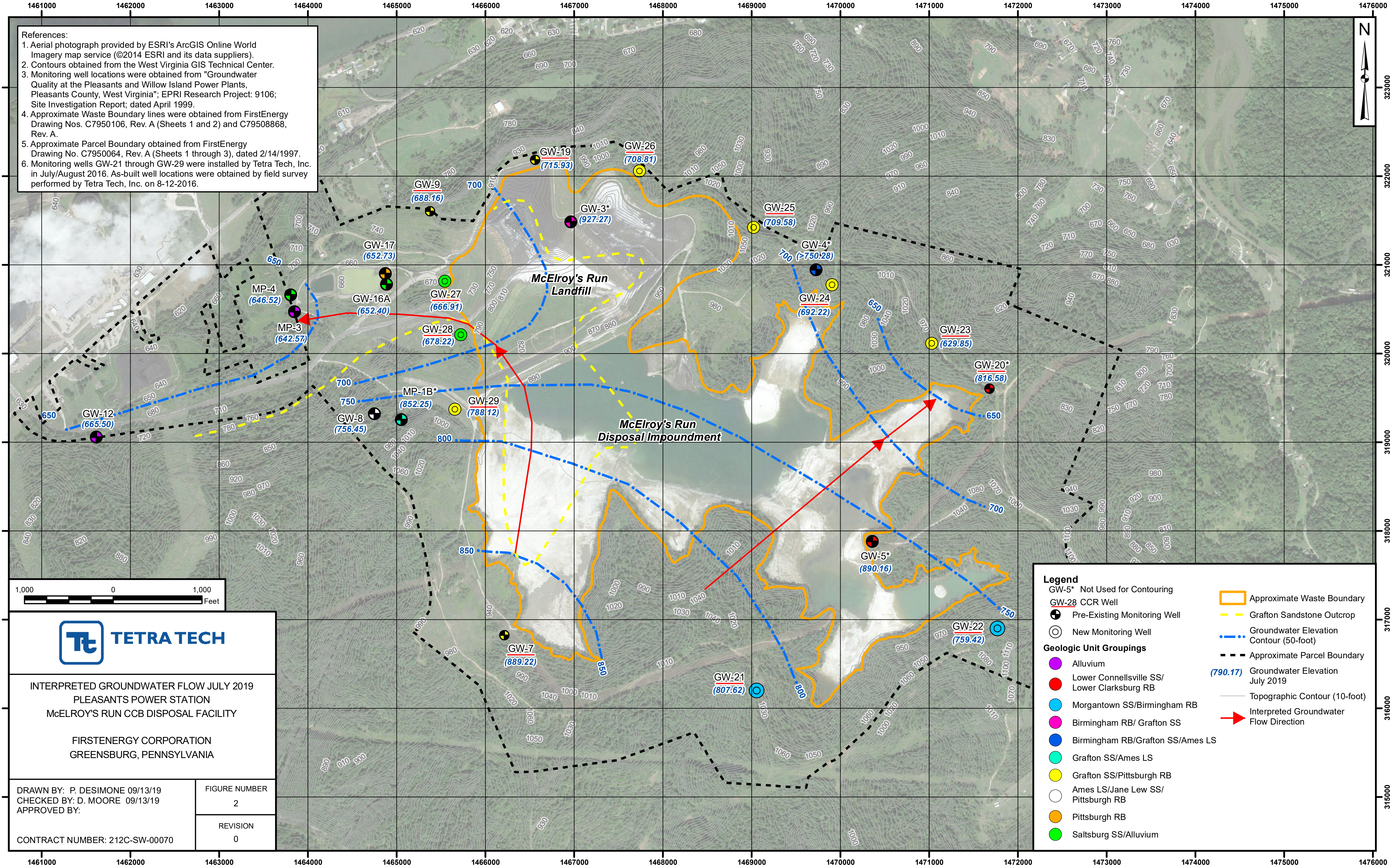

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6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

TETRA TECH

INTERPRETED GROUNDWATER FLOW JULY 2019
PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 09/13/19
CHECKED BY: D. MOORE 09/13/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
2

REVISION
0

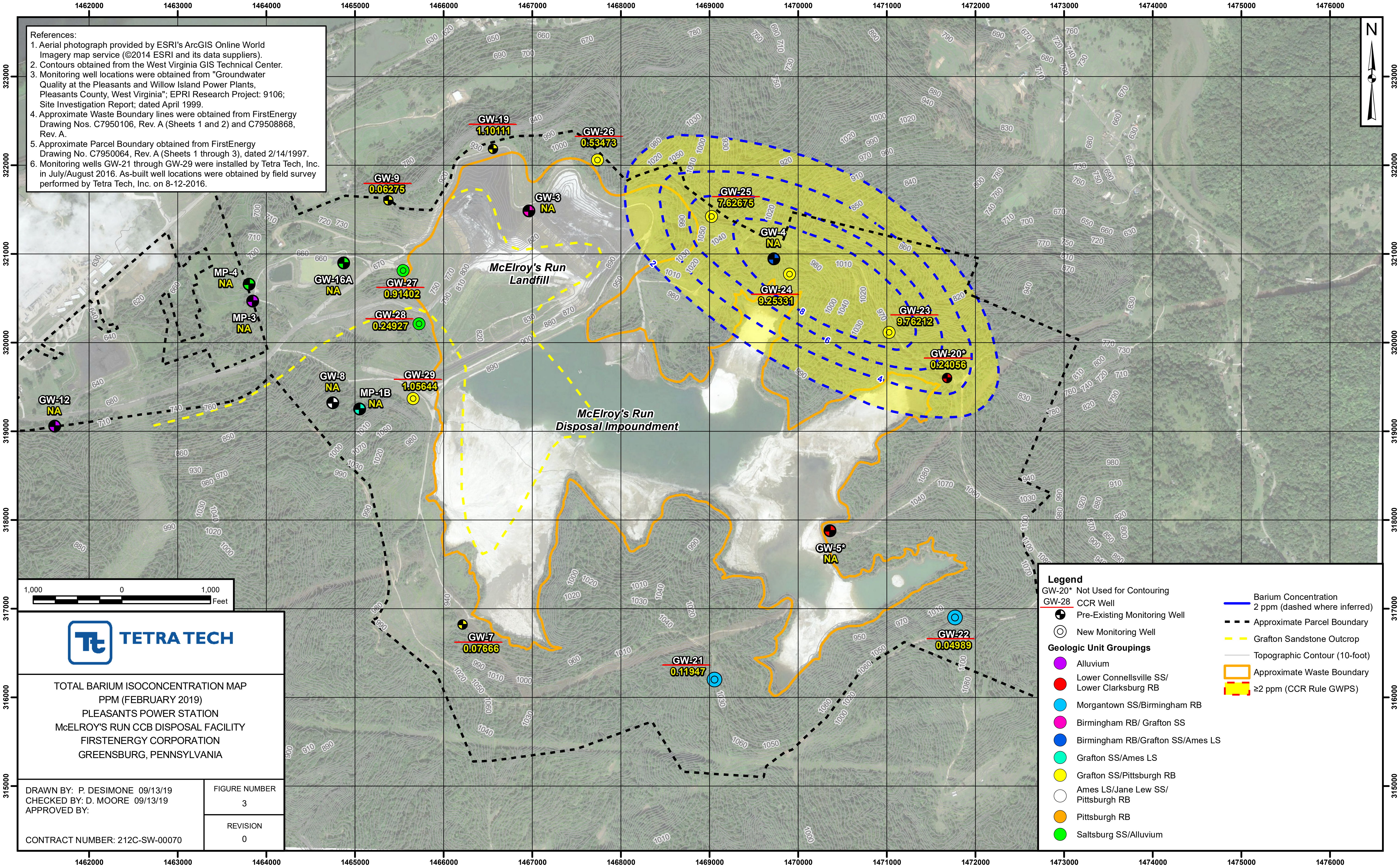
Legend

GW-5* Not Used for Contouring
GW-28 CCR Well
Pre-Existing Monitoring Well
New Monitoring Well

Geologic Unit Groupings

- ● Alluvium
- ● Lower Connellsville SS/ Lower Clarksburg RB
- ● Morgantown SS/Birmingham RB
- ● Birmingham RB/ Grafton SS
- ● Birmingham RB/Grafton SS/Ames LS
- ● Grafton SS/Ames LS
- ● Grafton SS/Pittsburgh RB
- ○ Ames LS/Jane Lew SS/ Pittsburgh RB
- ● Pittsburgh RB
- ● Saltsburg SS/Alluvium

Approximate Waste Boundary
Grafton Sandstone Outcrop
Groundwater Elevation Contour (50-foot)
Approximate Parcel Boundary
(790.17) Groundwater Elevation July 2019
Topographic Contour (10-foot)
Interpreted Groundwater Flow Direction



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5. Approximate Parcel Boundary obtained from FirstEnergy Drawing No. C7950064, Rev. A (Sheets 1 through 3), dated 2/14/1997.
6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

TETRA TECH

TOTAL BARIUM ISOCONCENTRATION MAP
PPM (FEBRUARY 2019)
PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY
FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 09/13/19
CHECKED BY: D. MOORE 09/13/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
3

REVISION
0

Legend

GW-20* Not Used for Contouring
GW-28 CCR Well
⊕ Pre-Existing Monitoring Well
◎ New Monitoring Well

Geologic Unit Groupings

● Alluvium
● Lower Connellsville SS/ Lower Clarksburg RB
● Morgantown SS/Birmingham RB
● Birmingham RB/ Grafton SS
● Birmingham RB/Grafton SS/Ames LS
● Grafton SS/Ames LS
● Grafton SS/Pittsburgh RB
○ Ames LS/Jane Lew SS/ Pittsburgh RB
● Pittsburgh RB
● Saltsburg SS/Alluvium

Barium Concentration 2 ppm (dashed where inferred)
Approximate Parcel Boundary
Grafton Sandstone Outcrop
Topographic Contour (10-foot)
Approximate Waste Boundary
≥2 ppm (CCR Rule GWPS)

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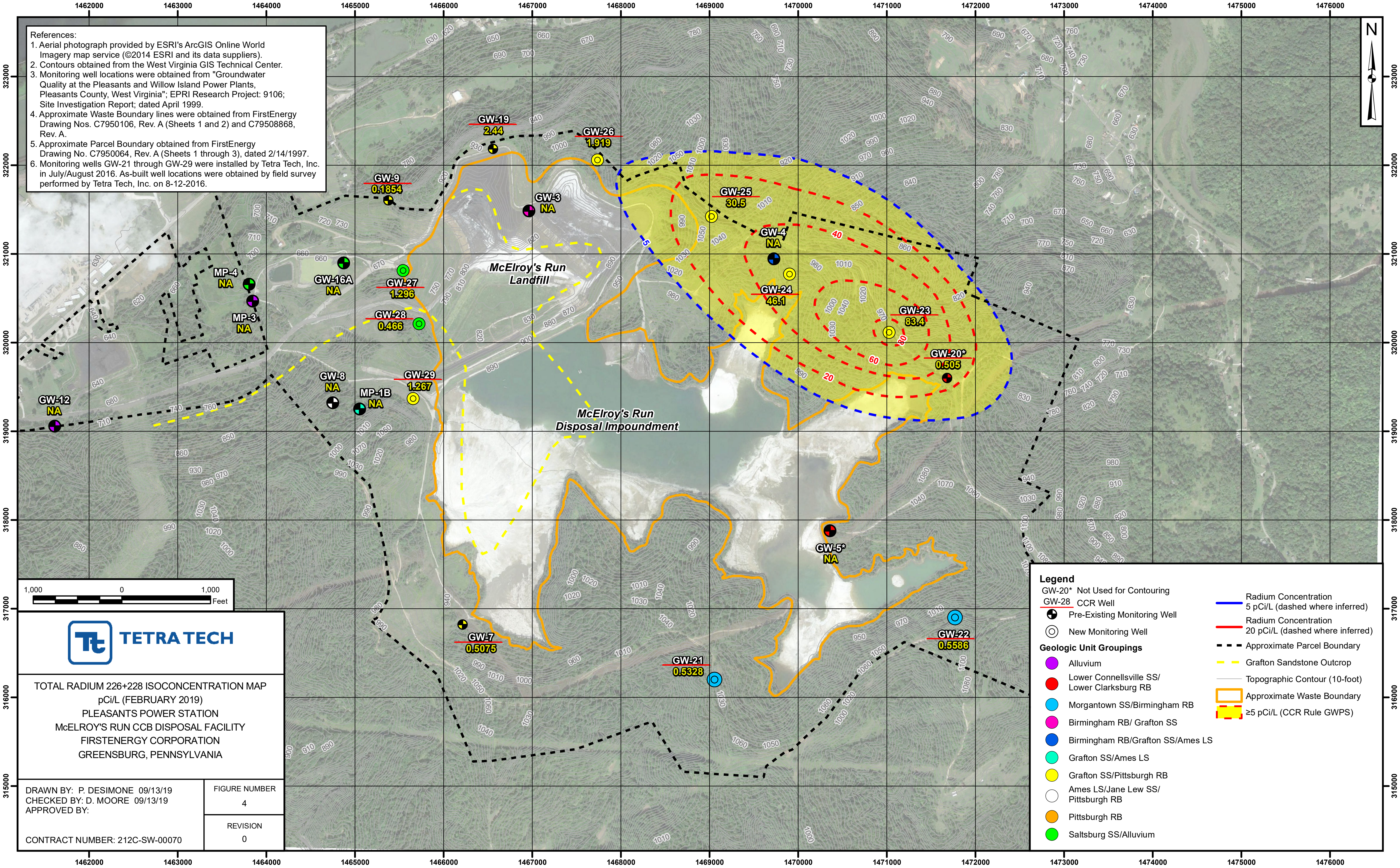

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6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

Legend

GW-20* Not Used for Contouring
GW-28 CCR Well
◐ Pre-Existing Monitoring Well
◎ New Monitoring Well

Geologic Unit Groupings

- ● Alluvium
- ● Lower Connellsville SS/ Lower Clarksburg RB
- ● Morgantown SS/Birmingham RB
- ● Birmingham RB/ Grafton SS
- ● Birmingham RB/Grafton SS/Ames LS
- ● Grafton SS/Ames LS
- ● Grafton SS/Pittsburgh RB
- ○ Ames LS/Jane Lew SS/ Pittsburgh RB
- ● Pittsburgh RB
- ● Saltsburg SS/Alluvium

- Radium Concentration 5 pCi/L (dashed where inferred)
- Radium Concentration 20 pCi/L (dashed where inferred)
- Approximate Parcel Boundary
- Grafton Sandstone Outcrop
- Topographic Contour (10-foot)
- Approximate Waste Boundary
- ≥5 pCi/L (CCR Rule GWPS)

TETRA TECH

TOTAL RADIUM 226+228 ISOCONCENTRATION MAP
pCi/L (FEBRUARY 2019)
PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY
FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 09/13/19
CHECKED BY: D. MOORE 09/13/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
4

REVISION
0

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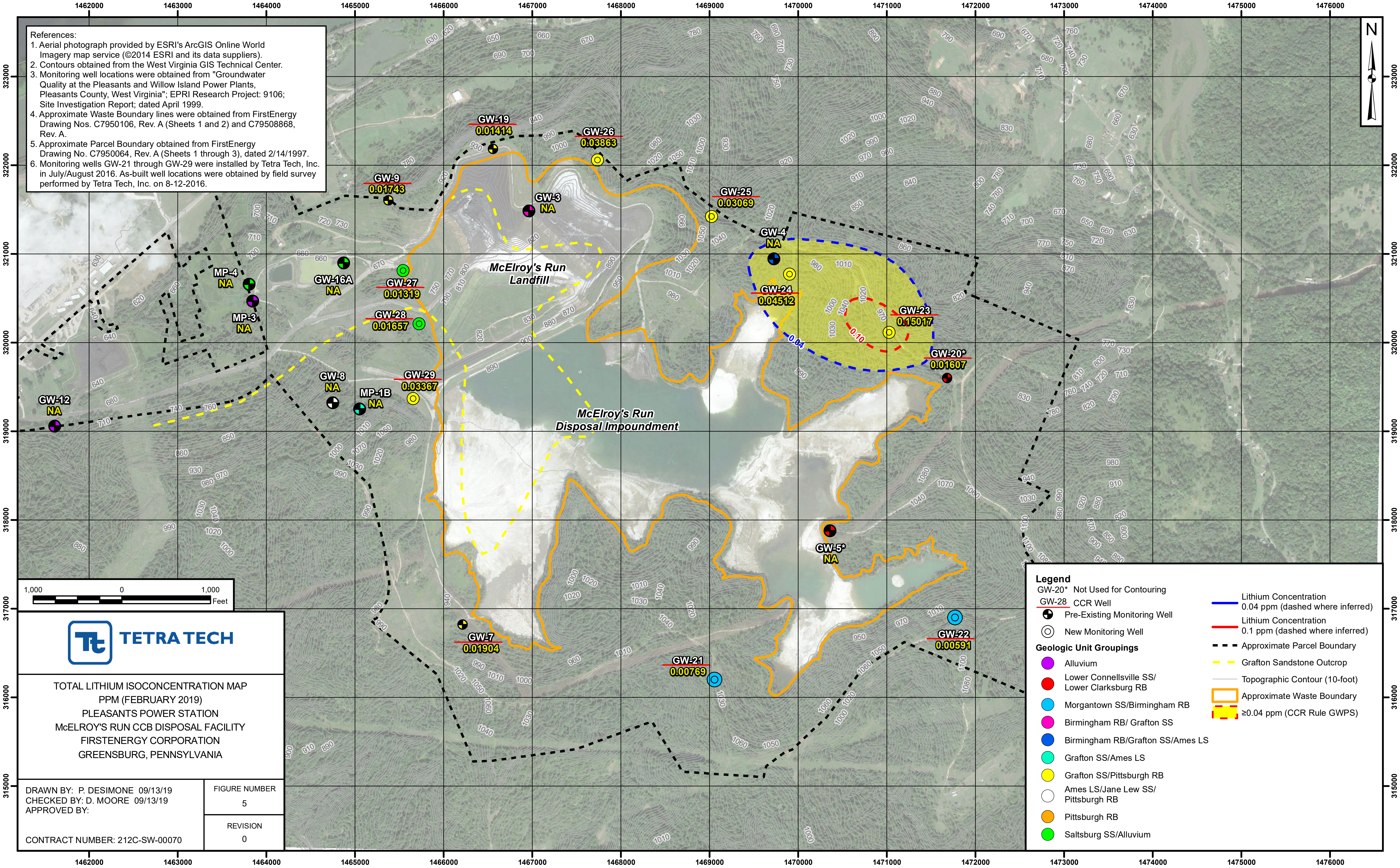

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6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

TETRA TECH

TOTAL LITHIUM ISOCONCENTRATION MAP
PPM (FEBRUARY 2019)
PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY
FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 09/13/19
CHECKED BY: D. MOORE 09/13/19
APPROVED BY:

FIGURE NUMBER
5

REVISION
0

CONTRACT NUMBER: 212C-SW-00070

Legend

GW-20* Not Used for Contouring
GW-28 CCR Well
⊕ Pre-Existing Monitoring Well
◎ New Monitoring Well

Geologic Unit Groupings

● Alluvium
● Lower Connellsville SS/ Lower Clarksburg RB
● Morgantown SS/Birmingham RB
● Birmingham RB/ Grafton SS
● Birmingham RB/Grafton SS/Ames LS
● Grafton SS/Ames LS
● Grafton SS/Pittsburgh RB
○ Ames LS/Jane Lew SS/ Pittsburgh RB
● Pittsburgh RB
● Saltsburg SS/Alluvium

Lithium Concentration 0.04 ppm (dashed where inferred)
Lithium Concentration 0.1 ppm (dashed where inferred)
Approximate Parcel Boundary
Grafton Sandstone Outcrop
Topographic Contour (10-foot)
Approximate Waste Boundary
≥0.04 ppm (CCR Rule GWPS)

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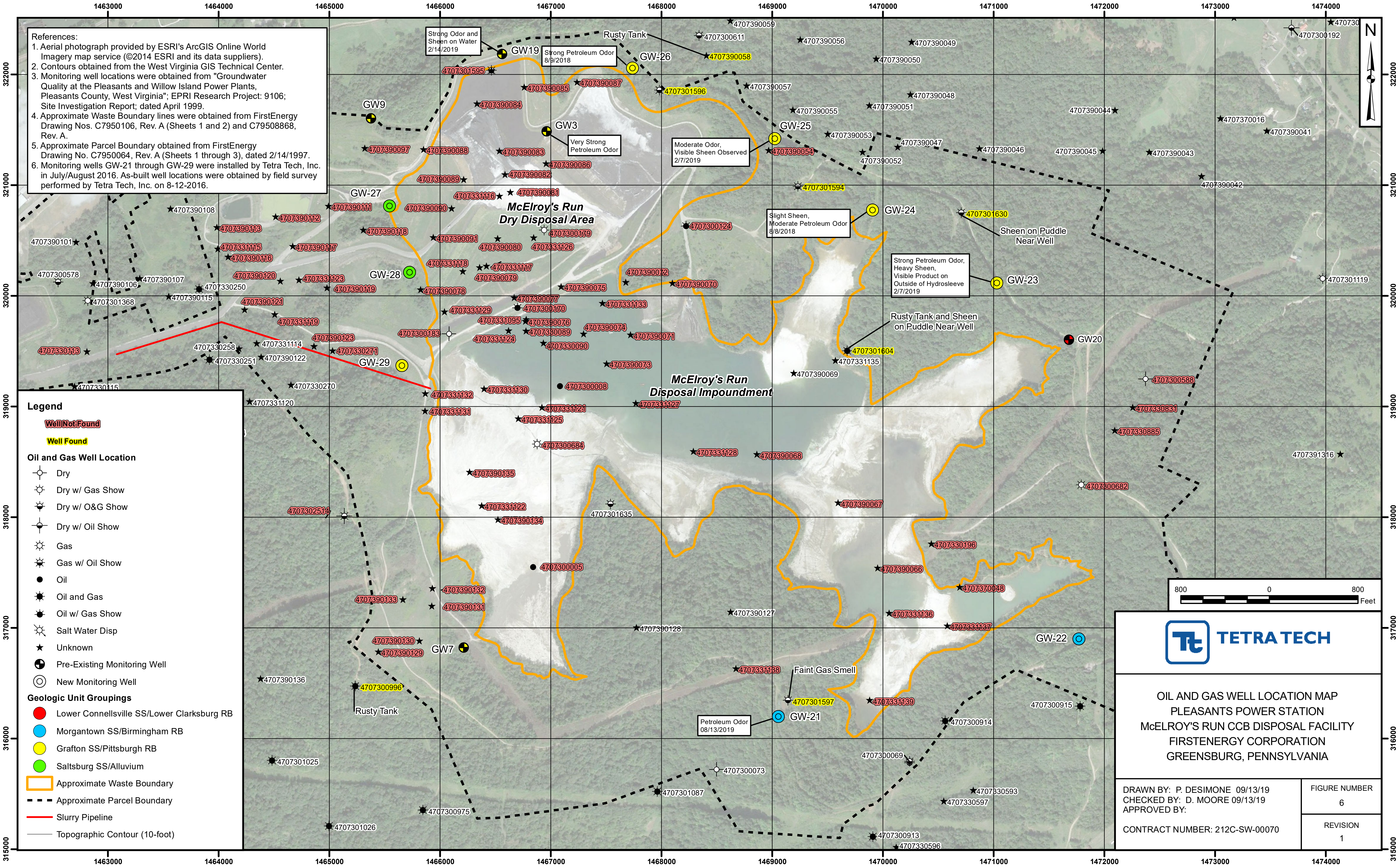

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6. Monitoring wells GW-21 through GW-29 were installed by Tetra Tech, Inc. in July/August 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 8-12-2016.

Legend

Well Not Found

Well Found

Oil and Gas Well Location
- ⌖ Dry
- ☼ Dry w/ Gas Show
- ☼ Dry w/ O&G Show
- ⌖ Dry w/ Oil Show
- ☼ Gas
- ☼ Gas w/ Oil Show
- ● Oil
- ✹ Oil and Gas
- ✹ Oil w/ Gas Show
- ☼ Salt Water Disp
- ★ Unknown
- ◑ Pre-Existing Monitoring Well
- ◎ New Monitoring Well

Geologic Unit Groupings
- 🔴 Lower Connellsville SS/Lower Clarksburg RB
- 🔵 Morgantown SS/Birmingham RB
- 🟡 Grafton SS/Pittsburgh RB
- 🟢 Saltsburg SS/Alluvium
- 🟧 Approximate Waste Boundary
- ---- Approximate Parcel Boundary
- — Slurry Pipeline
- — Topographic Contour (10-foot)

TETRA TECH

OIL AND GAS WELL LOCATION MAP
PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY
FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 09/13/19
CHECKED BY: D. MOORE 09/13/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00070

FIGURE NUMBER
6

REVISION
1

ATTACHMENT A

Boring Logs with Observations of Potential Oil and Gas Well Impacts

Figur 1.

PROJECT McElroys Run
GAI PROJECT NO. 81-237-44
CONTRACT NO.
DATES DRILLED: 9-2-93 thru. 9-7-93 & 9-21-93
DATES INSTRUMENTED:

gai CONSULTANTS, INC.

NON - SAMPLED BOREHOLE LOG

BOREHOLE NO. GW-3
NORTH COORDINATE: 500,943.98
EAST COORDINATE: 2,346,506.67
SURFACE ELEVATION: 942.98
INSPECTOR: A. Caffas

DEPTH		MATERIAL DESCRIPTION					REMARKS
FROM	TO						
0.0	3.0	Tan-Brn Silty Clay trace Dec. Shale					
3.0	12.0	Tan-Brn Dec. to Highly Weathered Silty Shale					
12.0	12.5	Red/Brn Clayey Shale					
12.5	26.0	Tan Highly Weathered to Dec. Silty Shale					
26.0	30.0	Tan-Gry Highly Weathered Shale					
30.0	38.0	Gry Silty Shale w/ Sandy Zones					Stopped @ 30.0' 9-2-93, Casing set to ~30.0' Resumed drilling 9-7-93 @ ~1030
38.0	40.0	Red w/ Gry Claystone					
40.0	41.0	Tan-Gry Finegrained Sandstone to Siltstone					
41.0	47.0	Tan Sandstone					Limy
47.0	50.0	Gry Siltstone					
50.0	51.0	Tan Siltstone					
51.0	52.0	Brn Sandstone					Moist
52.0	57.0	Tan & Gry Sandstone					
57.0	60.0	Gry Sandstone w/ Shale Partings					
60.0	69.0	Gry (w/ Tan-Brn Zones) Sandstone					Driller started adding water @ 61.0' (hole dry to 61.0') Iron Staining 65.0'-69.0'
69.0	73.0	Gry Interbedded Sandstone & Clayey Shale					Light Hydrocarbon odor
73.0	81.0	Gry Sandstone					Slightly limy cementation, weakly cemented sand particles Iron Staining 76.0'-80.0'
81.0	86.0	Gry Sandstone					Limy
86.0	90.0	DK Gry-BL Limestone & Sandstone					
90.0	95.0	Gry Sandstone					Limy

SUMMARY:

DRILLING (LF): 13 3/4" ~~13 7/8"~~ 30.0 , 10 5/8" ~~12 1/4"~~ 235.0 , 9 7/8" ____ , 7 7/8" ____ , 5 7/8" ____
CASING (LF): 12" 31.3 , 10" ____ , 8" ____ , 6" ____
THERMOCOUPLE (LF): ____ GAS SAMPLING TUBE (LF): ____ INSTRUMENTATION: ____ CAP: ____
STANDBY TIME: ____ EXPLANATION: ____ *BOREHOLE NO.* GW-3
BOREHOLE SEAL: ____ EXPLANATION: ____
PAGE 1 of 3
REMARKS: Davey - Kent DR-30 Trackmounted Air Rotary Drill used to drill borehole.

Field Classification Sheet for Non-Sampled Borehole

Figur 1.

PROJECT McElroys Run Disposal Site
GAI PROJECT NO. 81-237-44
CONTRACT NO.
DATES DRILLED: 8/30 - 8/31/93
DATES INSTRUMENTED:

CONSULTANTS, INC.

NON - SAMPLED BOREHOLE LOG

BOREHOLE NO. GW-4
NORTH COORDINATE:
EAST COORDINATE:
SURFACE ELEVATION: ~ 920.0 Ft.
INSPECTOR: F. Lotito

DEPTH		MATERIAL DESCRIPTION					REMARKS
FROM	TO						
0	14.5	Decomposed Tan Silty shale					- large Tan sandstone Fragments
14.5	20.0	GRAY claystone					
20.0	23.0	Red silty shale					
23.0	24.0	GRAY shale					
24.0	27.5	GRAY Sandstone					
27.5	36.0	GRAY and GRAY/green shale					
36.0	37.0	Red shale					
37.0	38.5	GRAY Sandstone					
38.5	40.0	GRAY SANDY SHALE					
40.0	58.0	GRAY Sandstone					57.0' Hydrocarbon odor
58.0	60.0	DK. GRAY Claystone					
60.0	65.0	GRAY Sandstone					
65.0	67.0	Lt. GRAY Sandstone					Thin limestone layer between
67.0	75.0	Red/Brn. Claystone					65.0'-74.0'
75.0	77.0	DK. GRAY Claystone					
77.0	82.0	Red/Brn. Claystone					stopped at 80.0' on 8-30-93
82.0	83.0	Limestone					started at 80.0' on 8-31-93
83.0	89.0	Red/Brn. Claystone/shale					
89.0	91.5	Blue/GRAY Limy Claystone					
91.5	93.0	Red/GRAY Limy Claystone					

SUMMARY:

DRILLING (LF): ~~13 7/8"~~ 13 3/4" 27.0 , 12 1/4" ____ , ~~9 7/8"~~ 10 5/8" 199.5 , 7 7/8" ____ , 5 7/8" ____

CASING (LF): ~~12"~~ 12 3/4" 28.5 , 10" ____ , 8" ____ , 6" ____

THERMOCOUPLE (LF): ____ GAS SAMPLING TUBE (LF): ____ INSTRUMENTATION: ____ CAP: ____

STANDBY TIME: ____ EXPLANATION: ____

BOREHOLE NO. GW-4

BOREHOLE SEAL: ____ EXPLANATION: ____

PAGE 1 of 4

REMARKS: Lambert Drilling Co., Jim Crockett - Foreman, Nick Cursi - Driller, Helpers - Randy Kennedy, Bill Minor, Dale Myers, Aux; Davey Kent DR-30 Track-mounted Drill Rig

Field Classification Sheet for Non-Sampled Borehole

figur 1.

PROJECT APS-McElroys Run
GAI PROJECT NO. 81-237-44
CONTRACT NO.
DATES DRILLED: 9/13-9/14/93
DATES INSTRUMENTED:

gai CONSULTANTS, INC.

NON - SAMPLED BOREHOLE LOG

BOREHOLE NO. GW-5
NORTH COORDINATE:
EAST COORDINATE:
SURFACE ELEVATION:
INSPECTOR: F.J. Lotito

DEPTH		MATERIAL DESCRIPTION					REMARKS
FROM	TO						
130.0	133.0	Grey Clayshale					
133.0	134.0	Grey Fine-grained Sandstone					
134.0	136.5	Brn. Clayshale					~135.0' Hydrocarbon odor
136.5	138.0	Dark Grey Clayshale					
138.0	146.0	Red/Brn. Clayshale					
146.0	158.0	Grey to Grey/Red Clayshale					
158.0	159.0	Grey Silty Clayshale					
159.0	173.0	Grey Sandstone					
173.0	174.0	Grey Clayshale					
174.0	177.0	Grey Sandstone					
177.0	178.5	Grey Clayshale					
178.5	179.0	Grey Sandstone					
179.0	179.5	Grey Clayshale					
179.5	193.0	Grey Sandstone					~180.0' Excess water coming
193.0	199.0	Grey to Red/Brn. Clayshale					out of borehole, water
199.0	210.0	Grey Medium-grained Sandstone					has Hydrocarbon odor
210.0	213.0	Grey Clayshale					and sheen
213.0	214.0	Grey Sandstone					
214.0	215.0	Grey Clayshale					
215.0	240.0	Grey Sandstone					~225.0' Drilling resumed 0815 on 9/14, no water being added to air rotary, borehole producing alot of water.

SUMMARY:

DRILLING (LF): 13 7/8" ____, 12 1/4" ____, 9 7/8" ____, 7 7/8" ____, 5 7/8" ____

CASING (LF): 12" ____, 10" ____, 8" ____, 6" ____

THERMOCOUPLE (LF): ____ GAS SAMPLING TUBE (LF): ____ INSTRUMENTATION: ____ CAP: ____

STANDBY TIME: ____ EXPLANATION: ____

BOREHOLE NO. GW-5

BOREHOLE SEAL: ____ EXPLANATION: ____

PAGE 2 of 3

REMARKS:

Field Classification Sheet for Non-Sampled Borehole

Figur 1.

PROJECT APS - McElroys Run
GAI PROJECT NO. 81-237-44
CONTRACT NO.
DATES DRILLED: 9/23/93, 9/27/93
DATES INSTRUMENTED:

gai CONSULTANTS, INC.

NON - SAMPLED BOREHOLE LOG

BOREHOLE NO. GW-6
NORTH COORDINATE:
EAST COORDINATE:
SURFACE ELEVATION:
INSPECTOR: F.J. Lotito

DEPTH		MATERIAL DESCRIPTION					REMARKS
FROM	TO						
112.0	114.5	Grey shale					
114.5	118.0	Grey Sandstone					
118.0	120.0	Red/Brn Claystone					
120.0	121.0	Grey shale					
121.0	140.0	Grey Fine-Med. grained Sandstone					
140.0	145.0	Grey Shale					
145.0	147.0	Grey Claystone					
147.0	168.0	Grey to Red/Brn Claystone					
168.0	169.0	Grey Silty Shale					Top of Grafton
169.0	172.0	Grey Fine-Med. grained Sandstone					
172.0	173.0	Red/Brn Claystone					
173.0	186.0	Grey Fine-Med. grained Sandstone					
186.0	190.0	Grey shale to silty shale					
193.0	195.0	Grey Fine-Med. grained Sandstone					Blk. crude w/ cuttings & water
195.0	196.0	Grey/Red Silty Shale					~193.0 - 250.0'
196.0	198.0	Grey Sandstone					
198.0	207.0	Grey Siltstone					
207.0	210.0	Red/Brn. Siltstone					
210.0	214.0	Grey Siltstone					
214.0	221.0	Red/Brn Claystone					

SUMMARY:

DRILLING (LF): 13 7/8" ____, 12 1/4" ____, 9 7/8" ____, 7 7/8" ____, 5 7/8" ____
CASING (LF): 12" ____, 10" ____, 8" ____, 6" ____
THERMOCOUPLE (LF): ____ GAS SAMPLING TUBE (LF): ____ INSTRUMENTATION: ____ CAP: ____
STANDBY TIME: ____ EXPLANATION: ____
BOREHOLE SEAL: ____ EXPLANATION: ____
REMARKS:

BOREHOLE NO. GW-6

PAGE 2 of 3

Field Classification Sheet for Non-Sampled Borehole

. igu. d.

PROJECT APS- McElroys Run
GAI PROJECT NO. 81-237-44
CONTRACT NO.
DATES DRILLED: 9/29/93
DATES INSTRUMENTED:

gai CONSULTANTS, INC.

NON - SAMPLED BOREHOLE LOG

BOREHOLE NO. GW-7
NORTH COORDINATE:
EAST COORDINATE:
SURFACE ELEVATION:
INSPECTOR: F.J. Lotito

DEPTH		MATERIAL DESCRIPTION					REMARKS
FROM	TO						
0.0	20.0	Brn Silty Clay					
20.0	35.0	Brn Silty clay w/ Red/Grey Claystone					
35.0	38.0	Red/Brn silty clay					
38.0	42.0	Brn silty clay; Grey Sandstone 38-40.0'					
42.0	109.0	Grey and Red/Brn Claystone					
109.0	138.0	Grey Fine-Med. grained Sandstone					~114.0' Hydrocarbon odor, Black
138.0	146.0	Grey Claystone					Crude w/ cuttings
146.0	148.5	Grey Fine-Med. grained Sandstone					Top of Grafton 109.0'
148.5	150.0	Grey Sandy Siltstone					
150.0	153.5	Grey Fine-Med. grained Sandstone					
153.5	166.0	Grey Sandy Siltstone					
166.0	169.0	Grey Siltstone					
169.0	170.0	Brn. Fossiliferous Limestone					Ames LS

SUMMARY:
DRILLING (LF): ~~13 7/8"~~ 12 1/4" 20.0', ~~12 1/4"~~ 10 5/8" 150.0', 9 7/8" ____, 7 7/8" ____, 5 7/8" ____
CASING (LF): 12" 20.0', 10" ____, 8" ____, 6" ____
THERMOCOUPLE (LF): ____ GAS SAMPLING TUBE (LF): ____ INSTRUMENTATION: ____ CAP: ____
STANDBY TIME: ____ EXPLANATION: ____
BOREHOLE SEAL: ____ EXPLANATION: ____
REMARKS: Lambert Drilling Co., Davey-Kent DR-30 Track-mounted Drill Rig, Driller- Nick Cursi; Helpers- Randy Kennedy, Auz Kennedy

BOREHOLE NO. GW-7
PAGE 1 of 2

Field Classification Sheet for Non-Sampled Borehole

PROJECT APS - McElroys Run
GAI PROJECT NO. 81-237-44
CONTRACT NO.
DATES DRILLED: 10/25/93
DATES INSTRUMENTED:

gai CONSULTANTS, INC.

NON - SAMPLED BOREHOLE LOG

BOREHOLE NO. GW-7
NORTH COORDINATE: 496,263.30
EAST COORDINATE: 2,345,907.90
SURFACE ELEVATION: 916.83
INSPECTOR: F. J. Lotito

DEPTH		MATERIAL DESCRIPTION					REMARKS
FROM	TO						
0.0	6.0	Brn./Yellow Clay					
6.0	6.5	Brn. Clay w/ Grey Limestone nodules					
6.5	18.0	Red/Brn. and Brn./Yellow Clay					
18.0	22.0	Grey Sandy Shale					
22.0	30.0	Grey Fine-grained Sandstone					
30.0	39.0	Grey Silty Claystone					
39.0	40.0	Red/Brn Claystone					
40.0	45.0	Grey Claystone w/ Tan Cherty Limestone					
45.0	49.5	Grey Fine-grained Sandstone					
49.5	51.0	Grey Claystone					
51.0	53.0	Grey Fine-grained Sandstone w/ Cherty Matrix					
53.0	60.0	Grey Fine-grained Sandstone					
60.0	77.5	Grey Silty Claystone					~77.0' Blk. Natural Crude w/ odor
77.5	80.0	Dk. Grey Fossilliferous Limestone					Ames LS
80.0	84.0	Dk. Grey Limestone					
84.0	87.0	Blk. Coal					
87.0	99.0	Dk. Grey Claystone					
99.0	102.0	Grey Limestone					
		Bottom of Boring 102.0'					

SUMMARY:

DRILLING (LF): ~~13 7/8"~~ 13 1/4" 20.0', ~~12 1/4"~~ 10 5/8" 82.0', 9 7/8" ____, 7 7/8" ____, 5 7/8" ____

CASING (LF): ~~12"~~ 12 1/4" 19.5', 10" ____, 8" ____, 6" ____

THERMOCOUPLE (LF): ____ GAS SAMPLING TUBE (LF): ____ INSTRUMENTATION: ____ CAP: ____

STANDBY TIME: ____ EXPLANATION: ____

BOREHOLE NO. GW-7

BOREHOLE SEAL: ____ EXPLANATION: ____

PAGE 1 of 1

REMARKS:

gai CONSULTANTS, INC.

PROJECT APS- McELROYS RUN PROJECT NO. 81-237-66
ELEVATION 903.19 GWL 0 HRS 17' (AFTER HOLE PLUG) BORING NO. P-96-4
24 HRS 23'
DATE 5/20/96 FIELD ENGINEER RON ARCURI PAGE NO. 9 OF 16

DEPTH FEET	BLOWS PER SIX INCHES OR CORE RECOVERY/RUN	SAMPLE NO., TYPE & RECOVERY OR % ROCK RECOVERY	RQD (%)	DESCRIPTION: PROFILE	DESCRIPTION: SOIL DENSITY— CONSISTENCY OR ROCK HARDNESS	DESCRIPTION: COLOR	DESCRIPTION: MATERIAL CLASSIFICATION	USCS OR ROCK BROKENNESS	REMARKS*
1	2	3	4	5	6	7	8	9	10
			7.8/		MED. SOFT	GRAY	SILTSTONE	M	
		7.8/	/10.0				(CLAYSTONE 242.2'-243.3' & 242.7'-243.5')		
		/10.0 98%	78%						
					↓	↓	↓	↓	
245.0		◆		244.8	MED. SOFT	GRAY	SANDY SILTSTONE	M	
			10.0/						
		10.0/	/10.0						
		/10.0 100%	100%						
250.0									
				253.1	↓	↓	↓	↓	
					MED. HARD	GRAY	SANDSTONE	M	
255.0		◆		254.8					
									RUN SMELLS LIKE OIL
			[illegible]/						
		9.8/	/10.0						
		/10.0 98%	[illegible]						
260.0									
									ENDED DRILLING ON
265.0		◆		264.8					5/20/96 AT 264.8'
			10.0/						
		10.0/	/10.0						
		/10.0 100%	100%						
270.0					↓	↓	↓	↓	

REMARKS** HQ ROCK CORING WITH WATER

PROJECT NO. 81-237-66
BORING NO. P-96-4

*POCKET PENETROMETER READINGS
**METHOD OF ADVANCING AND CLEANING BORING

gai CONSULTANTS, INC.

PROJECT ALLEGHENY POWER - MCELROY'S RUN PROJECT NO. 81-237-72
ELEVATION ________ GWL 0 HRS ________ BORING NO. P-96-5
HRS
DATE 7 OCT 96 FIELD ENGINEER J.M. GALVIN PAGE NO. 14 OF 19

DEPTH FEET	BLOWS PER SIX INCHES OR CORE RECOVERY/RUN	SAMPLE NO., TYPE & RECOVERY OR % ROCK RECOVERY	RQD (%)	DESCRIPTION: PROFILE	DESCRIPTION: SOIL DENSITY— CONSISTENCY OR ROCK HARDNESS	DESCRIPTION: COLOR	DESCRIPTION: MATERIAL CLASSIFICATION	USCS OR ROCK BROKENNESS	REMARKS*
1	2	3	4	5	6	7	8	9	10
					MED HARD	GRAY	SILTSTONE	M	
394.8	◈								
400	10.0 10.0	100%	100						
404.8	◈								
				406.1 406.8			LIMESTONE (AMES)		FOSSILIFEROUS
					MED HARD		SILTSTONE		
410	10.0 10.0	100%	100						
				411.8					
					HARD		SANDSTONE (JANE LEW)		MID ∠ CLOSED
									FRACS AT 412.8,
414.8	◈								413.1 FT. MID ∠
									OPEN FRAC AT
									413.2, CRUDE
									OIL ODOR 411.8
									-442.6 FT
420	10.0 10.0	100%	100						

REMARKS** ________________________________

PROJECT NO. 81-237-72
BORING NO. P-96-5

*POCKET PENETROMETER READINGS
**METHOD OF ADVANCING AND CLEANING BORING

CONSULTANTS, INC.

PROJECT ALLEGHENY POWER - MCELROY'S RUN
PROJECT NO. 81-237-72
ELEVATION ______ GWL 0 HRS ______
HRS
BORING NO. P-96-5
DATE 7 OCT 96 FIELD ENGINEER J.M. GALVIN
PAGE NO. 15 OF 19

DEPTH FEET	BLOWS PER SIX INCHES OR CORE RECOVERY/RUN	SAMPLE NO., TYPE & RECOVERY OR % ROCK RECOVERY	RQD (%)	DESCRIPTION PROFILE	SOIL DENSITY—CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS OR ROCK BROKENNESS	REMARKS*
1	2	3	4	5	6	7	8	9	10
					HARD	GRAY	SANDSTONE (JANE LEW)	M	CRUDE OIL ODOR
									411.8-442.6 FT
424.8									
									OPEN, MID TO LOW
									∠ FRACS AT 430.9,
430	10.0 10.0	100%	96						431.6, 432.7,
									432.9, 436.4
434.8									
									CLAY FILLED
									HORIZ FRAC AT
									437.8
440	10.0 10.0	100%	96						
				442.6	↓	↓	↓	↓	
					MED SOFT	RED +	CLAYSTONE (PITTSBURGH	BR	MID ∠ OPEN
444.8						GRAY	RED BEDS)		FRAC AT 446.4
									450.6 FT
									WEATHERED ZONE
450	10.0 10.0	100%	72		↓	↓	↓	↓	AT 449.2 FT

REMARKS** ______

PROJECT NO. 81-237-72
BORING NO. P-96-5

*POCKET PENETROMETER READINGS
**METHOD OF ADVANCING AND CLEANING BORING

PROJECT McELROY'S RUN

GAI PROJECT NO.: 81-237-31

CONTRACT NO.:

DATE STARTED: 7/26/90

DATE COMPLETED: 7/31/90

SIGNATURE OF INSPECTOR:

BOREHOLE NO.: N-3

DRILLING COMPANY: LAMBERT DRILLING CO.

DRILL TYPE: ACKER AD-2

NAME OF DRILLER: DON REMERER

CORE SIZE: NQ (2" DIAM.)

NUMBER OF CORE BOXES: 28

NORTH COORDINATE: S 6384

EAST COORDINATE: E 9352

SURFACE ELEVATION: 916.4

DEPTH OF HOLE: 414.8

GWL @ COMPLETION: 12.3

24 HR 33.1

DRILLING DATA						ROCK DESCRIPTION				DISCONTINUITIES						REMARKS
DEPTH (FT.)	CORE BOX NO.	CORE RECOVERY (FT.)	CORE RUN (FT.)	CORE RECOVERY (%)	RQD (%)	COLOR	ROCK HARDNESS	MATERIAL CLASSIFICATION	ROCK BROKENNESS	TYPE	ORIENTATION	TIGHTNESS	DEGREE OF WEATHERING	FILLING MATERIAL	AVG. FRACTURE SPACING (FT.)	
400.0						GRAY	M.HARD	SANDSTONE – FINE	MASSIVE							
							-HARD	GRAINED								
404.6								404.6								
	27+28	10	10	100	100	GREEN/		SANDSTONE –								
						GRAY		FINE TO MEDIUM								OILY ODOR
								408.0 GRAINED								
								OIL SEAM								SANDSTONE SEAM
410.0																SATURATED WITH
								410.6								NATURAL CRUDE
																OIL, 408-410.6
414.6																
								BOTTOM OF BORING								
								EL. 501.8								

EPRI West Virginia
Groundwater Study

Allegheny Power System

Log of Well GW-13

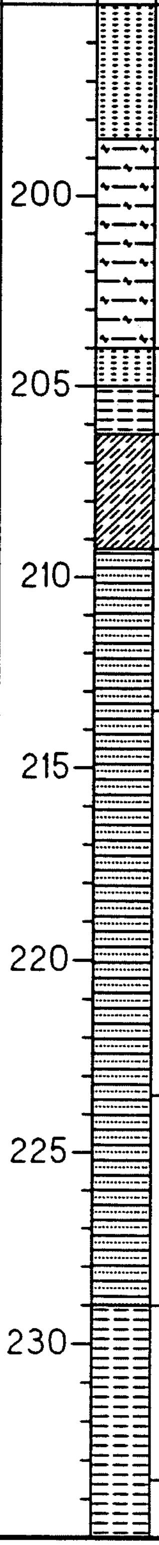
McElroy's Run Disposal Facility
Pleasants/Willow Island Power Station

Sheet 6 of 7

JOB NUMBER: 2008-202

LOGGED BY: G. Goldstein

Sample No./ Type	Sample Depth From/To	SPT (Blows/6")/ ROP (ft/min)	Recovery/ RQD (%)
20/NQ	193.5-203.5'	1.4	100/92
21/NQ	203.5-213.5'	0.6	100/96
22/NQ	213.5-223.5'	0.4	100/100
23/NQ	223.5-233.5'	1.6	100/82
24/NQ	233.5-243.5'		100/100



Materials Description

CLAYSTONE, 10 R 3/4, dark reddish brown, soft, weathered, highly fractured/faulted, not reactive to dilute HCL.

CLAYSTONE, N3, dark gray, fresh soft, not reactive to dilute HCL.

CLAYEY SILTSTONE, N4, medium dark gray, soft, fresh, not reactive to dilute HCL.

CLAYSTONE, 5 YR 4/1, brownish gray, soft, fresh, not reactive to dilute HCL.

CLAYEY SILT, N4, medium dark gray, interbedded silt and clayey silt.

SANDSTONE, N5, medium gray, medium sand grain size, hard, fresh, with quartz, not reactive to dilute HCL. Crude oil odor.

SANDSTONE, 5 G 4/1, dark greenish gray, medium sand grain size, fresh, hard, with quartz and chlorite. 3" limey seam at 217' BGS. Visual crude oil staining, crude oil odor.

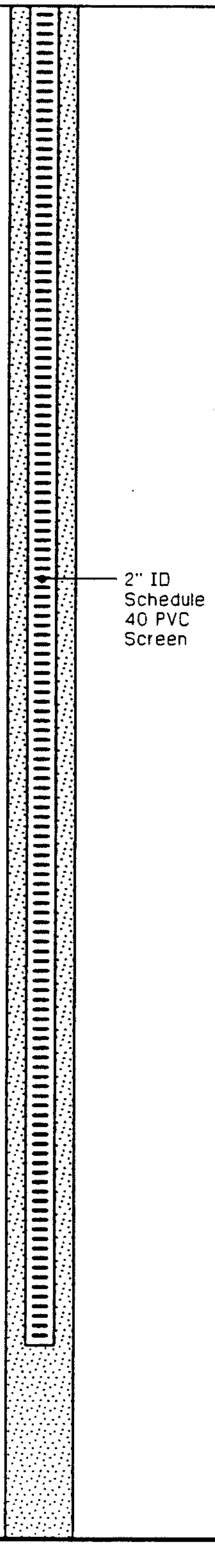
10" vertical fracture at 218.5' BGS.

Same

CLAYSTONE, N4, medium dark gray, very soft, fresh, not reactive to dilute HCL.

Same

Well Completion



cementation, and fracturing. In accordance with stress relief fracture theory, well yields are highest in the valleys, moderate on the hillsides, and minimal on the ridges (Shultz, 1984).

FIELD INVESTIGATION METHODS

Seven new monitoring wells (GW-13, GW-14, and GW-16 through GW-20) were installed for this study in 1995 (Figure 3-1). The wells were installed at locations where the bedrock aquifer has the potential for significant fracture development due to stress relief. In addition, ten existing monitoring wells were sampled for the study, and numerous boring logs from previous studies were available for geologic interpretation.

Monitoring wells GW-13, GW-14, and GW-20 are located on the east side of the McElroy's Run watershed. The wells were aligned along an eastward-trending transect identified as a potential groundwater flow path from the impoundment toward the neighboring French Creek watershed. The location of the transect coincides with small tributary valleys in the two watersheds. Wells GW-13 and GW-20 were installed as a cluster in order to investigate vertical gradients and water quality near the impoundment. Well GW-14 is located about 600 ft farther along the transect from the impoundment than the cluster. Boring GW-15 was drilled about 500 ft farther along the transect than GW-14. However, a thin layer (0.34 ft) of floating petroleum, analyzed as crude oil, was encountered in the borehole, and the borehole was abandoned.

Wells GW-16, GW-17, and GW-18 were installed in the valley bottom downstream from the impoundment dam. These three wells, along with existing wells MP-3 and MP-4, form a transect along the valley bottom from the dam to the Ohio River valley. Wells GW-16 and GW-17 were installed as a cluster to investigate vertical gradients and water quality near the toe of the dam. The MP-3/MP-4 well cluster is located approximately 1500 ft downgradient from the GW-16/17 cluster. MP-4 is installed in the shallow bedrock aquifer; MP-3 is an overburden well installed in the McElroy's Run valley alluvium. GW-18 is a bedrock well sited at the base of the McElroy's Run valley, near its junction with the Ohio River valley

Well GW-19 is located north of the impoundment. The well is aligned with pre-existing well GW-3 along a potential flow path through the ridge that separates the impoundment valley from the Ohio River.

Construction of these wells included coring, drilling, geophysical logging and packer testing. Each of these operations is summarized below. Additional detail is provided in Appendix A.

EPRI West Virginia
Groundwater Study

Allegheny Power System

Log of Well GW-19

McElroy's Run Disposal Facility
Pleasant's/Willow Island Power Station

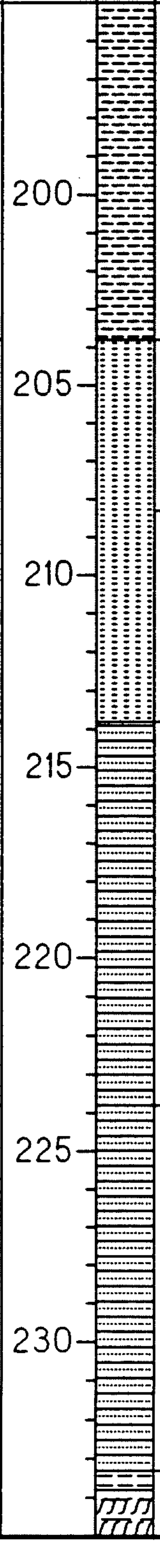
Sheet 6 of 7

JOB NUMBER: 2008-202

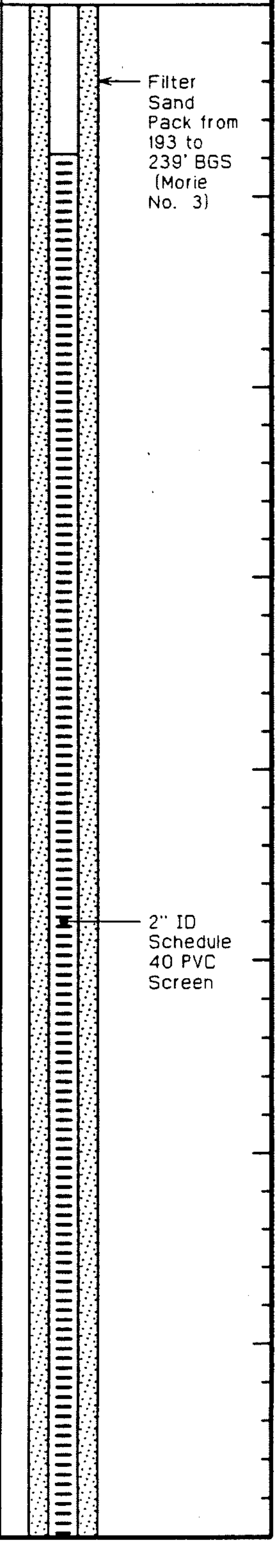
LOGGED BY: G. Goldstein

Sample No./ Type	Sample Depth From/To	SPT (Blows/6")/ ROP (ft/min)	Recovery/ RQD (%)	Materials Description
19/NQ	193.8-203.8'	1.4 1.2	100/87	CLAYSHALE, 5 G 6/1, greenish gray, hard, fresh, minor calcite viens, not reactive to dilute HCL. Horizontal fracture at 198.8' BGS.
20/NQ	203.8-213.8'	0.8	100/95	CLAYEY SILTSTONE, N7, light gray, medium hardness, fresh, minor calcite, not reactive to dilute HCL. SILTSTONE, N7, light gray, hard, fresh, not reactive to dilute HCL. Large fracture at 211.8' BGS ~1' long.
21/NQ	213.8-223.8'	0.8 0.6	100/25	SANDSTONE, N6, medium light gray, fine to medium sand grain size, hard fresh, not reactive to dilute HCL. Crude oil odor. Series of fractures in bottom 5' of core.
22/NQ	223.8-233.8'	0.8	100/95	SANDSTONE, N7, light gray, hard, fresh, small 3" clay seam at ~229' BGS, minor quartz, not reactive to dilute HCL. Crude oil odor.
23/NQ	233.8-243.8'	1.2	100/95	CLAYSTONE, N7, light gray, soft, fresh, few fossils, not reactive to dilute HCL.

Depth (feet) / Graphic Log



Well Completion



LOG OF BORING GW-24

(Page 2 of 6)

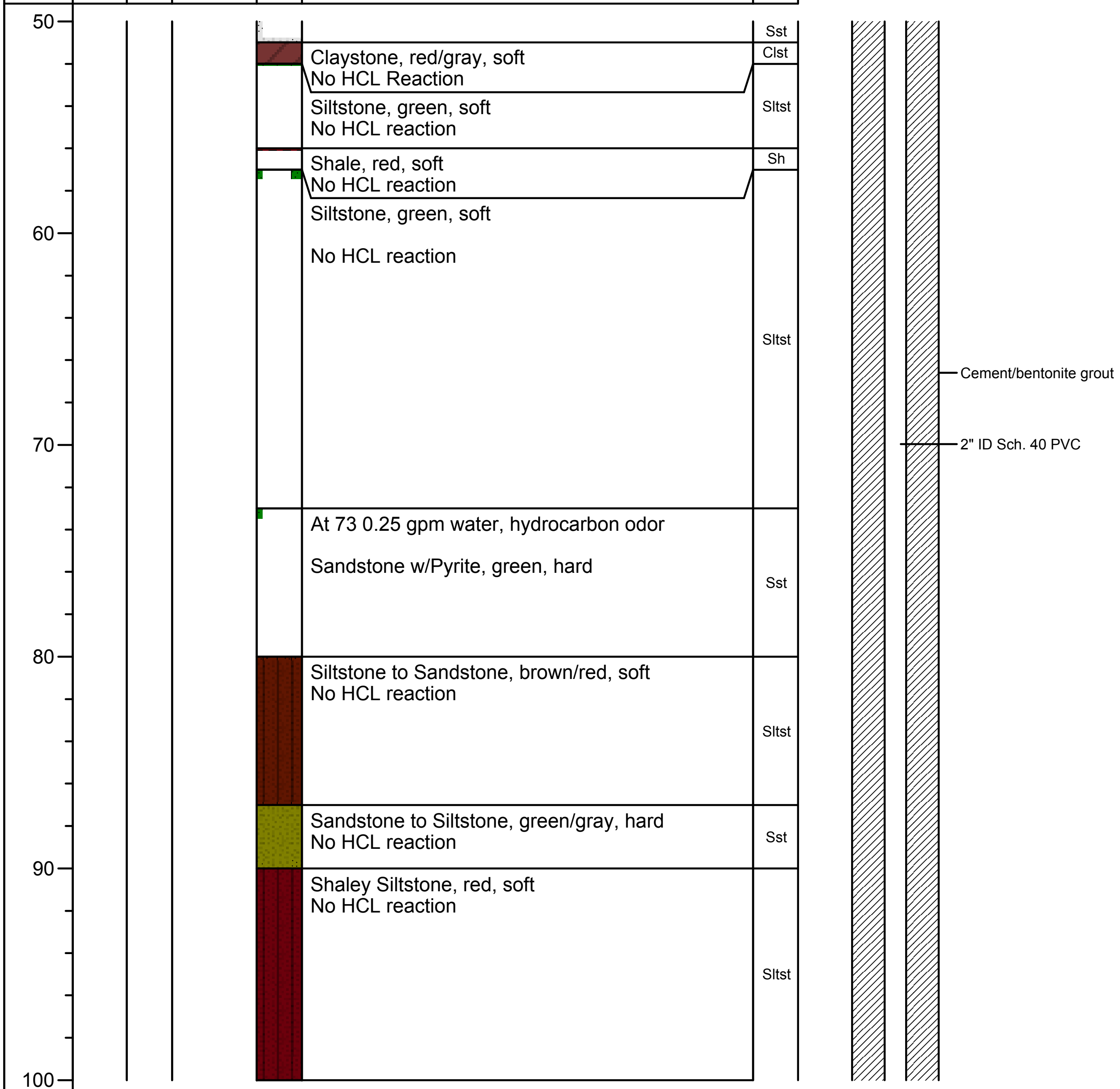
Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/12/16	Ground Elevation	: 944.56
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1469894.54	Northing	: 320797.11

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion



DESCRIPTION	USCS or Rock type
	Sst
Claystone, red/gray, soft No HCL Reaction	Clst
Siltstone, green, soft No HCL reaction	Sltst
Shale, red, soft No HCL reaction	Sh
Siltstone, green, soft No HCL reaction	Sltst
At 73 0.25 gpm water, hydrocarbon odor Sandstone w/Pyrite, green, hard	Sst
Siltstone to Sandstone, brown/red, soft No HCL reaction	Sltst
Sandstone to Siltstone, green/gray, hard No HCL reaction	Sst
Shaley Siltstone, red, soft No HCL reaction	Sltst

11-21-2017 Z:\000_Primary Work\First Energy\M-Tech\GW-24\GW-24_5.bor

TETRA TECH

LOG OF BORING GW-25

(Page 5 of 7)

Tetra Tech, Inc.
661 Andersen Dr
Pittsburgh, PA 15220

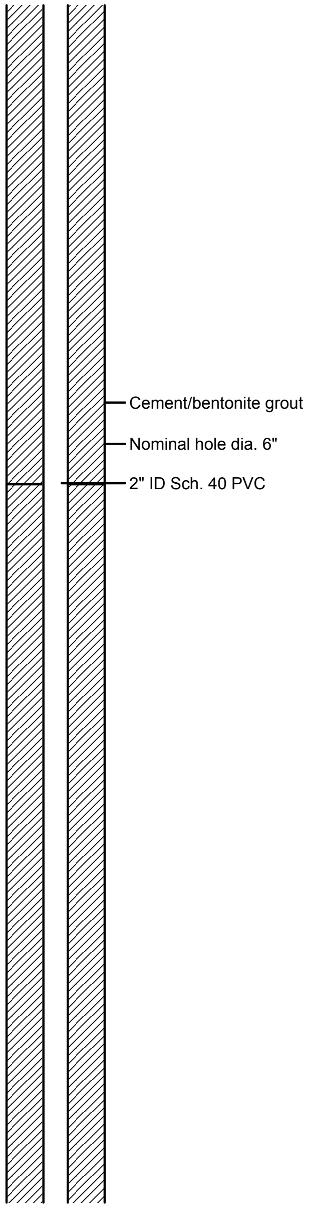
First Energy CCR, Pleasants Power

Project	: 212C-SW-00069	Drilling Contractor	: Eichelbergers
Site	: Pleasants Power	Logged By	: Scott Anderson
Date	: 7/25/16	Ground Elevation	: 1009.13
Drilling Method	: Rotary Air Hammer	Driller	: Randy Hoffman
East	: 1468884.46	Northing	: 321494.03

Sample Type
- ☒ Split Spoon
- ▦ Air Hammer Drill Cuttings

Water Levels
- ▼ During Drilling
- ▽ After Completion

Depth in Feet	Sample Type	Rec. %	Blow Count	GRAPHIC	DESCRIPTION	USCS or Rock type
200						Sst
					Sandstone, Limestone, Shale, purple/red, hard	Sst
210					Limestone green/gray with Claystones red, soft Strong HCL reaction At 214-215 Claystone red At 216-216.5 Claystone red	LS
220						
230					Very fine Sandstone green/gray and Siltstone, hard No HCL reaction At 230 Hydrocarbon odor Below 235, more Shaley	
240					Increasing Sandstone with depth to 250	Sst
250						



ATTACHMENT B

GW-23 Oil Fingerprinting Laboratory Report

FirstEnergy

BETA Laboratory
ISO 9001 Registered

File No. 17-95225

BETA Laboratory

Chemical Analysis
6670 Beta Dr., Mayfield Village OH 44143 (440)-604-9832

TO Edward Newbaker **MAIL STOP** G-CH

FROM J. L. Hirsch **DATE** 4/28/17
PHONE 824-9832 **MAIL STOP** BETA
SUBJECT Analysis of oil floating on a Pleasants GW-23-CCR water sample

Requisition No.: 170428008
LSN# AK06089

A water sample from the Pleasants Ground Water 23-CCR location was submitted for water analysis but when the container was opened an oil film was present on the water's surface. The oil was extracted off the water and analyzed using a FT Infrared Spectrometer.

Results:

1) The oil was identified and a straight chain hydrocarbon oil (mineral oil).

Discussion:

The oil was extracted off the surface of the water using a dropper and the water was removed from the residue. The oil was then analyzed on the FT Infrared Spectrometer. ATTACHMENT 1 shows the results.

The FT Infrared Spectrometer was calibrated with Standard Reference Material (SRM)1921b, which is a matte finish polystyrene film certified by the National Institute of Standards and Technology (NIST). There was no Sample Analysis Request / Chain of Custody submitted for this analysis.

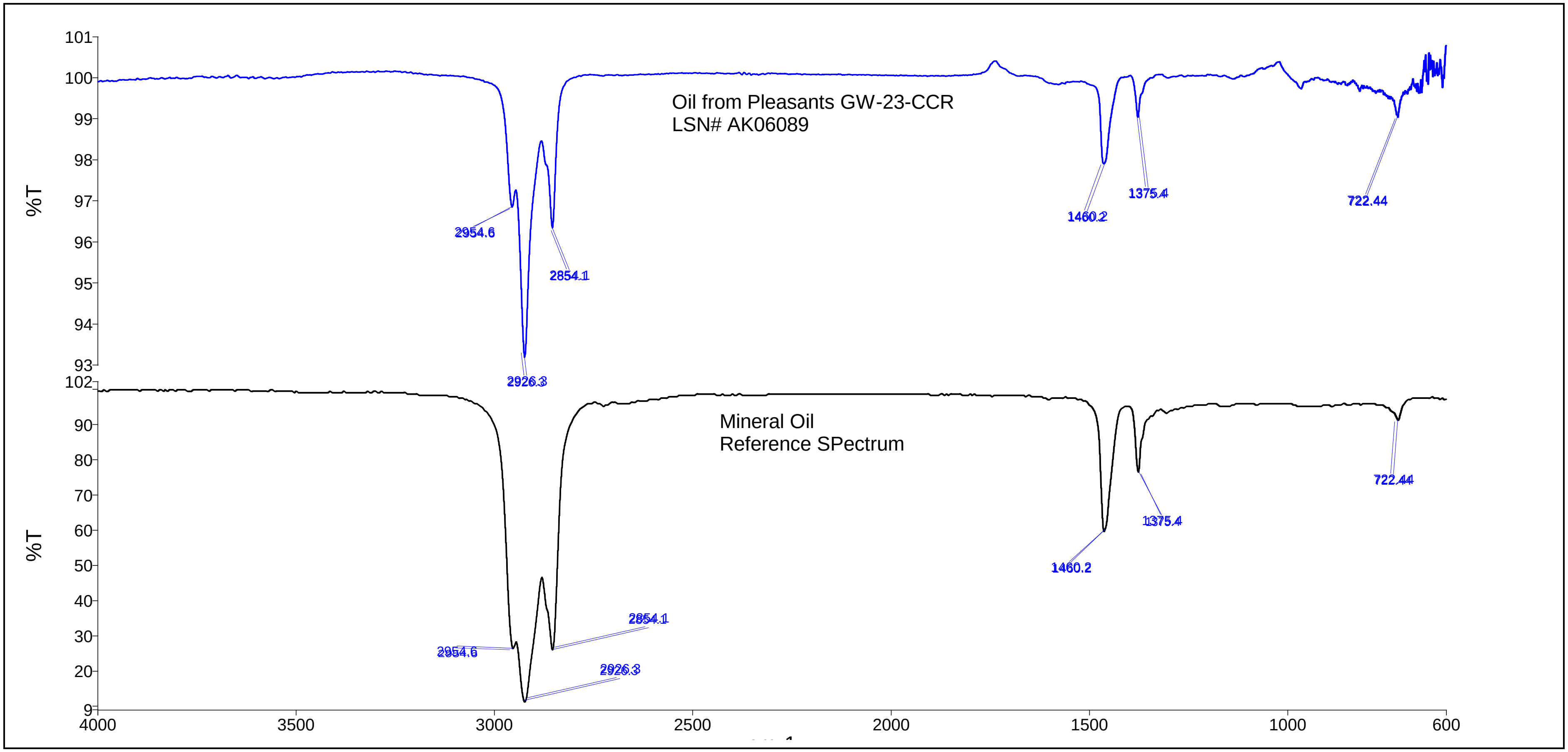
Material Test Equipment

Instrument Model: Perkin Elmer Frontier FT-IR Spectrometer, BETA 0755, Calibration Due: 5/4/17

Analysis Performed By__________________ on 4/27/17

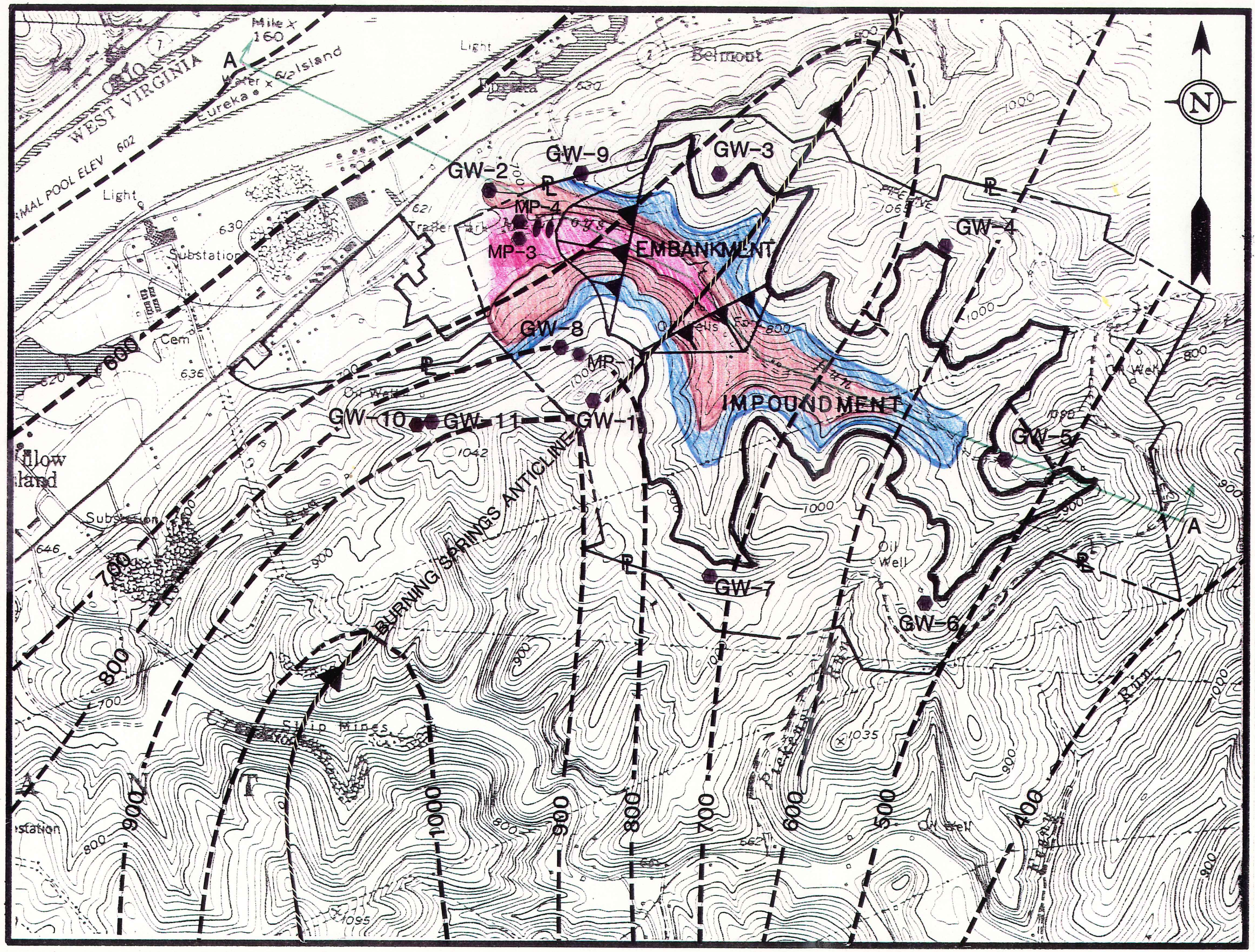
Reviewed By__________________. Date 4/28/17

ATTACHMENT 1: FTIR Spectrographic Analysis of the oil removed from the surface of the Pleasants GW-23-CCR water sample indicates the oil is a straight chain hydrocarbon mineral oil.
Instrument: Perkin Elmer Frontier FT-IR Spectrometer, BETA 0755, Calibration due 5/4/17
Performed by J. Hirsch on 4/27/17



APPENDIX B

Geologic Cross-Sections



LEGEND

⬢ MONITORING WELL LOCATION

FORMATION

🟦 APPROX. GRAFTON SANDSTONE

⬛ APPROX. AMES LIMESTONE–LOWER HARLEM COAL

🟥 APPROX. PITTSBURGH RED BEDS

● SEDIMENTATION POND

A — A LINE FOR GEOLOGIC CROSS-SECTION (FIG. 2)

– – 500 – – ELEVATION CONTOUR-TOP OF AMES LIMESTONE

FIGURE 1

REFERENCE:

7.5 MINUTE SERIES, U.S.G.S. TOPOGRAPHIC QUADRANGLE,

WILLOW ISLAND, WEST VIRGINIA 1957,

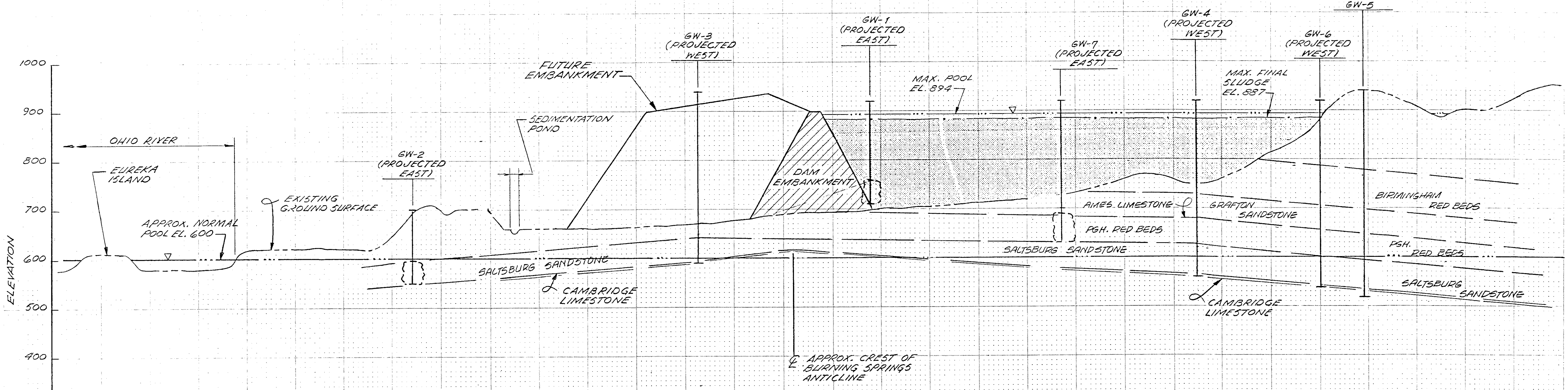
PHOTOREVISED 1976

gai CONSULTANTS, INC.
Engineers • Geologists • Planners
Environmental Specialists
570 Beatty Rd. • Pittsburgh,
Monroeville, Pa. 15146
412-856-6400

GEOLOGIC MAP, SITE PLAN
AND MONITORING WELL LOCATIONS FOR
McELROY'S RUN EMBANKMENT AND IMPOUNDMENT AREA

ALLEGHENY POWER SYSTEM
MONONGAHELA POWER COMPANY
PLEASANTS POWER STATION
PLEASANTS COUNTY, W. VA.

DWN. JAL
CHKD. [illegible]
APPD. JDP
DATE 8-24-92
SCALE: 1"≈1200'
DRAWING NUMBER
81-237-11
REV



SECTION A-A

APPROX. HORIZONTAL SCALE: 1"=400'
VERTICAL SCALE: 1"=100'

LEGEND

GW-1 | PROPOSED BORING LOCATION

—··— APPROX. OHIO RIVER POOL EL. 600

▨ FGD SLUDGE

{ } UPDIP BORING PROJECTED ONTO SECTION

NOTE:
THE STRATA IN THE UPSTREAM END OF THE IMPOUNDMENT ARE PROJECTED.

REFERENCE:
GAI REPORT TITLED "SUPPLEMENT TO SOLID WASTE/NPDES PERMIT APPLICATION NO. WV0079171 SOLID WASTE PORTION McELROY'S RUN DISPOSAL FACILITY PLEASANTS POWER STATION PLEASANTS COUNTY, WEST VIRGINIA. GROUND-WATER ASSESSMENT," DATE OCTOBER, 1990

DESCRIPTION	NO.	DATE
REVISED TITLE BLOCK	2	9-1-92
REVISED PROPOSED MONITORING WELL LOCATIONS AND NUMBERS	1	2/24/92

REVISIONS

FIGURE 2

GENERALIZED GEOLOGIC SECTION A-A
McELROY'S RUN

gai CONSULTANTS, INC.
Engineers • Geologists • Planners
Environmental Specialists
570 Beatty Rd • Pittsburgh
Monroeville, Pa. 15146
412-856-6400

ALLEGHENY POWER SYSTEM
MONONGAHELA POWER COMPANY
PLEASANTS POWER STATION
PLEASANTS COUNTY, W. VA.

DRAWN: G.Y.
CHECKED: SRW
APPROVED: SRW
DATE: 2-24-92
SCALE: AS NOTED
DRAWING NUMBER: 81-237-E22
REV: 2

ATTACHMENT 3-4

Semi-Annual Selection of Remedy Report (1Q and 2Q 2020)

SEMI-ANNUAL SELECTION OF REMEDY (SoR) PROGRESS REPORT (Q1 and Q2 2020)

McELROY'S RUN COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY

Pleasants Power Station
Pleasants County, West Virginia

Prepared for:

Allegheny Energy Supply Company
A Wholly Owned Subsidiary of FirstEnergy

800 Cabin Hill Drive
Greensburg, PA 15601

Prepared by:

Tetra Tech, Inc.

400 Penn Center Boulevard, Suite 200
Pittsburgh, PA 15235
Phone: (412) 829-3600
Fax: (412) 829-3260

Tetra Tech Project No. 212C-SW-00070

August 2020

TABLE OF CONTENTS

1.0 INTRODUCTION

This Semi-Annual Selection of Remedy (SoR) Progress Report was prepared by Tetra Tech, Inc. (Tetra Tech) on behalf of Allegheny Energy Supply Company (AESC) for the Coal Combustion Byproduct Disposal Facility ("CCBDF", "CCR unit", or "Site") at the Pleasants Power Station (hereinafter referred to as the "Station"). The Station and CCBDF are located near the town of Belmont in Pleasants County, West Virginia. The period covered by this report is the first two quarters (Q1 and Q2) of calendar year 30th). (January 1st through June

As per 40 CFR 257.97(a), once a Coal Combustion Residual (CCR) unit has completed an Assessment of Corrective Measures (ACM) and transitions to SoR, "The owner or operator must prepare a semiannual report describing the progress in selecting and designing the remedy." Accordingly, this report summarizes the progress to date in selecting and designing the remedy for addressing arsenic concentrations in groundwater downgradient of the CCR unit and also includes a summary of anticipated SoR activities which will be conducted over the next SoR reporting period.

Detailed background information on the CCR unit, hydrogeologic site conditions, and CCR monitoring results can be found in various other documents on the CCBDF's publicly accessible website, the most recent of which being the 2019 Annual CCR Rule Groundwater Monitoring and Corrective Action Report (McElroy's Run CCB Disposal Facility 2019 Annual GWMCA Report). The following section provides background information as it relates to the SoR at the CCR unit.

1.1 Background

Groundwater Assessment Monitoring (AM) conducted at the site in accordance with the federal CCR Rule identified arsenic, barium, lithium and radium concentrations in certain downgradient CCR monitoring wells which were at Statistically Significant Levels (SSLs) above their corresponding Groundwater Protection Standards (GWPS). Pursuant to 40 CFR 257.95(g)(3)(ii), Tetra Tech performed an Alternative Source Demonstration (ASD) to assess if the Appendix IV SSLs determined for sampling events AM-1, -2, and -3 were attributable to a release from the CCR unit or from a demonstrable alternative source(s). The Appendix IV ASD is included as Attachment A of the ACM Report prepared for the Site (McElroy's Run CCB Disposal Facility 2019 ACM Report) and determined that the barium and radium SSLs can be attributed to historical and current oil and gas exploration and production activities that have occurred at the Site; that the source of the lithium SSLs are currently indeterminate but there is a high potential they are also attributable to oil and gas impacts at the Site; and that the arsenic SSLs could not be attributed to sources other than the CCR unit. As such, a transition to Nature and Extent (N&E) of release characterization and ACM for arsenic per 40 CFR 257.96 of the CCR Rule were implemented.

As required by 40 CFR 257.96(c), the ACM conducted by Tetra Tech on behalf of FE included an analysis of the effectiveness of potential corrective measures in meeting the remedy requirements and objectives as described under 40 CFR 257.97. The ACM Report evaluated the following corrective measures against the criteria referenced in 40 CFR 257.96(c): Source Control, Groundwater Extraction and Treatment, In-Situ Technologies and Monitored Natural Attenuation (MNA).

Based on the evaluation of viable remediation technologies, MNA, combined with source control by the eventual installation of a final cover system, ranks highest among the evaluated options. In September 2019, pursuant to 40 CFR 257.96(d), the ACM Report was posted in the CCR unit's Operating Record, and then subsequently posted to the facility's publicly accessible website on October 16, 2019 (McElroy's Run CCB Disposal Facility 2019 ACM Report).

1.2 SoR Regulatory Basis

SoR activities must be completed in compliance with 40 CFR 257.97(a), which states that as soon as feasible after completion of the ACM, a remedy must be selected that, at a minimum, meets the performance standards listed in 40 CFR 257.97(b), and considers the evaluation factors listed in 40 CFR 257.97(c).

2.0 CURRENT STATUS OF THE SELECTION OF REMEDY PROGRAM

The following activities have been performed during the current reporting period as part of selecting the remedy at the Site:

- 40 CFR 257.95(g)(1)(i) requires that the extent of groundwater impacts be defined by installing additional monitoring wells as necessary. In order to fulfill this requirement, six new downgradient monitoring wells, including three off-site locations, have been identified and field staked. These new monitoring wells will serve to better characterize the extent of arsenic in groundwater and to evaluate potential natural attenuation impacts on arsenic concentrations downgradient of the CCR unit. For the proposed off-site well locations, FE is currently negotiating right-of-access and lease agreements with the landowners so the new wells can be installed.
- Initiating development of a Natural Attenuation Evaluation Work Plan to include evaluating historic concentrations of parameters which can affect the natural attenuation of arsenic (e.g., iron, pH, ORP, etc.) as well as planning the sampling and analysis program that would be associated with future MNA activities.

- Initiated a review of candidate technologies with regard to their potential to meet the performance standards listed in 40 CFR 257.97(b) and the evaluation factors listed in 40 CFR 257.97(c).
- Continued AM with a sampling event in February 2020, which included sampling of the site's eleven CCR monitoring wells with analyses for all Appendix III and Appendix IV parameters along with targeted general chemistry parameters to assist in evaluating potential natural attenuation impacts.
- Determined February 2020 groundwater flow patterns in the monitoring network area downgradient of the CCR unit and found they were consistent with established flow patterns at the Site.

3.0 PLANNED SOR ACTIVITIES

The following activities are planned as part of the ongoing SoR process:

- Continue evaluation of the historic groundwater monitoring data set for relationships between key parameters affecting arsenic natural attenuation and arsenic concentrations in groundwater.
- Complete development of the Arsenic Natural Attenuation Evaluation Work Plan.
- Install, develop, and sample the six additional downgradient groundwater monitoring wells for arsenic and natural attenuation parameters.
- Continue evaluating the candidate technologies identified in the ACM against the performance standards listed in 40 CFR 257.97(b) and the evaluation factors listed in 40 CFR 257.97(c).
- As required by 40 CFR 257.96(e), FE will discuss the results of the corrective measures assessment at least 30 days prior to the final selection of remedy, in a public meeting.
- Upon completion of all required SoR activities, FE will prepare a final report describing the selected remedy and how it, at a minimum, meets the performance standards listed in 40 CFR 257.97(b) and considers the evaluation factors listed in 40 CFR 257.97(c).
- As required by 40 CFR 257.97(d), FE will specify, as part of the selected arsenic remedy, a schedule(s) for implementing and completing remedial activities.
- Complete the second scheduled 2020 AM sampling event at the Site.

Should the final remedy for the CCR unit not be selected during 3Q or 4Q 2020, then another Semi-Annual SoR Report will be prepared as required by 40 CFR 257.97(a).

ATTACHMENT 4-1

40 CFR 257.103(f)(2)(v)(C)(1) Compliance Certification

Attachment 4-1

Owner's Certification of Compliance Under 40 CFR § 257.103(f)(2)(v)(C)(1)

I hereby certify that, based on my inquiry of those persons who are immediately responsible for compliance with environmental regulations for the McElroy's Run Disposal Impoundment and Landfill (collectively the "Facility"), the Facility is in compliance with all of the requirements contained in 40 C.F.R. Part 257, Subpart D – *Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments*. The FirstEnergy publicly accessible CCR Compliance website is up-to-date and contains all the necessary documentation and notification postings.

On behalf of Allegheny Energy Supply Company, LLC:

George J. Farah
Vice President, Utility Services

ATTACHMENT 4-2

Structural Stability Assessment Report

McElroy’s Run Impoundment
Structural Stability Assessment Report

Allegheny Energy Supply Company, LLC
A FirstEnergy Company
Pleasants Power Station
Pleasants County, West Virginia

October 2016

Prepared for:
Allegheny Energy Supply Company, LLC
A FirstEnergy Company
800 Cabin Hill Drive
Greensburg, Pennsylvania 15601

Prepared by:
GAI Consultants, Inc.
Murrysville Office
4200 Triangle Lane
Export, Pennsylvania 15632-1358

Table of Contents

Certification/Statement of Professional Opinion

The Structural Stability Assessment for the McElroy's Run Impoundment was prepared by GAI Consultants, Inc. (GAI). The Assessment Report was based on certain information that, other than for information GAI originally prepared, GAI has relied on, but not independently verified. Therefore this Certification/Statement of Professional Opinion is limited to the information available to GAI at the time the Assessment Report was written. On the basis of and subject to the foregoing, it is my professional opinion as a Professional Engineer licensed in the State of West Virginia, that the Assessment has been prepared in accordance with good and accepted engineering practices as exercised by other engineers practicing in the same discipline(s), under similar circumstances, and at the time and in the same locale. It is my professional opinion that the Structural Stability Assessment was prepared consistent with the requirements of the United States Environmental Protection Agency's Federal Coal Combustion Residuals (CCR) Rule 40 CFR § 257.73(d), published in the Federal Register on April 17, 2015 with an effective date of October 19, 2015.

The use of the words "certification" and/or "certify" in this document shall be interpreted and construed as a Statement of Professional Opinion and is not and shall not to be interpreted or construed as a guarantee, warranty or legal opinion.

Arica L DiTullio

Arica L. DiTullio, P.E.
Engineering Manager

ARICA LEE DITULLIO
21760
Arica L DiTullio

1.0 Purpose

Pursuant to the Federal Coal Combustion Residuals (CCR) Rule 40 CFR § 257.73(d)(1), each CCR impoundment is required to conduct an initial and periodic structural stability assessment to establish whether the CCR unit can safely store the maximum volume of CCR and wastewater.

2.0 Introduction

The Pleasants Power Station (Station) is a coal-fired electric generating station located near the community of Willow Island in Pleasants County, West Virginia (WV). The Station consists of two generating units which are capable of producing 1,300 megawatts of electricity.

CCRs generated at the Station are placed in the McElroy's Run CCR surface impoundment (Impoundment), which is located approximately one-half mile east-southeast of the Station. The Impoundment is a captive facility that receives flue gas desulfurization scrubber by-product generated at the Station, effluent from the recirculation system through Sedimentation Ponds 1 and 2 of the adjacent landfill and their underdrains, and waste materials collected primarily as a result of general house-cleaning maintenance and/or repair at the Pleasants Power Station.

The dam of the Impoundment is approximately 243 feet (ft) high with a maximum storage of approximately 20,000 acre-ft. The crest of the dam is at elevation (El.) 900 ft, with El. 887.00 ft as the permitted final level of CCR and recommended normal operating pool level. The Impoundment area is approximately 253 acres. The Pleasants Landfill, which accepts coal ash waste from the Station, abuts the dam of the impoundment.

3.0 Information Review

GAI Consultants, Inc. (GAI) reviewed the documents listed under the References section, which includes:

- Prior Dam Safety Assessments;
- Design and as-built drawings; and
- Surveys.

The documents were reviewed to determine if the design, construction, operation, and maintenance of the CCR unit is consistent with recognized and generally accepted good engineering practices.

3.1 Stable Foundations

Stability of foundations and abutments can be assessed by observing site conditions during inspections, monitoring vertical and horizontal slope movements with survey monuments, performing slope stability analyses, and determining susceptibility to liquefaction.

Five survey monuments were installed in March of 1997 in the upstream slope of the embankment slightly below the crest near El. 900 ft. The monuments were installed when the embankment reached its maximum height, which is essentially the "end of construction case" for the original water impounding embankment. The most recent embankment survey was performed on March 30, 2015. The monuments were observed to have settled about 0.16 to 0.3 ft since installation in 1997. The monuments moved between 0.2 to 0.4 ft in a downstream direction (laterally) in the same time period. The majority of the aforementioned movement occurred within four to six years after completion of construction, with minimal movement occurring since that time. Neither the survey monuments nor visual evidence from field observations show any indication of deep-seated slide movement.

GAI performed stability analyses in 2016 (*Safety Factor Assessment Report*) to determine if the impoundment construction and operation satisfies the safety factors listed in § 257.73(e). The analyses were conducted assuming the maximum volume of impounded wastewater and CCR. The calculated static safety factor under the long-term, maximum storage pool and maximum surcharge pool loading conditions exceeded the minimum of 1.50 and 1.40, respectively stated in the Rule. The calculated seismic safety factor exceeded the minimum of 1.00 stated in the Rule.

Foundation soils in the valley of the McElroy's Dam embankment consist of alluvial and residual soils. These soils are clayey and cohesive, and thus are not susceptible to liquefaction. However, pockets of sandy soil exist within the site soils; therefore, liquefaction analyses were performed at four test boring locations by GAI in 2010 and updated in 2016. GAI determined that the sandy soils are not susceptible to liquefaction. Similarly, analyses were performed on the fly ash in the embankment, and it was determined that the fly ash in the embankment is not susceptible to liquefaction. The calculated safety factors in both cases exceeded the minimum of 1.20 stated in § 257.73(e).

A visual inspection of the Dam was performed on September 7, 2016 as part of the annual WV state inspection. During the inspection, GAI personnel did not identify any signs of distress or malfunction that would affect the structural condition of the Impoundment. No releases of CCR were observed during this 2016 inspection.

3.2 Slope Protection

The downstream embankment of McElroy's Run dam is vegetated to protect against erosion. The Pleasants Landfill is constructed on a portion of the downstream embankment and extends up the face of the dike. The landfill benches are built to direct stormwater off the face of the landfill while minimizing the possibility of erosion.

The upstream embankment is armored with riprap (18-inch thickness) in the area of the operational water level to protect the face from wave erosion.

3.3 Dike Compaction

Per the CCR rule, "EPA recognizes that it would be highly difficult for owners or operators of older units to certify with any certainty that the unit's construction meets the specific numeric compaction criteria found in the ASTM standards." Borings drilled (2010) through the embankment indicated that the density of fly ash increased with depth. Correlations of Standard Penetration Test resistance (i.e. N-value) obtained during drilling to density of in-place material indicate that the estimated relative density of the embankment ranges from 75 percent near the crest of the embankment to 100 percent at increasing depths. From this and the results of the aforementioned stability analyses, it can be concluded that the compaction of the embankment satisfies the range of loading conditions present at the impoundment.

3.4 Vegetated Slopes

On December 2, 2015, GAI performed a visual inspection of McElroy's Run Impoundment. As part of this inspection, GAI evaluated the vegetation on the slopes of the impoundment embankment. The McElroy's Run Landfill buttresses the lower portion of the impoundment's embankment. Due to the unique structure of the buttressed impoundment, only vegetation along the day lit portion of the impoundment embankment could be viewed. GAI found that the vegetation on the impoundment dike was well-trimmed. Minimal weed growth was observed, and no signs of tree growth were observed.

3.5 Spillway Capacity

The McElroy's Dam is a high hazard potential CCR surface impoundment. Per § 257.73(d)(1)(v)(B), a high hazard potential CCR surface impoundment must manage flow following the peak discharge from a probable maximum flood (PMF).

The principal spillway consists of a decant tower (Decant Tower No. 2) connected to a 36-inch diameter concrete pipe barrel that passes under the dam and dry ash landfill. Primary discharge through the principal spillway is controlled by a two-ft by two-ft square opening at El. 890 ft. There is a series of similar gates in the decant tower spaced at five-ft vertical increments, up to El. 890 ft, but all gates below El. 885 ft are located within the impoundment and have been permanently closed. The intake gate at El. 885 ft is normally closed, but is operated to facilitate discharge of runoff from storm events. The principal spillway outlet channel is constructed from fabricform, and it is a non-erodible construction designed to withstand sustained flow per § 257.73(d)(1)(v)(A). The emergency spillway is 20 ft in width with a crest at El. 893.5 ft. The emergency spillway is concrete lined, has an approach lined with stone rip-rap, and an outlet protected with grouted rip-rap.

The PMF was calculated in the Inflow Design Flood Control System Plan (IDFCSP). In the IDFCSP it was estimated that flow through the emergency spillway would be approximately 100 cubic ft per second (cfs) during the PMF event. The hydraulic capacity of the emergency spillway is estimated to be approximately 9,000 cfs, so the Dam will be able to control the PMF through the combination of spillways without overtopping the embankment.

3.6 Underlying Hydraulic Structures

The principal spillway outfall barrel, a 3,600 ft-long, 36-inch diameter precast concrete pipe, is located under the dam. The principal spillway discharges downstream of the Pleasants Landfill to a channel that leads to McElroy's Creek. Decant Towers Nos. 1 and 2 connect to the principal spillway; however, Decant Tower No. 1 has been completely sealed so that discharge is only possible through Decant Tower No. 2. The principal spillway pipe was inspected on December 11-12, 2014 by using robotics outfitted with cameras to observe the interior of the pipe. The principal spillway was considered to be in good condition.

Decant Tower No. 2 was observed in the same time period. The exterior and interior of the Decant Tower were observed to be in good condition, and recommendations for continued observation, repair and maintenance were made (*Results from Structural Condition Assessment of Principal Spillway Pipe and Decant Tower,* dated February 2015).

A siphon float (12-inch diameter) is used as the primary discharge from the impoundment. The siphon float is used to maintain the normal operating pool level at El. 887 ft. The siphon discharges to either the Station for use as make-up water or to a permitted outfall to the Ohio River.

3.7 Adjacent Water Bodies

The downstream slope of the McElroy's Run embankment abuts the Pleasants Landfill, and cannot be inundated by an adjacent water body; thus, a structural stability analysis with adjacent water bodies was not performed.

4.0 Corrective Measures

No deficiencies were detected in the structural stability analysis of McElroy's Run dam.

5.0 Conclusion

GAI reviewed previous structural stability analyses and relevant drawings and surveys for this Structural Stability Assessment. Based on the analyzes conducted for the conditions outlined in the CCR Rule, the McElroy's surface impoundment design, construction, and operations and maintenance is consistent with good engineering practices for the volume of CCR and wastewater contained in the impoundment.

6.0 References

CHA Tech Services, LLC. 2010.
Assessment of Dam Safety, Coal Combustion Surface Impoundments (Task 3), Final Report, April 2010.

D'Appolonia. 1979.
McElroy's Run Disposal Site, Slope Stability Analysis. Drawing No. 101-6514-137, February 1979.

D'Appolonia. 1981.
McElroy's Run Disposal Site, Phase II Construction Field Moisture-Density Relationship and Grain Size Analyses. Drawing No. 101-6514-176, August 1981.

Electric Power Research Institute. 2009.
Coal Ash: Characteristics, Management and Environmental Issues, September 2009.

GAI Consultants, Inc. 2010.
Responses to Address the Recommendations of the EPA Concerning Pleasants Power Station (McElroy's Run CCB Disposal Site). Rep. N.p.: n.p., 2010.

GAI Consultants, Inc. 2016.
Inflow Design Flood Control System Plan, October 2016.

GAI Consultants, Inc. 2016.
Initial Hazard Potential Classification Assessment Report, October 2016.

GAI Consultants, Inc. 2016.
McElroy's Run Impoundment Safety Factor Assessment Report, October 2016.

GAI Consultants, Inc. 2015.
Results from Structural Condition Assessment of Primary Spillway Pipe and Decant Tower, Pleasants Power Station, February 2015.

GAI Consultants, Inc. 2009.
Stability Analyses of McElroy's Run Embankment; March, 2009.

GAI Consultants, Inc. 1996.
As-Built Construction Sequence, Drawing No. 101-6514-196, GAI Drawing No. 81-237-F13, October 1996.

GAI Consultants, Inc. 2015.
McElroy's Run CCB Impoundment Riprap Erosion Repair, July 2015.

Pleasants Power Station McElroy's Run Disposal Site Embankment Survey; April, 2015. Provided by FirstEnergy Corp.

ATTACHMENT 4-3

Safety Factor Assessment Report

McElroy’s Run Impoundment
Safety Factor Assessment Report

Allegheny Energy Supply Company, LLC
A FirstEnergy Company
Pleasants Power Station
Pleasants County, West Virginia

October 2016

Prepared for:
Allegheny Energy Supply Company, LLC
A FirstEnergy Company
800 Cabin Hill Drive
Greensburg, Pennsylvania 15601

Prepared by:
GAI Consultants, Inc.
Murrysville Office
4200 Triangle Lane
Export, Pennsylvania 15632-1358

Table of Contents

Certification/Statement of Professional Opinion

The Safety Factor Assessment (Assessment) Report for the McElroy's Run Impoundment was prepared by GAI Consultants, Inc. (GAI). The Assessment Report was based on certain information that, other than for information GAI originally prepared, GAI has relied on, but not independently verified. Therefore, this Certification/Statement of Professional Opinion is limited to the information available to GAI at the time the Assessment Report was written. On the basis of and subject to the foregoing, it is my professional opinion as a Professional Engineer licensed in the State of West Virginia (WV), that the Assessment has been prepared in accordance with good and accepted engineering practices, as exercised by other engineers practicing in the same discipline(s), under similar circumstances, and at the time and in the same locale. It is my professional opinion that this Safety Factor Assessment was prepared consistent with the requirements of the United States Environmental Protection Agency's Federal Coal Combustion Residuals (CCR) Rule 40 CFR § 257.73(e), published in the Federal Register on April 17, 2015 with an effective date of October 19, 2015.

The use of the words "certification" and/or "certify" in this document shall be interpreted and construed as a Statement of Professional Opinion and is not and shall not to be interpreted or construed as a guarantee, warranty or legal opinion.

Arica L DiTullio

Arica L. DiTullio, P.E.

Engineering Manager

ARICA LEE DITULLIO
21760
Arica L DiTullio

1.0 Purpose

Pursuant to the Federal Coal Combustion Residuals (CCR) Rule 40 CFR § 257.73(e)(1)(i-iv), each CCR impoundment is required to conduct an initial and periodic safety factor assessment to determine whether the CCR unit achieves the minimum safety factors at the critical cross section of the embankment. The critical cross section is the cross section anticipated to be the most susceptible of all cross sections to structural failure based on appropriate engineering considerations including loading conditions.

2.0 Introduction

The Pleasants Power Station (Station) is a coal-fired electric generating station located near the community of Willow Island in Pleasants County, West Virginia (WV). The Station consists of two generating units, which are capable of producing 1,300 megawatts of electricity.

CCRs generated at the Station are placed in the McElroy's Run CCR surface impoundment (Impoundment), which is located approximately one-half mile east-southeast of the Station. The Impoundment is a captive facility that receives flue gas desulfurization scrubber by-product generated at the Station, effluent from the recirculation system through Sedimentation Ponds 1 and 2 of the adjacent landfill and their underdrains, and waste materials collected primarily because of general house-cleaning maintenance and/or repair at the Pleasants Station.

The dam of the Impoundment is approximately 243 feet (ft) high with a maximum storage of approximately 20,000 acre-ft. The crest of the dam is at elevation (El.) 900 ft, with El. 887.00 ft as the permitted final level of CCR and recommended normal operating pool level. The Impoundment area is approximately 253 acres.

3.0 Factor of Safety Assessment

GAI reviewed all the documents listed under the References (Section 5.0) in its assessment to determine if the impoundment meets the following safety factors:

i. (3.1) The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.

ii. (3.2) The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.

iii. (3.3) The calculated seismic factor of safety must equal or exceed 1.00.

iv. (3.4) For dikes constructed of soils that are susceptible to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

The stability assessments were evaluated using the Slope/W software package (GeoStudio 2007, version 7.15 by GeoSlope International). All analyses were conducted using the Bishop Method. The critical section is shown on Drawing APSC 506-190 (see Appendix A-3.1). The material strength parameters used in the analyses were obtained from a response to EPA comments letter written by GAI in 2010. These parameters were developed based on previous subsurface explorations, laboratory testing, and engineering judgement. The phreatic surface used in the analyses was based on water level readings taken from embankment piezometers.

All calculations are included in Appendix A.

3.1 Long-Term Maximum Storage Pool Loading Condition

Pursuant to the CCR Rule, the maximum storage pool loading is, "the maximum water level that can be maintained that will result in full development of a steady-state seepage condition." Additionally, "the maximum storage pool loading needs to consider a pool elevation in the CCR unit that is equivalent to the lowest elevation of the invert of the spillway, i.e., the lowest overflow point of the perimeter of the embankment." (emergency spillway)

The principal spillway riser structure has a two-foot-by-two-foot opening at El. 890 ft. The spillway maintains an operational sluice gate at El. 885 ft, which is kept closed. Therefore, the long-term maximum storage pool loading condition will have a water elevation of 890 ft (GAI Inflow Design Plan). The CCR material in the Impoundment was permitted to an elevation of 887 ft. The calculated factor of safety is 1.89, which exceeds the requirement for the long term maximum storage pool condition (1.50).

3.2 Maximum Surcharge Pool Loading Condition

The maximum surcharge pool loading condition is based on the inflow design flood, which is the probable maximum flood (PMF). The maximum water surface elevation during the PMF is 894.8 ft. This water elevation corresponds to a water depth in the emergency spillway of 1.3 ft. The CCR material in the Impoundment was set at elevation 887 ft, which corresponds to the maximum permitted level. The calculated factor of safety is 1.89, which exceeds the requirement for the maximum surcharge pool condition (1.40).

3.3 Seismic Factor of Safety

The seismic factor of safety is run with a seismic loading event with a 2 percent probability of exceedance in 50 years, based on the United States Geological Survey (USGS) seismic hazard maps. A peak ground acceleration of 0.1g (acceleration of gravity) was used in the analysis. This value was obtained from a response to an EPA comments letter written by GAI in 2010.

The seismic condition was conducted using the long-term maximum storage pool loading condition. This represents a conservative analysis, as there is a reasonable chance this situation could occur, and it results in full development of the steady-state seepage condition. The calculated factor of safety is 1.36, which exceeds the requirement for a seismic event (1.00).

3.4 Liquefaction Factor of Safety

In 2010, GAI conducted a liquefaction analysis of the foundation soils. The soils underneath the Impoundment were found not to be susceptible to liquefaction. A corresponding analysis in 2010 was conducted on the compacted fly ash in the embankment. The three boring locations analyzed were CP-9, CP-11, and CP-13. CP-9 and CP-13 did not have a groundwater table and the blow counts (i.e. N-value) in the fly ash exceeded 30. According to "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils, 2001," soils with blow counts exceeding 30 are not susceptible to liquefaction. Based on this report, the downstream portion of the embankment is not susceptible to liquefaction.

In 2016, a modification to the 2010 liquefaction analysis on CP-9 was conducted in order to analyze the embankment with a water level. The Station collects data for the piezometers located in and around the embankment. Highest water elevations in the center of the embankment are located in the bottom ash blanket. Boring log data is unavailable for the piezometers located in the centerline of the embankment. Therefore, to complete the liquefaction analysis, CP-9 boring data was used based on proximity to the centerline of the embankment. The liquefaction analysis was performed using the "Simplified Procedure". The highest water level recorded over the past year in CP-1A, CP-4, and CP-6 was applied to the analysis for CP-9 to determine the susceptibility to liquefaction. The analysis determined that the embankment liquefaction minimum factor of safety is 8.50, which exceeds the requirement of 1.20 for liquefaction.

4.0 Conclusion

GAI reviewed previous stability analyses for this Safety Factor Assessment and conducted new analyses in order to meet the requirements of the CCR Rule. Based on the analyses conducted for the conditions outlined in the CCR Rule, the McElroy's Run impoundment meets or exceeds the required factors of safety.

5.0 References

GAI Consultants. *Inflow Design Flood Control System Plan*. January 2016.

GAI Consultants. *Liquefaction Evaluation & Analysis*. June 2016.

GAI Consultants. *Responses to Address the Recommendations of the EPA Concerning Pleasants Power Station (McElroy's Run CCB Disposal Site).* Rep. N.p.: n.p., 2010.

GAI Consultants. *Sludge Stabilization Facility: McElroy’s Run Disposal Site As-Built Construction Sequence*. Drawing APSC 506-190.

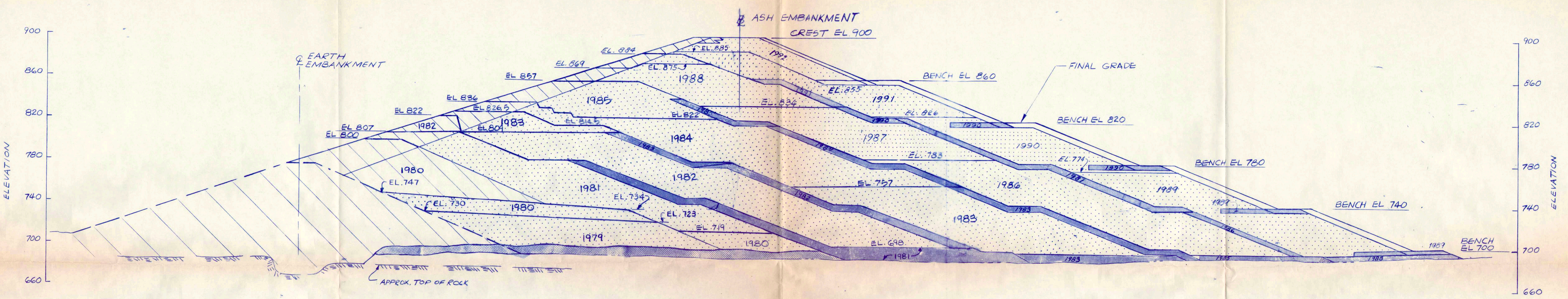
Liquefaction Resistance of Soils: Summary Report, from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils, 2001.

APPENDIX A

Calculations

APPENDIX A-3.1

Long-Term Maximum Storage Pool Loading Condition



TYPICAL TRANSVERSE SECTION

SCALE: 1" = 40'

40' 0 40' 80'

LEGEND

▥	APPROXIMATE TOP OF ROCK
—·—	EXISTING GROUND SURFACE
— — —	EARTH EMBANKMENT (PHASE I)
——	PROPOSED GRADE
▒	SAND FILTER
▆	BOTTOM ASH
▨	CLAY
░	FLY ASH

△3

REFERENCE DRAWINGS:

1. APS DWG.NO.101-6514-104 REV.4 McELROY'S RUN DISPOSAL SITE-TRANSVERSE AND LONGITUDINAL SECTIONS OF EMBANKMENT
2. UNNUMBERED DRAWING TITLED McELROY'S RUN EMBANKMENT, PLEASANTS POWER STATION, BY H. DESKINS, DATED 1-31-83.

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Monroeville, Pa. 15146
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PROJ. NO. 81-237

DWG. NO. 81-237-F13

OCT 31 1996

ISSUE No	DATE	DWN	CHKD	APP	APP	APP	ISSUED FOR
7	2-8-93	G.Y.	TRG	TDD			AS-BUILT THRU DEC. 1992
6	1-15-92	G.Y.	TDD	TDD			AS-BUILT THRU DEC. 1991
5	2-6-91	REM	TRG	TRG			AS BUILT THRU DEC. 1990
4	2-21-90	NER	TRG	TDD			AS-BUILT THRU FEB. 1990
3	3-2-89	G.Y.	[illegible]	TDD			AS-BUILT THRU FEB. 1989
2	2-8-88	F.P.	TRG	TDD			As Built Thru JAN. 1988
1	12-23-86	FP	TRG	TDD			As-Built Thru DEC. 1986
0	2-10-86	RAC	JAB	TDD			AS-BUILT THRU DECEMBER 1985

SCALE
AS SHOWN

ENGINEER
STATE REG
No.
OCT 31 1996

PLEASANTS POWER STATION-UNITS NO. 1 & NO. 2

MONONGAHELA POWER COMPANY
THE POTOMAC EDISON COMPANY
WEST PENN POWER COMPANY

SLUDGE STABILIZATION FACILITY
McELROYS RUN DISPOSAL SITE
AS-BUILT CONSTRUCTION SEQUENCE

APSC 506-190

DRAWING NUMBER
101-6514-196

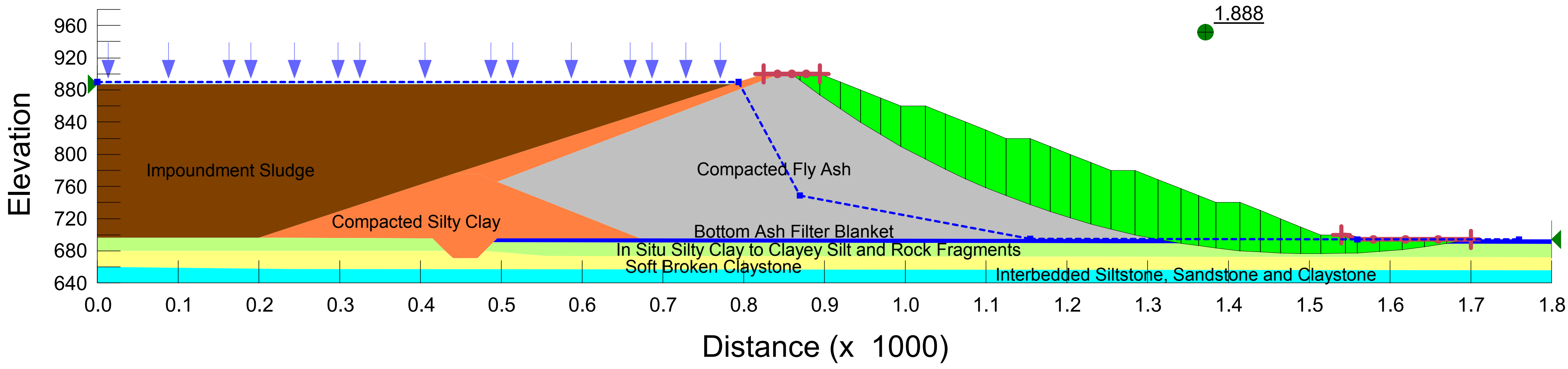
REVISION
△7

BRUNING 44-142 43457-2

BY: TIM DATE:03/08/2016

PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY
LONG TERM MAXIMUM STORAGE POOL LOADING CONDITION

EMERGENCY SPILLWAY ELEVATION: 893.5-FT
WATER ELEVATION 890-FT
CCR ELEVATION 887-FT



Name: Compacted Silty Clay Unit Weight: 132.9 pcf Cohesion: 228 psf Phi: 26.8 °
Name: In Situ Silty Clay to Clayey Silt and Rock Fragments Unit Weight: 127.8 pcf Cohesion: 49 psf Phi: 24.8 °
Name: Soft Broken Claystone Unit Weight: 135 pcf Cohesion: 1238 psf Phi: 32 °
Name: Interbedded Siltstone, Sandstone and Claystone
Name: Compacted Fly Ash Unit Weight: 113.1 pcf Cohesion: 0 psf Phi: 29.7 °
Name: Bottom Ash Filter Blanket Unit Weight: 110 pcf Cohesion: 0 psf Phi: 35 °
Name: Impoundment Sludge Unit Weight: 70 pcf Cohesion: 0 psf Phi: 0.1 °

Horizontal Scale: 2400
Vertical Scale: 2400

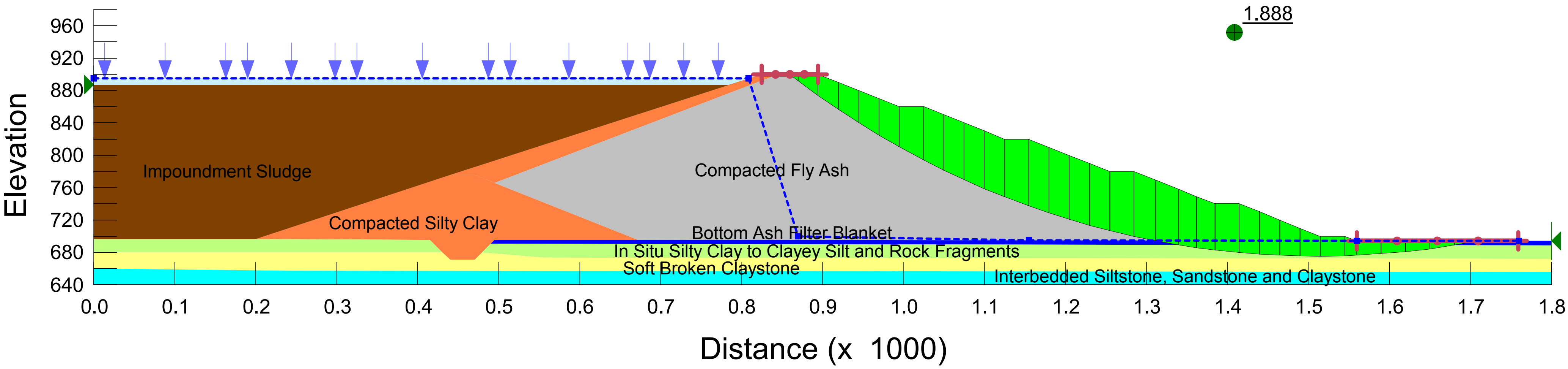
APPENDIX A-3.2

Maximum Surcharge Pool Loading Condition

BY: TIM DATE:03/08/2016

PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY
MAXIMUM SURCHARGE POOL LOADING CONDITION

SPILLWAY ELEVATION 893.5-FT
WATER ELEVATION 894.8-FT
CCR ELEVATION 887-FT



Name: Compacted Silty Clay Unit Weight: 132.9 pcf Cohesion: 228 psf Phi: 26.8 °
Name: In Situ Silty Clay to Clayey Silt and Rock Fragments Unit Weight: 127.8 pcf Cohesion: 49 psf Phi: 24.8 °
Name: Soft Broken Claystone Unit Weight: 135 pcf Cohesion: 1238 psf Phi: 32 °
Name: Interbedded Siltstone, Sandstone and Claystone
Name: Compacted Fly Ash Unit Weight: 113.1 pcf Cohesion: 0 psf Phi: 29.7 °
Name: Bottom Ash Filter Blanket Unit Weight: 110 pcf Cohesion: 0 psf Phi: 35 °
Name: Impoundment Sludge Unit Weight: 70 pcf Cohesion: 0 psf Phi: 0.1 °

Horizontal Scale: 2400
Vertical Scale: 2400

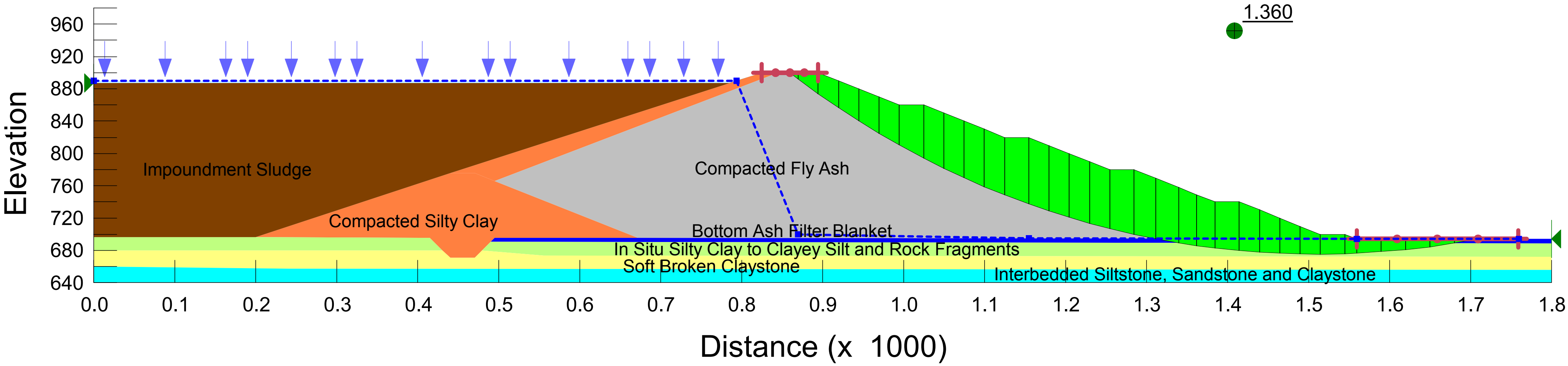
APPENDIX A-3.3

Seismic Factor of Safety

BY: TIM DATE:03/08/2016

PLEASANTS POWER STATION
McELROY'S RUN CCB DISPOSAL FACILITY
SEISMIC LONG TERM MAXIMUM STORAGE POOL LOADING CONDITION

SPILLWAY ELEVATION 893.5-FT
WATER ELEVATION 890-FT
CCR ELEVATION 887-FT
Seismic Value: 0.1



Name: Compacted Silty Clay Unit Weight: 132.9 pcf Cohesion: 228 psf Phi: 26.8 °
Name: In Situ Silty Clay to Clayey Silt and Rock Fragments Unit Weight: 127.8 pcf Cohesion: 49 psf Phi: 24.8 °
Name: Soft Broken Claystone Unit Weight: 135 pcf Cohesion: 1238 psf Phi: 32 °
Name: Interbedded Siltstone, Sandstone and Claystone
Name: Compacted Fly Ash Unit Weight: 113.1 pcf Cohesion: 0 psf Phi: 29.7 °
Name: Bottom Ash Filter Blanket Unit Weight: 110 pcf Cohesion: 0 psf Phi: 35 °
Name: Impoundment Sludge Unit Weight: 70 pcf Cohesion: 0 psf Phi: 0.1 °

Horizontal Scale: 2400
Vertical Scale: 2400

APPENDIX A-3.4

Liquefaction Factor of Safety

OBJECTIVE:

To evaluate the liquefaction resistance for the existing McElroy's Run Coal Combustion Residual (CCR) embankment at the Pleasants Power Station, Pleasants County, West Virginia.

METHODOLOGY:

Evaluate existing subsurface conditions in conjunction with the highest observed temporal phreatic surfaces to determine if liquefaction analyses are required. Field test data gathered from Standard Penetration Tests (SPT) are used to quantify the factor of safety against liquefaction (FS_L) during a design earthquake of magnitude 6.1 using the "Simplified Procedure for Evaluating Liquefaction Potential".

REFERENCES:

1. Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils, 2001.
2. MSHA Manual on Coal Waste Embankments, Chapter 7 Seismic Design: Stability and Deformation Analyses, May 2009.
3. GAI Consultants Inc., 2010. *Responses to Address the Recommendations of the EPA Concerning Pleasants Power Station (McElroy's Run CCB Disposal Site).* December 22, 2010.
4. United States Geological Survey, Earthquake Hazards Program, National Seismic Hazard Mapping Project (2008).
5. United States Environmental Protection Agency, 2015. *40 CFR Parts 257 and 261 Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule.* April 17, 2015.

ANALYSIS:

The CCR Rule (Section 257.73(e)(1)(iv)) states "for dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20".

To evaluate liquefaction potential of the embankment, the site stratigraphy must be understood with respect to soil classification, groundwater conditions, overburden and age of the soil deposits. Information from site visits and previous subsurface investigations conducted for the project site were employed to determine the site conditions for liquefaction evaluation. The following paragraphs explain the methodology used in this analysis.

A previous GAI report (Reference 3) determined that the downstream portion of the embankment met the target factor of safety for liquefaction. Piezometer readings show that there is a phreatic surface through the centerline of the embankment (CP-1A, CP-4, and CP-6).

Since piezometers in the centerline of the embankment were installed as the embankment height increased due to placement of CCR, there is no SPT data to evaluate the liquefaction potential of the central part of the embankment. Therefore, CP-9 was selected as it best represents the typical cross section of the embankment. The boring logs show that most of the embankment is constructed of CCR material (i.e. fly ash). The crest of the embankment is at elevation 900 feet, while the boring log for CP-9 shows a ground surface elevation of 875 feet. From 875 feet to 900 feet, the embankment was built from compacted CCR. For a thorough analysis each individual soil interval in the boring log was evaluated for liquefaction resistance.

Reviewing the piezometer data for the past year (June 2015-May 2016), the highest recorded phreatic surface was 743.7 feet in CP-6. . According to the Reference 3, CCR material was placed and compacted to a unit weight of 113.1 pcf.

To determine the potential for liquefaction using the "Simplified Procedure", SPT blow counts were used in conjunction with a design earthquake event having a magnitude 6.1. The earthquake magnitude was obtained from Reference 4.

The following steps, and associated equations, were used to determine factors of safety against liquefaction (FS_L) in accordance with the "Simplified Procedure". Since each individual soil interval was analyzed, a spreadsheet was used to facilitate FS_L calculations for the analyzed boring. Copies of the spreadsheets is included in Attachment 1 of the report.

Step 1: Develop cross-section including soil properties, layer geometry, groundwater elevation, and average N-values for the analysis (Refer to stability analyses for typical cross-sections).

Step 2: Determine SPT blow count correction factors for the energy ratio (C_E), borehole diameter (C_B), rod length (C_R), and sampling method (C_S) as shown in Table 2 of Reference 1. For the drilling program, safety hammers or automatic trip hammers were used on all of the rigs (C_E = 0.7 -- conservative value); hollow stem augers with a diameter of approximately 3.25 inches were used for all of the holes (C_B=1.0); standard split-spoon samplers without liners were advanced in all the holes (C_S=1.0); and rod lengths up to approximately 25-feet were used.

Step 3: Calculate standard blow counts, N_{60}, by multiplying the field measured N-values by the correction factors determined in Step 2.

Step 4: Determine the effective vertical stress (σ_{vo}') for existing in-situ soil conditions at each test depth as follows:

$\sigma_{vo}' = \gamma_T \times z$ if the test depth, z, is above the water table depth, h

$\sigma_{vo}' = (\gamma_{sat} - \gamma_w) \times (z - h) + \gamma_T \times h$ if z>h

Step 5: Determine overburden pressure correction factor (C_N) for each test depth from Table 2 in Reference 1, with P_a = 1.04 tsf:

$$C_N = \sqrt{P_a / \sigma_{vo}'}$$

C_N shall be limited to 1.7

Step 6: Determine the design total vertical stress and the design effective vertical stresses at each test depth using the fly ash impoundment and/or fly ash embankment overburden. Unit weight for embankment fill and CCR material are based off values from Reference 4.

Step 7: Determine SPT blow counts normalized to overburden pressure, $(N_1)_{60} = N_{60}{*}C_N$

Step 8: Correct for fines content, by applying fines correction coefficients to (α and β) to $(N_1)_{60}$. Fines contents of the CCR were quantified by laboratory testing. To be conservative, a fines contents were based off of minimal values from lab data provided in Reference 3. If multiple soil layers were encountered in a boring, the minimum value for fines was used. Using Eq. 5 from Ref. 1:

$$(N_1)_{60cs} = \alpha + \beta (N_1)_{60}$$

Step 9: Determine the stress reduction factor, r_d. (Reference 1)

$$(r_d) = 1.0 - 0.00765z \text{ for z} \le 9.15 \text{ m}$$

or

$$(r_d) = 1.174 - 0.0267z \text{ for z} < 9.15 \text{ m} \le 23 \text{ m}$$

or

$$(r_d) = \frac{(1.000 - 0.4113z^{0.5} + 0.04052z + 0.001753z^{1.5})}{(1.000 - 0.4177z^{0.5} + 0.05729z - 0.006205z^{1.5} + 0.001210z^2)} \text{ for z} > 23 \text{ m}$$

z is in meters

Step 10: Calculate the Cyclic Stress Ratio (CSR) using $a_{max} = 0.1g$, historic value for the site:

$$CSR = \left(\frac{0.65 \times a_{\max}}{g}\right) \times r_d \times \left(\frac{\sigma_{vo}}{\sigma_{vo}'}\right)$$

Step 11: Determine the Cyclic Resistance Ratio (CRR) for an earthquake of magnitude 6.1 based on the $(N_1)_{60cs}$ values (For $(N_1)_{60cs} < 30$).

$$CRR_{7.5} = \frac{1}{34 - (N_1)_{60}} + \frac{(N_1)_{60}}{135} + \frac{50}{(10 \times (N_1)_{60} + 45)^2} - \frac{1}{200}$$

Step 12: Calculate the earthquake Magnitude Scaling Factor (MSF) based on recommendations by Idriss for engineering practice, (Reference 1):

$$MSF = 10^{2.24}/M^{2.56}$$

Step 13: Calculate K_σ based on Reference 1,

$$K_\sigma = (\sigma'_{vo} / P_a)^{(f-1)}$$

where f = 0.6 for relative densities greater than or equal to 80%, f = 0.7 for relative densities greater than 40% but less than 80% and f = 0.8 for relative densities less than 40%.

Step 14: Calculate the corrected Cyclic Resistance Ratio using the previously determined correction factors and $CRR_{7.5}$.

$$CRR = K_\sigma \times K_\alpha \times CRR_{7.5}$$

Where K_α = 1 based on recommendations from Reference 1

Step 15: Calculate the factor of safety against liquefaction, FS_L.

$$FS_L = \frac{CRR}{CSR} \times MSF$$

SUMMARY:

Materials in the embankment consisted of compacted CCR material. SPT data from the borings were used to analyze the potential for liquefaction resulting from a design earthquake with magnitude of 6.1, using the "Simplified Procedure".

To be conservative, each individual soil interval in the analysis section boring was evaluated for liquefaction potential. Results of the analyses for borings in the embankment exceed the minimum 1.20 factor of safety required in the CCR Rule (Section 257.73(e)(1)(iv)).

ATTACHMENT 1

FS_L SPREADSHEETS

BORING CP-9

G.S. Elev. = 875.0
$\gamma_{overburden}$ = 113.1 (pcf)
γ_{sat} = 118.1 (pcf)
γ_{CCR} = 113.1

W.T. Elev. = 743.7
Est. EQ Mag 6.1

Bottom of CCR Elev. = 705.0
Top of CCR Elev. = 900.0

Fines Content = 91 Based on composite sample (CP-9,11,12,13,14)
Relative Density= 35%
f= 0.8

Atmospheric Pressure 100 kPa
1.04 tsf

				Table 2(1)						Eq. (9)(1)			Eq. (8)(1)	Eq. (6)(1)	Eq. (7)(1)	Eq. (5)(1)	Eq. (2)(1)		Eq. (1)(1)	Eq. (4)(1)	Eq. (24)(1)	Eq. (31)(1)			Eq. (30)(1)
Test Depth (m)	Test Depth (ft)	N	C_E	C_B	C_S	C_R	N_{60}	Test Elev. (ft MSL)	Existing σ'_{vo} (tsf)	C_N	Design σ_{vo} (tsf)	Design σ_{vo}' (tsf)	$(N_1)_{60}$	α	β	$(N_1)_{60cs}$	r_d	a_{max}	CSR	$CRR_{7.5}$	MSF	K_σ	K_α	CRR	FS_L
0.5	1.5	6	0.7	1.0	1.0	0.75	3	873.5	0.08	1.70	1.50	1.50	5	5	1.2	11	1.00	0.1	0.065	0.12	1.7	0.93	1.00	0.11	-
2.0	6.5	2	0.7	1.0	1.0	0.75	1	868.5	0.37	1.68	1.78	1.78	2	5	1.2	7	0.98	0.1	0.064	0.09	1.7	0.90	1.00	0.08	-
3.5	11.5	3	0.7	1.0	1.0	0.80	2	863.5	0.65	1.26	2.06	2.06	3	5	1.2	9	0.97	0.1	0.063	0.10	1.7	0.87	1.00	0.09	-
5.0	16.5	4	0.7	1.0	1.0	0.85	2	858.5	0.93	1.06	2.35	2.35	2	5	1.2	7	0.96	0.1	0.062	0.09	1.7	0.85	1.00	0.08	-
6.6	21.5	2	0.7	1.0	1.0	0.95	1	853.5	1.22	0.92	2.63	2.63	1	5	1.2	6	0.95	0.1	0.062	0.08	1.7	0.83	1.00	0.07	-
8.1	26.5	2	0.7	1.0	1.0	0.95	1	848.5	1.50	0.83	2.91	2.91	1	5	1.2	6	0.94	0.1	0.061	0.08	1.7	0.81	1.00	0.06	-
9.6	31.5	21	0.7	1.0	1.0	0.95	14	843.5	1.78	0.76	3.20	3.20	11	5	1.2	18	0.92	0.1	0.060	0.19	1.7	0.80	1.00	0.15	-
11.1	36.5	22	0.7	1.0	1.0	1.00	15	838.5	2.06	0.71	3.48	3.48	11	5	1.2	18	0.88	0.1	0.057	0.19	1.7	0.79	1.00	0.15	-
12.6	41.5	11	0.7	1.0	1.0	1.00	8	833.5	2.35	0.67	3.76	3.76	5	5	1.2	11	0.84	0.1	0.055	0.12	1.7	0.77	1.00	0.09	-
14.2	46.5	18	0.7	1.0	1.0	1.00	13	828.5	2.63	0.63	4.04	4.04	8	5	1.2	15	0.79	0.1	0.051	0.16	1.7	0.76	1.00	0.12	-
15.7	51.5	7	0.7	1.0	1.0	1.00	5	823.5	2.91	0.60	4.33	4.33	3	5	1.2	9	0.75	0.1	0.049	0.10	1.7	0.75	1.00	0.08	-
17.2	56.5	22	0.7	1.0	1.0	1.00	15	818.5	3.20	0.57	4.61	4.61	9	5	1.2	16	0.71	0.1	0.046	0.17	1.7	0.74	1.00	0.13	-
18.7	61.5	54	0.7	1.0	1.0	1.00	38	813.5	3.48	0.55	4.89	4.89	21	5	1.2	30	0.67	0.1	0.044	0.47	1.7	0.73	1.00	0.34	-
20.3	66.5	17	0.7	1.0	1.0	1.00	12	808.5	3.76	0.53	5.17	5.17	6	5	1.2	12	0.63	0.1	0.041	0.13	1.7	0.73	1.00	0.09	-
21.8	71.5	47	0.7	1.0	1.0	1.00	33	803.5	4.04	0.51	5.46	5.46	17	5	1.2	30	0.59	0.1	0.038	0.47	1.7	0.72	1.00	0.34	-
23.3	76.5	83	0.7	1.0	1.0	1.00	58	798.5	4.33	0.49	5.74	5.74	28	5	1.2	30	0.56	0.1	0.036	0.47	1.7	0.71	1.00	0.33	-
24.8	81.5	31	0.7	1.0	1.0	1.00	22	793.5	4.61	0.47	6.02	6.02	10	5	1.2	17	0.54	0.1	0.035	0.18	1.7	0.70	1.00	0.13	-
26.4	86.5	23	0.7	1.0	1.0	1.00	16	788.5	4.89	0.46	6.31	6.31	7	5	1.2	13	0.53	0.1	0.034	0.14	1.7	0.70	1.00	0.10	-
27.8	91.3	93	0.7	1.0	1.0	1.00	65	783.7	5.16	0.45	6.58	6.58	29	5	1.2	30	0.52	0.1	0.034	0.47	1.7	0.69	1.00	0.32	-
29.4	96.5	91	0.7	1.0	1.0	1.00	64	778.5	5.46	0.44	6.87	6.87	28	5	1.2	30	0.51	0.1	0.033	0.47	1.7	0.69	1.00	0.32	-
30.9	101.5	80	0.7	1.0	1.0	1.00	56	773.5	5.74	0.43	7.15	7.15	24	5	1.2	30	0.50	0.1	0.033	0.47	1.7	0.68	1.00	0.32	-
32.3	105.9	73	0.7	1.0	1.0	1.00	51	769.1	5.99	0.42	7.40	7.40	21	5	1.2	30	0.49	0.1	0.032	0.47	1.7	0.68	1.00	0.32	-
34.0	111.5	37	0.7	1.0	1.0	1.00	26	763.5	6.31	0.41	7.72	7.72	11	5	1.2	18	0.48	0.1	0.031	0.19	1.7	0.67	1.00	0.13	-
35.4	116.3	82	0.7	1.0	1.0	1.00	57	758.7	6.58	0.40	7.99	7.99	23	5	1.2	30	0.47	0.1	0.031	0.47	1.7	0.67	1.00	0.31	-
37.0	121.5	86	0.7	1.0	1.0	1.00	60	753.5	6.87	0.39	8.28	8.28	23	5	1.2	30	0.47	0.1	0.031	0.47	1.7	0.66	1.00	0.31	-
38.6	126.5	72	0.7	1.0	1.0	1.00	50	748.5	7.15	0.38	8.57	8.57	19	5	1.2	30	0.46	0.1	0.030	0.47	1.7	0.66	1.00	0.31	-
40.1	131.5	50	0.7	1.0	1.0	1.00	35	743.5	7.43	0.37	8.85	8.84	13	5	1.2	21	0.46	0.1	0.030	0.23	1.7	0.65	1.00	0.15	8.50
41.6	136.5	79	0.7	1.0	1.0	1.00	55	738.5	7.57	0.37	9.15	8.98	20	5	1.2	29	0.45	0.1	0.030	0.41	1.7	0.65	1.00	0.27	15.30
43.1	141.5	81	0.7	1.0	1.0	1.00	57	733.5	7.71	0.37	9.44	9.12	21	5	1.2	30	0.44	0.1	0.030	0.47	1.7	0.65	1.00	0.31	17.57
44.7	146.5	70	0.7	1.0	1.0	1.00	49	728.5	7.85	0.36	9.74	9.26	18	5	1.2	27	0.44	0.1	0.030	0.34	1.7	0.65	1.00	0.22	12.47
46.2	151.5	75	0.7	1.0	1.0	1.00	53	723.5	7.99	0.36	10.03	9.40	19	5	1.2	28	0.43	0.1	0.030	0.37	1.7	0.64	1.00	0.24	13.60
47.7	156.5	63	0.7	1.0	1.0	1.00	44	718.5	8.13	0.36	10.33	9.54	16	5	1.2	24	0.43	0.1	0.030	0.27	1.7	0.64	1.00	0.17	9.63
49.2	161.5	64	0.7	1.0	1.0	1.00	45	713.5	8.27	0.35	10.62	9.68	16	5	1.2	24	0.43	0.1	0.031	0.27	1.7	0.64	1.00	0.17	9.32
50.7	166.5	66	0.7	1.0	1.0	1.00	46	708.5	8.41	0.35	10.92	9.82	16	5	1.2	24	0.42	0.1	0.030	0.27	1.7	0.64	1.00	0.17	9.63
51.7	169.5	70	0.7	1.0	1.0	1.00	49	705.5	8.49	0.35	11.09	9.90	17	5	1.2	25	0.42	0.1	0.031	0.29	1.7	0.64	1.00	0.19	10.42

If the water table was not present in a layer, then FS_L was not calculated.

FS_{min} 8.50

Notes:

σ'_{vo}	Vertical Effective Stress (tons/ft^2)
$(N_1)_{60}$	Standardized and Normalized SPT blow counts (blows/foot)
r_d	Stress Reduction Factor (dimensionless)
a_{max}	Peak horizontal ground surface acceleration (in g)
CSR	Cyclic stress ratio based on design earthquake (dimensionless)
$CRR_{7.5}$	Cyclic resistance ratio based on an earthquake of magnitude 7.5 (dimensionless)
MSF	Magnitude scaling factor (dimensionless)
K_σ	High overburden stress correction factor (dimensionless)
K_α	Ground slope correction factor (dimensionless) [advised not to be used by reference]
CRR	Corrected cyclic resistance ratio based on overburden pressure and ground surface slope (dimensionless) = CRR7.5 * Kσ * Kα
FS_L	Factor of safety against liquefaction (dimensionless)

References:

(1) Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils, 2001

(2) MSHA Manual on Coal Waste Embankments, Chapter 7 Seismic Design: Stability and Deformation Analyses, May 2009

ATTACHMENT 2

REFERENCES

Preface

Evaluation of soil liquefaction resistance is an important aspect of geotechnical engineering practice. To update and enhance criteria that are routinely applied in practice, workshops were convened in 1996 and 1998 to gain consensus from 20 experts on updates and augmentations that should be made to standard procedures that have evolved over the past 30 years. At the outset, the goal was to develop this state-of-the-art summary of consensus recommendations. A commitment was also made to those who participated in the workshops that all would be listed as co-authors. Unfortunately, the previous publication of this summary paper (April 2001) listed only the co-chairs of the workshop, Profs. Youd and Idriss, as authors; the remaining workshop participants were acknowledged in a footnote. In order to correct this error and to fully acknowledge and credit those who significantly contributed to the work, this paper is being republished in its entirety, at the request of the journal's editors, with all the participants named as co-authors. All further reference to this paper should be to this republication. The previous publication should no longer be cited. Also, several minor errors are corrected in this republication.

LIQUEFACTION RESISTANCE OF SOILS: SUMMARY REPORT FROM THE 1996 NCEER AND 1998 NCEER/NSF WORKSHOPS ON EVALUATION OF LIQUEFACTION RESISTANCE OF SOILS[a]

By T. L. Youd,[1] Chair, Member, ASCE, I. M. Idriss,[2] Co-Chair, Fellow, ASCE, Ronald D. Andrus,[3] Ignacio Arango,[4] Gonzalo Castro,[5] John T. Christian,[6] Richardo Dobry,[7] W. D. Liam Finn,[8] Leslie F. Harder Jr.,[9] Mary Ellen Hynes,[10] Kenji Ishihara,[11] Joseph P. Koester,[12] Sam S. C. Liao,[13] William F. Marcuson III,[14] Geoffrey R. Martin,[15] James K. Mitchell,[16] Yoshiharu Moriwaki,[17] Maurice S. Power,[18] Peter K. Robertson,[19] Raymond B. Seed,[20] and Kenneth H. Stokoe II[21]

ABSTRACT: Following disastrous earthquakes in Alaska and in Niigata, Japan in 1964, Professors H. B. Seed and I. M. Idriss developed and published a methodology termed the "simplified procedure" for evaluating liquefaction resistance of soils. This procedure has become a standard of practice throughout North America and much of the world. The methodology which is largely empirical, has evolved over years, primarily through summary papers by H. B. Seed and his colleagues. No general review or update of the procedure has occurred, however, since 1985, the time of the last major paper by Professor Seed and a report from a National Research Council workshop on liquefaction of soils. In 1996 a workshop sponsored by the National Center for Earthquake Engineering Research (NCEER) was convened by Professors T. L. Youd and I. M. Idriss with 20 experts to review developments over the previous 10 years. The purpose was to gain consensus on updates and augmentations to the simplified procedure. The following topics were reviewed and recommendations developed: (1) criteria based on standard penetration tests; (2) criteria based on cone penetration tests; (3) criteria based on shear-wave velocity measurements; (4) use of the Becker penetration test for gravelly soil; (4) magnitude scaling factors; (5) correction factors for overburden pressures and sloping ground; and (6) input values for earthquake magnitude and peak acceleration. Probabilistic and seismic energy analyses were reviewed but no recommendations were formulated.

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[a] This Summary Report, originally published in April 2001, is being republished so that the contribution of all workshop participants as authors can be officially recognized. The original version listed only two authors, plus a list of 19 workshop participants. This was incorrect; all 21 individuals should have been identified as authors. ASCE deeply regrets the error.

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Note. Discussion open until March 1, 2002. To extend the closing date one month, a written request must be filed with the ASCE Manager of Journals. The manuscript for this paper was submitted for review and possible publication on January 18, 2000; revised November 14, 2000. This paper is part of the ***Journal of Geotechnical and Geoenvironmental Engineering***, Vol. 127, No. 10, October, 2001. ©ASCE, ISSN 1090-0241/01/0010-0817–0833/$8.00 + $.50 per page. Paper No. 22223.

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INTRODUCTION

Over the past 25 years a methodology termed the "simplified procedure" has evolved as a standard of practice for evaluating the liquefaction resistance of soils. Following disastrous earthquakes in Alaska and in Niigata, Japan in 1964, Seed and Idriss (1971) developed and published the basic "simplified procedure." That procedure has been modified and improved periodically since that time, primarily through landmark papers by Seed (1979), Seed and Idriss (1982), and Seed et al. (1985). In 1985, Professor Robert V. Whitman convened a workshop on behalf of the National Research Council (NRC) in which 36 experts and observers thoroughly reviewed the state-of-knowledge and the state-of-the-art for assessing liquefaction hazard. That workshop produced a report (NRC 1985) that has become a widely used standard and reference for liquefaction hazard assessment. In January 1996, T. L. Youd and I. M. Idriss convened a workshop of 20 experts to update the simplified procedure and incorporate research findings from the previous decade. This paper summarizes recommendations from that workshop (Youd and Idriss 1997).

To keep the workshop focused, the scope of the workshop was limited to procedures for evaluating liquefaction resistance of soils under level to gently sloping ground. In this context, liquefaction refers to the phenomena of seismic generation of large pore-water pressures and consequent softening of granular soils. Important postliquefaction phenomena, such as residual shear strength, soil deformation, and ground failure, were beyond the scope of the workshop.

The simplified procedure was developed from empirical evaluations of field observations and field and laboratory test data. Field evidence of liquefaction generally consisted of surficial observations of sand boils, ground fissures, or lateral spreads. Data were collected mostly from sites on level to gently sloping terrain, underlain by Holocene alluvial or fluvial sediment at shallow depths (<15 m). The original procedure was verified for, and is applicable only to, these site conditions. Similar restrictions apply to the implementation of the updated procedures recommended in this report.

Liquefaction is defined as the transformation of a granular material from a solid to a liquefied state as a consequence of increased pore-water pressure and reduced effective stress (Marcuson 1978). Increased pore-water pressure is induced by the tendency of granular materials to compact when subjected to cyclic shear deformations. The change of state occurs most readily in loose to moderately dense granular soils with poor drainage, such as silty sands or sands and gravels capped by or containing seams of impermeable sediment. As liquefaction occurs, the soil stratum softens, allowing large cyclic deformations to occur. In loose materials, the softening is also accompanied by a loss of shear strength that may lead to large shear deformations or even flow failure under moderate to high shear stresses, such as beneath a foundation or sloping ground. In moderately dense to dense materials, liquefaction leads to transient softening and increased cyclic shear strains, but a tendency to dilate during shear inhibits major strength loss and large ground deformations. A condition of cyclic mobility or cyclic liquefaction may develop following liquefaction of moderately dense granular materials. Beneath gently sloping to flat ground, liquefaction may lead to ground oscillation or lateral spread as a consequence of either flow deformation or cyclic mobility. Loose soils also compact during liquefaction and reconsolidation, leading to ground settlement. Sand boils may also erupt as excess pore water pressures dissipate.

CYCLIC STRESS RATIO (CSR) AND CYCLIC RESISTANCE RATIO (CRR)

Calculation, or estimation, of two variables is required for evaluation of liquefaction resistance of soils: (1) the seismic demand on a soil layer, expressed in terms of CSR; and (2) the capacity of the soil to resist liquefaction, expressed in terms of CRR. The latter variable has been termed the cyclic stress ratio or the cyclic stress ratio required to generate liquefaction, and has been given different symbols by different writers. For example, Seed and Harder (1990) used the symbol CSRℓ, Youd (1993) used the symbol CSRL, and Kramer (1996) used the symbol CSR_L to denote this ratio. To reduce confusion and to better distinguish induced cyclic shear stresses from mobilized liquefaction resistance, the capacity of a soil to resist liquefaction is termed the CRR in this report. This term is recommended for engineering practice.

EVALUATION OF CSR

Seed and Idriss (1971) formulated the following equation for calculation of the cyclic stress ratio:

$$\text{CSR} = (\tau_{av}/\sigma'_{vo}) = 0.65(a_{\max}/g)(\sigma_{vo}/\sigma'_{vo})r_d \qquad (1)$$

where $a_{\max}$ = peak horizontal acceleration at the ground surface generated by the earthquake (discussed later); g = acceleration of gravity; σ_{vo} and σ'_{vo} are total and effective vertical overburden stresses, respectively; and r_d = stress reduction coefficient. The latter coefficient accounts for flexibility of the soil profile. The workshop participants recommend the following minor modification to the procedure for calculation of CSR.

For routine practice and noncritical projects, the following equations may be used to estimate average values of r_d (Liao and Whitman 1986b):

$$r_d = 1.0 - 0.00765z \quad \text{for } z \le 9.15 \text{ m} \qquad (2a)$$

$$r_d = 1.174 - 0.0267z \quad \text{for } 9.15 \text{ m} < z \le 23 \text{ m} \qquad (2b)$$

where z = depth below ground surface in meters. Some investigators have suggested additional equations for estimating r_d at greater depths (Robertson and Wride 1998), but evaluation of liquefaction at these greater depths is beyond the depths where the simplified procedure is verified and where routine applications should be applied. Mean values of r_d calculated from (2) are plotted in Fig. 1, along with the mean and range of values proposed by Seed and Idriss (1971). The workshop participants agreed that for convenience in programming spreadsheets and other electronic aids, and to be consistent with past practice, r_d values determined from (2) are suitable for use in routine engineering practice. The user should understand, however, that there is considerable variability in the

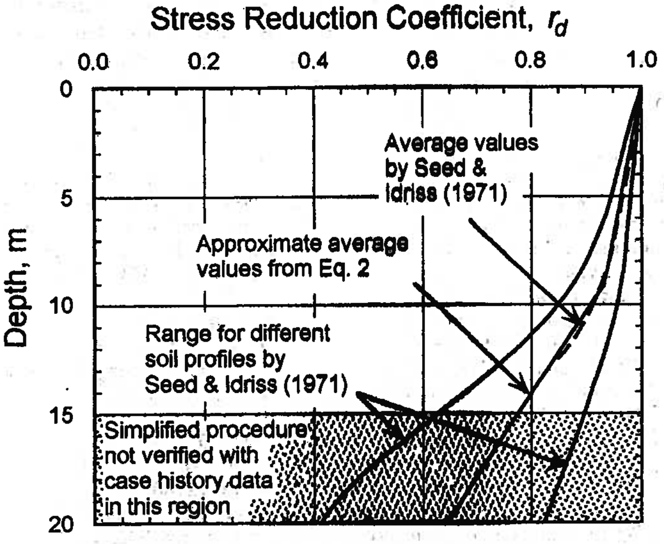


FIG. 1. r_d versus Depth Curves Developed by Seed and Idriss (1971) with Added Mean-Value Lines Plotted from Eq. (2)

flexibility and thus r_d at field sites, that r_d calculated from (2) are the mean of a wide range of possible r_d, and that the range of r_d increases with depth (Golesorkhi 1989).

For ease of computation, T. F. Blake (personal communication, 1996) approximated the mean curve plotted in Fig. 1 by the following equation:

$$r_d = \frac{(1.000 - 0.4113z^{0.5} + 0.04052z + 0.001753z^{1.5})}{(1.000 - 0.4177z^{0.5} + 0.05729z - 0.006205z^{1.5} + 0.001210z^2)} \quad (3)$$

where z = depth beneath ground surface in meters. Eq. (3) yields essentially the same values for r_d as (2), but is easier to program and may be used in routine engineering practice.

I. M. Idriss [Transportation Research Board (TRB) (1999)] suggested a new procedure for determining magnitude-dependent values of r_d. Application of these r_d require use of a corresponding set of magnitude scaling factors that are compatible with the new r_d. Because these r_d were developed after the workshop and have not been independently evaluated by other experts, the workshop participants chose not to recommend the new factors at this time.

EVALUATION OF LIQUEFACTION RESISTANCE (CRR)

A major focus of the workshop was on procedures for evaluating liquefaction resistance. A plausible method for evaluating CRR is to retrieve and test undisturbed soil specimens in the laboratory. Unfortunately, in situ stress states generally cannot be reestablished in the laboratory, and specimens of granular soils retrieved with typical drilling and sampling techniques are too disturbed to yield meaningful results. Only through specialized sampling techniques, such as ground freezing, can sufficiently undisturbed specimens be obtained. The cost of such procedures is generally prohibitive for all but the most critical projects. To avoid the difficulties associated with sampling and laboratory testing, field tests have become the state-of-practice for routine liquefaction investigations.

Several field tests have gained common usage for evaluation of liquefaction resistance, including the standard penetration test (SPT), the cone penetration test (CPT), shear-wave velocity measurements (V_s), and the Becker penetration test (BPT). These tests were discussed at the workshop, along with associated criteria for evaluating liquefaction resistance. The participants made a conscientious attempt to correlate liquefaction resistance criteria from each of the various field tests to provide generally consistent results, no matter which test is applied. SPTs and CPTs are generally preferred because of the more extensive databases and past experience, but the other tests may be applied at sites underlain by gravelly sediment or where access by large equipment is limited. Primary advantages and disadvantages of each test are listed in Table 1.

SPT

Criteria for evaluation of liquefaction resistance based on the SPT have been rather robust over the years. Those criteria are largely embodied in the CSR versus $(N_1)_{60}$ plot reproduced in Fig. 2. $(N_1)_{60}$ is the SPT blow count normalized to an overburden pressure of approximately 100 kPa (1 ton/sq ft) and a hammer energy ratio or hammer efficiency of 60%. The normalization factors for these corrections are discussed in the section entitled Other Corrections. Fig. 2 is a graph of calculated CSR and corresponding $(N_1)_{60}$ data from sites where liquefaction effects were or were not observed following past earthquakes with magnitudes of approximately 7.5. CRR curves on this graph were conservatively positioned to separate regions with data indicative of liquefaction from regions with data indicative of nonliquefaction. Curves were developed for granular soils with the fines contents of 5% or less, 15%, and 35% as shown on the plot. The CRR curve for fines contents <5% is the basic penetration criterion for the simplified procedure and is referred to hereafter as the "SPT clean-sand base curve." The CRR curves in Fig. 2 are valid only for magnitude 7.5 earthquakes. Scaling factors to adjust CRR curves to other magnitudes are addressed in a later section of this report.

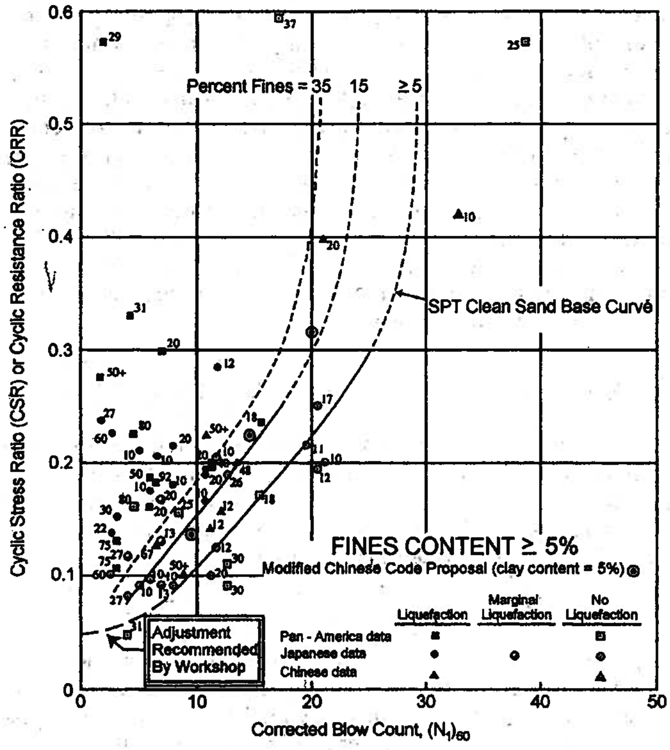


FIG. 2. SPT Clean-Sand Base Curve for Magnitude 7.5 Earthquakes with Data from Liquefaction Case Histories (Modified from Seed et al. 1985)

SPT Clean-Sand Base Curve

Several changes to the SPT criteria are recommended by the workshop participants. The first change is to curve the trajec-

TABLE 1. Comparison of Advantages and Disadvantages of Various Field Tests for Assessment of Liquefaction Resistance

	Test Type			
Feature	SPT	CPT	V_s	BPT
Past measurements at liquefaction sites	Abundant	Abundant	Limited	Sparse
Type of stress-strain behavior influencing test	Partially drained, large strain	Drained, large strain	Small strain	Partially drained, large strain
Quality control and repeatability	Poor to good	Very good	Good	Poor
Detection of variability of soil deposits	Good for closely spaced tests	Very good	Fair	Fair
Soil types in which test is recommended	Nongravel	Nongravel	All	Primarily gravel
Soil sample retrieved	Yes	No	No	No
Test measures index or engineering property	Index	Index	Engineering	Index

tory of the clean-sand base curve at low $(N_1)_{60}$ to a projected intercept of about 0.05 (Fig. 2). This adjustment reshapes the clean-sand base curve to achieve greater consistency with CRR curves developed for the CPT and shear-wave velocity procedures. Seed and Idriss (1982) projected the original curve through the origin, but there were few data to constrain the curve in the lower part of the plot. A better fit to the present empirical data is to bow the lower end of the base curve as indicated in Fig. 2.

At the University of Texas, A. F. Rauch (personal communication, 1998), approximated the clean-sand base curve plotted in Fig. 2 by the following equation:

$$\mathrm{CRR}_{7.5} = \frac{1}{34 - (N_1)_{60}} + \frac{(N_1)_{60}}{135} + \frac{50}{[10 \cdot (N_1)_{60} + 45]^2} - \frac{1}{200} \qquad (4)$$

This equation is valid for $(N_1)_{60} < 30$. For $(N_1)_{60} \geq 30$, clean granular soils are too dense to liquefy and are classed as nonliquefiable. This equation may be used in spreadsheets and other analytical techniques to approximate the clean-sand base curve for routine engineering calculations.

Influence of Fines Content

In the original development, Seed et al. (1985) noted an apparent increase of CRR with increased fines content. Whether this increase is caused by an increase of liquefaction resistance or a decrease of penetration resistance is not clear. Based on the empirical data available, Seed et al. developed CRR curves for various fines contents reproduced in Fig. 2. A revised correction for fines content was developed by workshop attendees to better fit the empirical database and to better support computations with spreadsheets and other electronic computational aids.

The workshop participants recommend (5) and (6) as approximate corrections for the influence of fines content (FC) on CRR. Other grain characteristics, such as soil plasticity, may affect liquefaction resistance as well as fines content, but widely accepted corrections for these factors have not been developed. Hence corrections based solely on fines content should be used with engineering judgment and caution. The following equations were developed by I. M. Idriss with the assistance of R. B. Seed for correction of $(N_1)_{60}$ to an equivalent clean sand value, $(N_1)_{60cs}$:

$$(N_1)_{60cs} = \alpha + \beta(N_1)_{60} \qquad (5)$$

where α and β = coefficients determined from the following relationships:

$$\alpha = 0 \quad \text{for FC} \leq 5\% \qquad (6a)$$

$$\alpha = \exp[1.76 - (190/\mathrm{FC}^2)] \quad \text{for } 5\% < \text{FC} < 35\% \qquad (6b)$$

$$\alpha = 5.0 \quad \text{for FC} \geq 35\% \qquad (6c)$$

$$\beta = 1.0 \quad \text{for FC} \leq 5\% \qquad (7a)$$

$$\beta = [0.99 + (\mathrm{FC}^{1.5}/1{,}000)] \quad \text{for } 5\% < \text{FC} < 35\% \qquad (7b)$$

$$\beta = 1.2 \quad \text{for FC} \geq 35\% \qquad (7c)$$

These equations may be used for routine liquefaction resistance calculations. A back-calculated curve for a fines content of 35% is essentially congruent with the 35% curve plotted in Fig. 2. The back-calculated curve for a fines contents of 15% plots to the right of the original 15% curve.

Other Corrections

Several factors in addition to fines content and grain characteristics influence SPT results, as noted in Table 2. Eq. (8) incorporates these corrections

$$(N_1)_{60} = N_m C_N C_E C_B C_R C_S \qquad (8)$$

where N_m = measured standard penetration resistance; C_N = factor to normalize N_m to a common reference effective overburden stress; C_E = correction for hammer energy ratio (ER); C_B = correction factor for borehole diameter; C_R = correction factor for rod length; and C_S = correction for samplers with or without liners.

TABLE 2. Corrections to SPT (Modified from Skempton 1986) as Listed by Robertson and Wride (1998)

Factor	Equipment variable	Term	Correction
Overburden pressure	—	C_N	$(P_a/\sigma'_{vo})^{0.5}$
Overburden pressure	—	C_N	$C_N \leq 1.7$
Energy ratio	Donut hammer	C_E	0.5–1.0
Energy ratio	Safety hammer	C_E	0.7–1.2
Energy ratio	Automatic-trip Donut-type hammer	C_E	0.8–1.3
Borehole diameter	65–115 mm	C_B	1.0
Borehole diameter	150 mm	C_B	1.05
Borehole diameter	200 mm	C_B	1.15
Rod length	<3 m	C_R	0.75
Rod length	3–4 m	C_R	0.8
Rod length	4–6 m	C_R	0.85
Rod length	6–10 m	C_R	0.95
Rod length	10–30 m	C_R	1.0
Sampling method	Standard sampler	C_S	1.0
Sampling method	Sampler without liners	C_S	1.1–1.3

Because SPT *N*-values increase with increasing effective overburden stress, an overburden stress correction factor is applied (Seed and Idriss 1982). This factor is commonly calculated from the following equation (Liao and Whitman 1986a):

$$C_N = (P_a/\sigma'_{vo})^{0.5} \qquad (9)$$

where C_N normalizes N_m to an effective overburden pressure σ'_{vo} of approximately 100 kPa (1 atm) P_a. C_N should not exceed a value of 1.7 [A maximum value of 2.0 was published in the National Center for Earthquake Engineering Research (NCEER) workshop proceedings (Youd and Idriss 1997), but later was reduced to 1.7 by consensus of the workshop participants] Kayen et al. (1992) suggested the following equation, which limits the maximum C_N value to 1.7, and in these writers' opinion, provides a better fit to the original curve specified by Seed and Idriss (1982):

$$C_N = 2.2/(1.2 + \sigma'_{vo}/P_a) \qquad (10)$$

Either equation may be used for routine engineering applications.

The effective overburden pressure σ'_{vo} applied in (9) and (10) should be the overburden pressure at the time of drilling and testing. Although a higher ground-water level might be used for conservatism in the liquefaction resistance calculations, the C_N factor must be based on the stresses present at the time of the testing.

The C_N correction factor was derived from SPT performed in test bins with large sand specimens subjected to various confining pressures (Gibbs and Holtz 1957; Marcuson and Bieganousky 1997a,b). The results of several of these tests are reproduced in Fig. 3 in the form of C_N curves versus effective overburden stress (Castro 1995). These curves indicate considerable scatter of results with no apparent correlation of C_N with soil type or gradation. The curves from looser sands, however, lie in the lower part of the C_N range and are reasonably approximated by (9) and (10) for low effective overburden pressures [200 kPa (<2 tsf)]. The workshop participants endorsed the use of (9) for calculation of C_N, but acknowledged that for overburden pressures >200 kPa (2 tsf) the results are uncertain. Eq. (10) provides a better fit for overburden

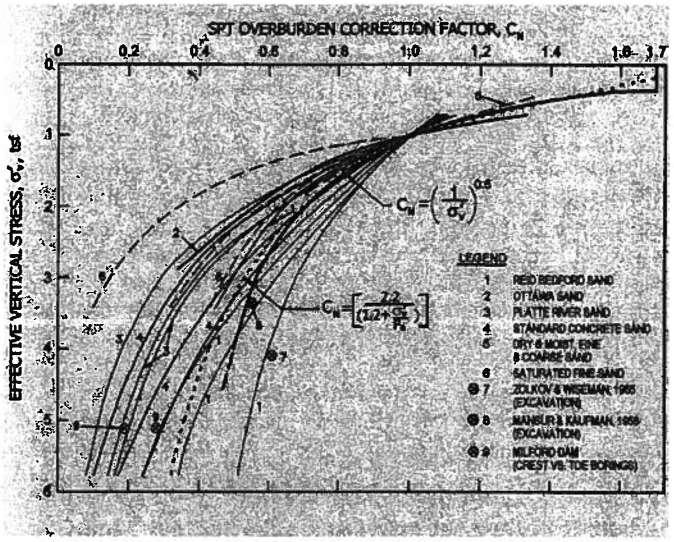


FIG. 3. C_N Curves for Various Sands Based on Field and Laboratory Test Data along with Suggested C_N Curve Determined from Eqs. (9) and (10) (Modified from Castro 1995)

pressures up to 300 kPa (3 tsf). For pressures >300 kPa (3 tsf), the uncertainty is so great that (9) should not be applied. At these high pressures, which are generally below the depth for which the simplified procedure has been verified, C_N should be estimated by other means.

Another important factor is the energy transferred from the falling hammer to the SPT sampler. An ER of 60% is generally accepted as the approximate average for U.S. testing practice and as a reference value for energy corrections. The ER delivered to the sampler depends on the type of hammer, anvil, lifting mechanism, and the method of hammer release. Approximate correction factors (C_E = ER/60) to modify the SPT results to a 60% energy ratio for various types of hammers and anvils are listed in Table 2. Because of variations in drilling and testing equipment and differences in testing procedures, a rather wide range in the energy correction factor C_E has been observed as noted in the table. Even when procedures are carefully monitored to conform to established standards, such as ASTM D 1586-99, some variation in C_E may occur because of minor variations in testing procedures. Measured energies at a single site indicate that variations in energy ratio between blows or between tests in a single borehole typically vary by as much as 10%. The workshop participants recommend measurement of the hammer energy frequently at each site where the SPT is used. Where measurements cannot be made, careful observation and notation of the equipment and procedures are required to estimate a C_E value for use in liquefaction resistance calculations. Use of good-quality testing equipment and carefully controlled testing procedures conforming to ASTM D 1586-99 will generally yield more consistent energy ratios and C_E with values from the upper parts of the ranges listed in Table 2.

Skempton (1986) suggested and Robertson and Wride (1998) updated correction factors for rod lengths <10 m, borehole diameters outside the recommended interval (65–125 mm), and sampling tubes without liners. Range for these correction factors are listed in Table 2. For liquefaction resistance calculations and rod lengths <3 m, a C_R of 0.75 should be applied as was done by Seed et al. (1985) in formulating the simplified procedure. Although application of rod-length correction factors listed in Table 2 will give more precise $(N_1)_{60}$ values, these corrections may be neglected for liquefaction resistance calculations for rod lengths between 3 and 10 m because rod-length corrections were not applied to SPT test data from these depths in compiling the original liquefaction case history databases. Thus rod-length corrections are implicitly incorporated into the empirical SPT procedure.

A final change recommended by workshop participants is the use of revised magnitude scaling factors rather than the original Seed and Idriss (1982) factors to adjust CRR for earthquake magnitudes other than 7.5. Magnitude scaling factors are addressed later in this report.

CPT

A primary advantage of the CPT is that a nearly continuous profile of penetration resistance is developed for stratigraphic interpretation. The CPT results are generally more consistent and repeatable than results from other penetration tests listed in Table 1. The continuous profile also allows a more detailed definition of soil layers than the other tools listed in the table. This stratigraphic capability makes the CPT particularly advantageous for developing liquefaction-resistance profiles. Interpretations based on the CPT, however, must be verified with a few well-placed boreholes preferably with standard penetration tests, to confirm soil types and further verify liquefaction-resistance interpretations.

Fig. 4 provides curves prepared by Robertson and Wride (1998) for direct determination of CRR for clean sands (FC ≤ 5%) from CPT data. This figure was developed from CPT case history data compiled from several investigations, including those by Stark and Olson (1995) and Suzuki et al. (1995). The chart, valid for magnitude 7.5 earthquakes only, shows calculated cyclic resistance ratio plotted as a function of dimensionless, corrected, and normalized CPT resistance q_{c1N} from sites where surface effects of liquefaction were or were not observed following past earthquakes. The CRR curve conservatively separates regions of the plot with data indicative of liquefaction from regions indicative of nonliquefaction.

Based on a few misclassified case histories from the 1989 Loma Prieta earthquake, I. M. Idriss suggested that the clean sand curve in Fig. 4 should be shifted to the right by 10–15%. However, a majority of workshop participants supported a curve in its present position, for three reasons. First, a purpose of the workshop was to recommend criteria that yield roughly equivalent CRR for the field tests listed in Table 1. Shifting the base curve to the right makes the CPT criteria generally more conservative. For example, for $(N_1)_{60} > 5$, q_{c1N}:$(N_1)_{60}$ ra-

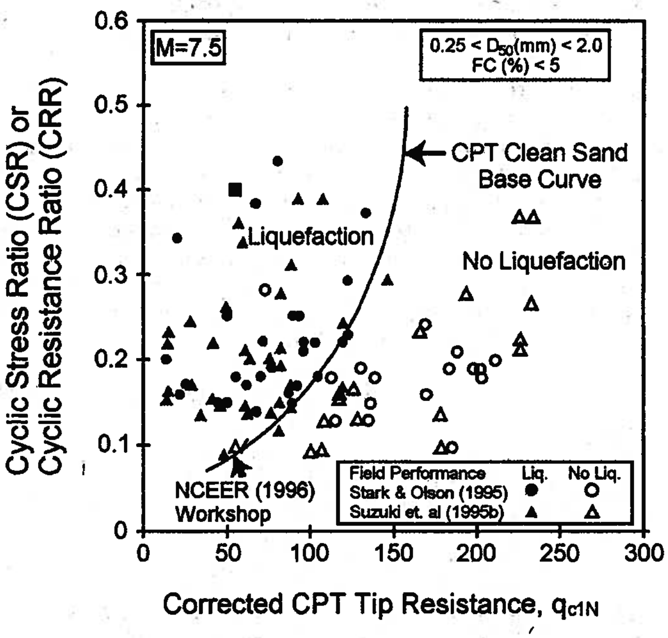


FIG. 4. Curve Recommended for Calculation of CRR from CPT Data along with Empirical Liquefaction Data from Compiled Case Histories (Reproduced from Robertson and Wride 1998)

tios between the two clean-sand base curves, plotted in Figs. 4 and 2, respectively, range from 5 to 8—values that are slightly higher than those expected for clean sands. Shifting the CPT base curve to the right by 10 to 15% would increase those ratios to unusually high values ranging from 6 to 9. Second, base curves, such as those plotted in Figs. 2 and 4, were intended to be conservative, but not necessarily to encompass every data point on the plot. Thus the presence of a few points beyond the base curve should be allowable. Finally, several studies have confirmed that the CPT criteria in Fig. 4 are generally conservative. Robertson and Wride (1998) verified these criteria against SPT and other data from sites they investigated. Gilstrap and Youd (1998) compared calculated liquefaction resistances against field performance at 19 sites and concluded that the CPT criteria correctly predicted the occurrence or nonoccurrence of liquefaction with >85% reliability.

The clean-sand base curve in Fig. 4 may be approximated by the following equation (Robertson and Wride 1998):

$$\text{If } (q_{c1N})_{cs} < 50 \quad \text{CRR}_{7.5} = 0.833[(q_{c1N})_{cs}/1{,}000] + 0.05 \tag{11a}$$

$$\text{If } 50 \leq (q_{c1N})_{cs} < 160 \quad \text{CRR}_{7.5} = 93[(q_{c1N})_{cs}/1{,}000]^3 + 0.08 \tag{11b}$$

where $(q_{c1N})_{cs}$ = clean-sand cone penetration resistance normalized to approximately 100 kPa (1 atm).

Normalization of Cone Penetration Resistance

The CPT procedure requires normalization of tip resistance using (12) and (13). This transformation yields normalized, dimensionless cone pentration resistance q_{c1N}

$$q_{c1N} = C_Q(q_c/P_a) \tag{12}$$

where

$$C_Q = (P_a/\sigma'_{vo})^n \tag{13}$$

and where C_Q = normalizing factor for cone penetration resistance; P_a = 1 atm of pressure in the same units used for σ'_{vo}; n = exponent that varies with soil type; and q_c = field cone penetration resistance measured at the tip. At shallow depths C_Q becomes large because of low overburden pressure; however, values >1.7 should not be applied. As noted in the following paragraphs, the value of the exponent n varies from 0.5 to 1.0, depending on the grain characteristics of the soil (Olsen 1997).

The CPT friction ratio (sleeve resistance f_s divided by cone tip resistance q_c) generally increases with increasing fines content and soil plasticity, allowing rough estimates of soil type and fines content to be determined from CPT data. Robertson and Wride (1998) constructed the chart reproduced in Fig. 5 for estimation of soil type. The boundaries between soil types 2–7 can be approximated by concentric circles and can be used to account for effects of soil characteristics on q_{c1N} and CRR. The radius of these circles, termed the soil behavior type index I_c is calculated from the following equation:

$$I_c = [(3.47 - \log Q)^2 + (1.22 + \log F)^2]^{0.5} \tag{14}$$

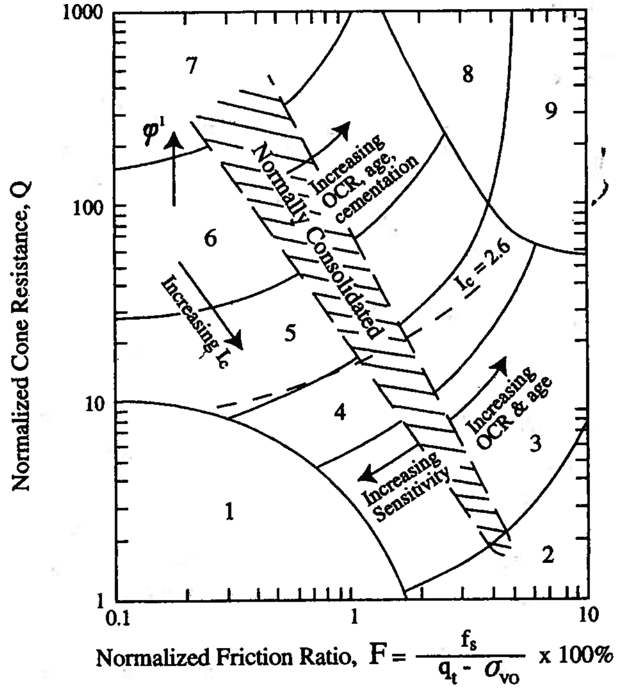
where

$$Q = [(q_c - \sigma_{vo})/P_a][(P_a/\sigma'_{vo})^n] \tag{15}$$

and

$$F = [f_s/(q_c - \sigma_{vo})] \times 100\% \tag{16}$$

The soil behavior chart in Fig. 5 was developed using an exponent n of 1.0, which is the appropriate value for clayey soil types. For clean sands, however, an exponent value of 0.5 is more appropriate, and a value intermediate between 0.5 and 1.0 would be appropriate for silts and sandy silts. Robertson and Wride recommended the following procedure for calculating the soil behavior type index I_c. The first step is to differentiate soil types characterized as clays from soil types characterized as sands and silts. This differentiation is performed by assuming an exponent n of 1.0 (characteristic of clays) and calculating the dimensionless CPT tip resistance Q from the following equation:



1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand*
9. Very stiff, fine grained*

**Heavily overconsolidated or cemented*

FIG. 5. CPT-Based Soil Behavior-Type Chart Proposed by Robertson (1990)

$$Q = [(q_c - \sigma_{vo})/P_a][P_a/\sigma'_{vo}]^{1.0} = [(q_c - \sigma_{vo})/\sigma'_{vo}] \tag{17}$$

If the I_c calculated with an exponent of 1.0 is >2.6, the soil is classified as clayey and is considered too clay-rich to liquefy, and the analysis is complete. However, soil samples should be retrieved and tested to confirm the soil type and liquefaction resistance. Criteria such as the Chinese criteria might be applied to confirm that the soil is nonliquefiable. The so-called Chinese criteria, as defined by Seed and Idriss (1982), specify that liquefaction can only occur if all three of the following conditions are met:

1. The clay content (particles smaller than 5 μ) is <15% by weight.
2. The liquid limit is <35%.
3. The natural moisture content is >0.9 times the liquid limit.

If the calculated I_c is <2.6, the soil is most likely granular in nature, and therefore C_q and Q should be recalculated using an exponent n of 0.5. I_c should then be recalculated using (14). If the recalculated I_c is <2.6, the soil is classed as nonplastic and granular. This I_c is used to estimate liquefaction resistance, as noted in the next section. However, if the recalculated I_c is

>2.6, the soil is likely to be very silty and possibly plastic. In this instance, q_{c1N} should be recalculated from (12) using an intermediate exponent n of 0.7 in (13). I_c is then recalculated from (14) using the recalculated value for q_{c1N}. This intermediate I_c is then used to calculate liquefaction resistance. In this instance, a soil sample should be retrieved and tested to verify the soil type and whether the soil is liquefiable by other criteria, such as the Chinese criteria.

Because the relationship between I_c and soil type is approximate, the consensus of the workshop participants is that all soils with an I_c of 2.4 or greater should be sampled and tested to confirm the soil type and to test the liquefiability with other criteria. Also, soil layers characterized by an $I_c > 2.6$, but with a normalized friction ratio $F < 1.0\%$ (region 1 of Fig. 5) may be very sensitive and should be sampled and tested. Although not technically liquefiable according to the Chinese criteria, such sensitive soils may suffer softening and strength loss during earthquake shaking.

Calculation of Clean-Sand Equivalent Normalized Cone Penetration Resistance $(q_{c1N})_{cs}$

The normalized penetration resistance (q_{c1N}) for silty sands is corrected to an equivalent clean sand value $(q_{c1N})_{cs}$, by the following relationship:

$$(q_{c1N})_{cs} = K_c q_{c1N} \tag{18}$$

where K_c, the correction factor for grain characteristics, is defined by the following equation (Robertson and Wride 1998):

$$\text{for } I_c \leq 1.64 \quad K_c = 1.0 \tag{19a}$$

$$\text{for } I_c > 1.64 \quad K_c = -0.403I_c^4 + 5.581I_c^3 - 21.63I_c^2 + 33.75I_c - 17.88 \tag{19b}$$

The K_c curve defined by (19) is plotted in Fig. 6. For $I_c > 2.6$, the curve is shown as a dashed line, indicating that soils in this range of I_c are most likely too clay-rich or plastic to liquefy.

With an appropriate I_c and K_c, (11) and (19) can be used to calculate $\text{CRR}_{7.5}$. To adjust CRR to magnitudes other than 7.5, the calculated $\text{CRR}_{7.5}$ is multiplied by an appropriate magnitude scaling factor. The same magnitude scaling factors are used with CPT data as with SPT data. Magnitude scaling factors are discussed in a later section of this report.

Olsen (1997) and Suzuki et al. (1995) Procedures

Olsen (1997), who pioneered many of the techniques for assessing liquefaction resistance from CPT soundings, suggested a somewhat different procedure for calculating CRR from CPT data. Reasons for recommending the Robertson and Wride (1998) procedure over that of Olsen are the ease of application and the ease with which relationships can be quantified for computer-aided calculations. Results from Olsen's procedure, however, are consistent with results from the procedure proposed here for shallow (<15 m deep) sediment beneath level to gently sloping terrain. Olsen (1997) noted that almost any CPT normalization technique will give results consistent with his normalization procedure for soil layers in the 3½–15 m depth range. For deeper layers, significant differences may develop between the two procedures. Those depths are also beyond the depth for which the simplified procedure has been verified. Hence any procedure based on the simplified procedure yields rather uncertain results at depths >15 m.

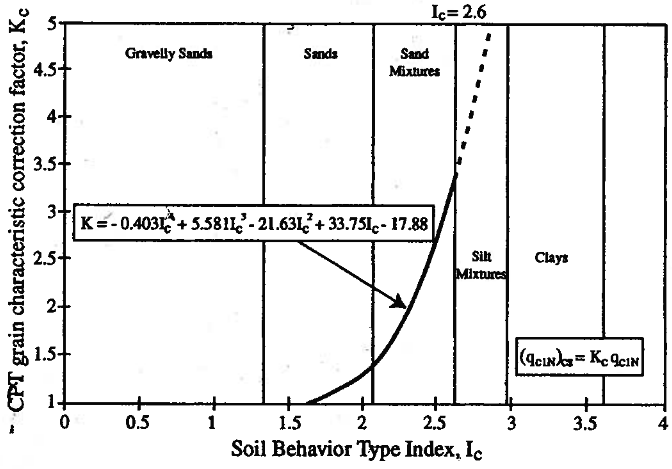


FIG. 6. Grain-Characteristic Correction Factor K_c for Determination of Clean-Sand Equivalent CPT Resistance (Reproduced from Robertson and Wride 1998)

Suzuki et al. (1995) also developed criteria for evaluating CRR from CPT data. Those criteria are slightly more conservative than those of Robertson and Wride (1998) and were considered by the latter investigators in developing the criteria recommended herein.

Correction of Cone Penetration Resistance for Thin Soil Layers

Theoretical as well as laboratory studies indicate that CPT tip resistance is influenced by softer soil layers above or below the cone tip. As a result, measured CPT tip resistance is smaller in thin layers of granular soils sandwiched between softer layers than in thicker layers of the same granular soil. The amount of the reduction of penetration resistance in soft layers is a function of the thickness of the softer layer and the stiffness of the stiffer layers.

Using a simplified elastic solution, Vreugdenhil et al. (1994) developed a procedure for estimating the thick-layer equivalent cone penetration resistance of thin stiff layers lying within softer strata. The correction applies only to thin stiff layers embedded within thick soft layers. Because the corrections have a reasonable trend, but appear rather large, Robertson and Fear (1995) recommended conservative corrections from the $q_{cA}/q_{cB} = 2$ curve sketched in Fig. 7.

Further analysis of field data by Gonzalo Castro and Peter Robertson for the NCEER workshop indicates that corrections based on the $q_{cA}/q_{cB} = 2$ curve may still be too large and not adequately conservative. They suggested, and the workshop participants agreed, that the lower bound of the range of field data plotted by G. Castro in Fig. 7 provides more conservative K_H values that should be used until further field studies and analyses indicate that higher values are viable. The equation for the lower bound of the field curve is

$$K_H = 0.25[((H/d_c)/17) - 1.77]^2 + 1.0 \tag{20}$$

where H = thickness of the interbedded layer in mm; q_{cA} and q_{cB} = cone resistances of the stiff and soft layers, respectively; and d_c = diameter of the cone in mm (Fig. 7).

V_s

Andrus and Stokoe (1997, 2000) developed liquefaction resistance criteria from field measurements of shear wave velocity V_s. The use of V_s as a field index of liquefaction resistance is soundly based because both V_s and CRR are similarly, but not proportionally, influenced by void ratio, effective confining stresses, stress history, and geologic age. The advantages of using V_s include the following: (1) V_s measurements are possible in soils that are difficult to penetrate with CPT and SPT or to extract undisturbed samples, such as gravelly soils, and at sites where borings or soundings may not be permitted; (2) V_s is a basic mechanical property of soil materials, directly related to small-strain shear modulus; and (3) the

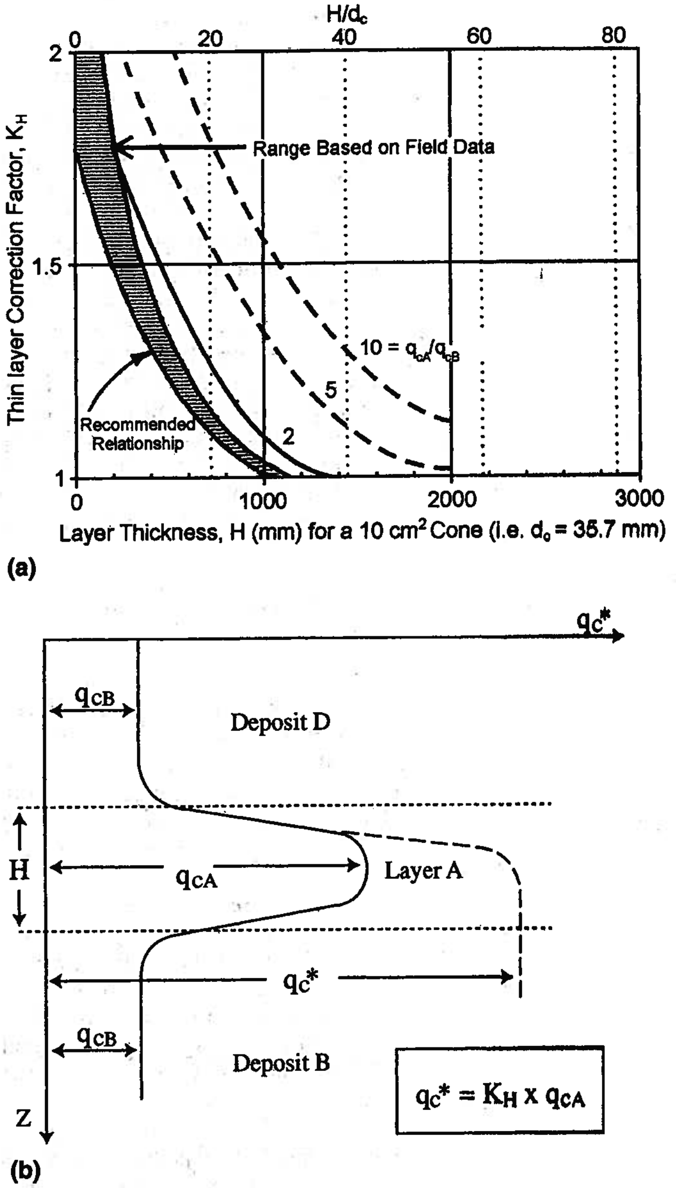


FIG. 7. Thin-Layer Correction Factor K_H for Determination of Equivalent Thick-Layer CPT Resistance (Modified from Robertson and Fear 1995)

small-strain shear modulus is a parameter required in analytical procedures for estimating dynamic soil response and soil-structure interaction analyses.

Three concerns arise when using V_s for liquefaction-resistance evaluations: (1) seismic wave velocity measurements are made at small strains, whereas pore-water pressure buildup and the onset of liquefaction are medium- to high-strain phenomena; (2) seismic testing does not provide samples for classification of soils and identification of nonliquefiable soft clay-rich soils; and (3) thin, low V_s strata may not be detected if the measurement interval is too large. Therefore the preferred practice is to drill sufficient boreholes and conduct in situ tests to detect and delineate thin liquefiable strata, nonliquefiable clay-rich soils, and silty soils above the ground-water table that might become liquefiable should the water table rise. Other tests, such as the SPT or CPT, are needed to detect liquefiable weakly cemented soils that may have high V_s values.

V_s Criteria for Evaluating Liquefaction Resistance

Following the traditional procedures for correcting penetration resistance to account for overburden stress, V_s is also corrected to a reference overburden stress using the following equation (Sykora 1987; Kayen et al. 1992; Robertson et al. 1992):

$$V_{s1} = V_s \left(\frac{P_a}{\sigma'_{vo}}\right)^{0.25} \qquad (21)$$

where V_{s1} = overburden-stress corrected shear wave velocity; P_a = atmospheric pressure approximated by 100 kPa (1 TSF); and σ'_{vo} = initial effective vertical stress in the same units as P_a. Eq. (21) implicitly assumes a constant coefficient of earth pressure K'_o which is approximately 0.5 for sites susceptible to liquefaction. Application of (21) also implicitly assumes that V_s is measured with both the directions of particle motion and wave propagation polarized along principal stress directions and that one of those directions is vertical (Stokoe et al. 1985).

Fig. 8 compares seven CRR-V_{s1} curves. The "best fit" curve by Tokimatsu and Uchida (1990) was determined from laboratory cyclic triaxial test results for various sands with <10% fines and 15 cycles of loading. The more conservative "lower bound" curve for Tokimatsu and Uchida's laboratory test results is also shown as a lower bound for liquefaction occurrences. The bounding curve by Robertson et al. (1992) was developed using field performance data from sites in Imperial Valley, Calif., along with data from four other sites. The curves by Kayen et al. (1992) and Lodge (1994) are from sites that did and did not liquefy during the 1989 Loma Prieta earthquake. Andrus and Stokoe's (1997) curve was developed for uncemented, Holocene-age soils with 5% or less fines using field performance data from 20 earthquakes and over 50 measurement sites. Andrus and Stokoe (2000) revised this curve based on new information and an expanded database that includes 26 earthquakes and more than 70 measurement sites.

Andrus and Stokoe (1997) proposed the following relationship between CRR and V_{s1}:

$$\text{CRR} = a\left(\frac{V_{s1}}{100}\right)^2 + b\left(\frac{1}{V^*_{s1} - V_{s1}} - \frac{1}{V^*_{s1}}\right) \qquad (22)$$

where V^*_{s1} = limiting upper value of V_{s1} for liquefaction occurrence; and a and b are curve fitting parameters. The first parenthetical term of (22) is based on a modified relationship

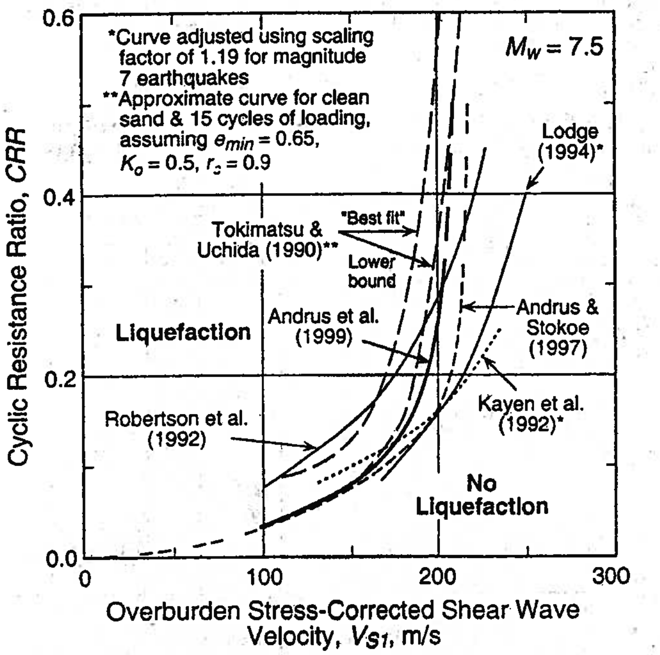


FIG. 8. Comparison of Seven Relationships between Liquefaction Resistance and Overburden Stress-Corrected Shear Wave Velocity for Granular Soils

between V_{s1} and CSR for constant average cyclic shear strain suggested by R. Dobry (personal communication to R. D. Andrus, 1996). The second parenthetical term is a hyperbola with a small value at low V_{s1}, and a very large value as V_{s1} approaches V^*_{s1}, a constant limiting velocity for liquefaction of soils.

CRR versus V_{s1} curves recommended for engineering practice by Andrus and Stokoe (2000) for magnitude 7.5 earthquakes and uncemented Holocene-age soils with various fines contents are reproduced in Fig. 9. Also plotted and presented in Fig. 9 are points calculated from liquefaction case history information for magnitude 5.9–8.3 earthquakes. The three curves shown were determined through an iterative process of varying the values of a and b until nearly all the points indicative of liquefaction were bounded by the curves with the least number of nonliquefaction points plotted in the liquefaction region. The final values of a and b used to draw the curves were 0.022 and 2.8, respectively. Values of V^*_{s1} were assumed to vary linearly from 200 m/s for soils with fines content of 35% to 215 m/s for soils with fines content of 5% or less.

The recommended curves shown in Fig. 9 are dashed above CRR of 0.35 to indicate that field-performance data are limited in that range. Also, they do not extend much below 100 m/s, because there are no field data to support extending them to the origin. The calculated CRR is 0.033 for a V_{s1} of 100 m/s. This minimal CRR value is generally consistent with intercept CRR values assumed for the CPT and SPT procedures. Eq. (22) can be scaled to other magnitude values through use of magnitude scaling factors. These factors are discussed in a later section of this paper.

BPT

Liquefaction resistance of nongravelly soils has been evaluated primarily through CPT and SPT, with occasional V_s measurements. CPT and SPT measurements, however, are not generally reliable in gravelly soils. Large gravel particles may interfere with the normal deformation of soil materials around the penetrometer and misleadingly increase penetration resistance. Several investigators have employed large-diameter penetrometers to surmount these difficulties; the Becker penetration test (BPT) in particular has become one of the more effectively and widely used larger tools. The BPT was developed in Canada in the late 1950s and consists of a 168-mm diameter, 3-m-long double-walled casing driven into the ground with a double-acting diesel-driven pile hammer. The hammer impacts are applied at the top of the casing and peneration is continuous. The Becker penetration resistance is defined as the number of blows required to drive the casing through an increment of 300 mm.

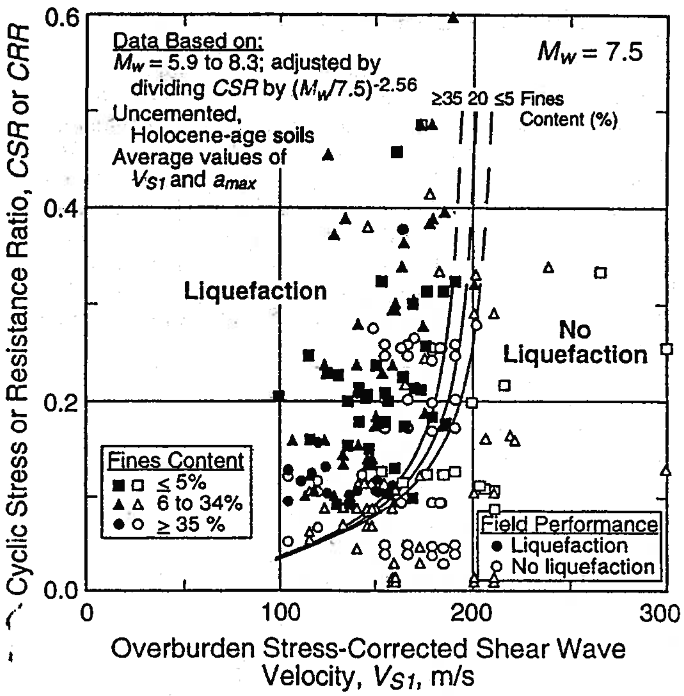


FIG. 9. Liquefaction Relationship Recommended for Clean, Uncemented Soils with Liquefaction Data from Compiled Case Histories (Reproduced from Andrus and Stokoe 2000)

The BPT has not been standardized, and several different types of equipment and procedures have been used. There are currently very few liquefaction sites from which BPT data have been obtained. Thus the BPT cannot be directly correlated with field behavior, but rather through estimating equivalent SPT N-values from BPT data and then applying evaluation procedures based on the SPT. This indirect method introduces substantial additional uncertainty into the calculated CRR.

To provide uniformity, Harder and Seed (1986) recommended newer AP-1000 drill rigs equipped with supercharged diesel hammers, 168-mm outside diameter casing, and a plugged bit. From several sites where both BPT and SPT tests were conducted in parallel soundings, Harder and Seed (1986) developed a preliminary correlation between Becker and standard penetration resistance [Fig. 10(a)]. Additional comparative data compiled since 1986 are plotted in Fig. 10(b). The original Harder and Seed correlation curve (solid line) is drawn in Fig. 10(b) along with dashed curves representing 20% over- and underpredictions of SPT blow counts. These plots indicate that SPT blow counts can be roughly estimated

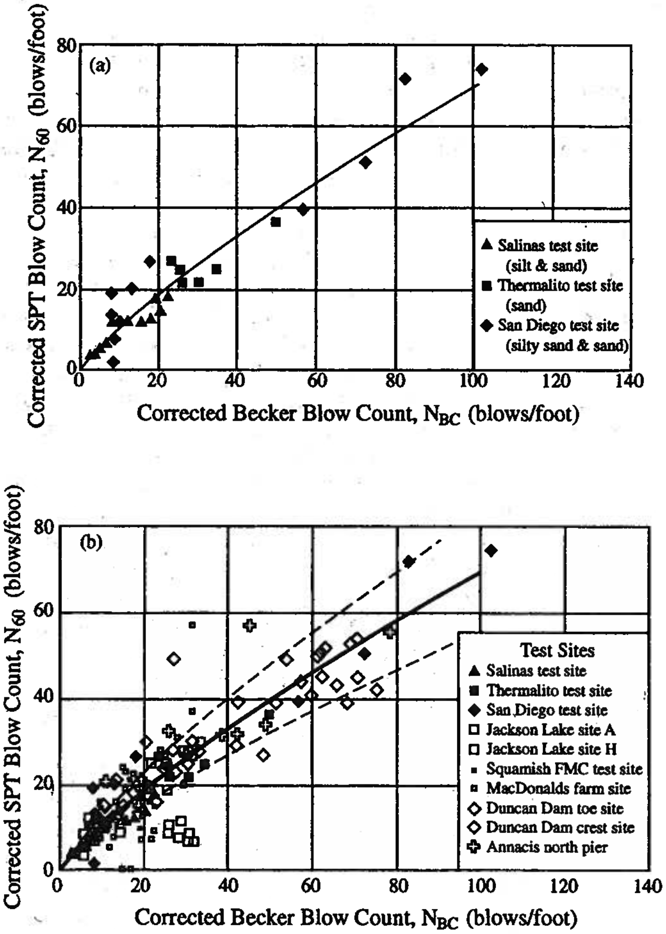


FIG. 10. Correlation between Corrected Becker Penetration Resistance N_{BC} and Corrected SPT Resistance N_{60}: (a) Harder and Seed (1986); (b) Data from Additional Sites (Reproduced from Harder 1997)

from BPT measurements. These plots indicate that although SPT blow counts can be roughly estimated from BPT measurements, there can be considerable uncertainty for calculating liquefaction resistance because the data scatter is greatest in the range of greatest importance [*N*-values of 0–30 blows/300 mm (ft)].

A major source of variation in BPT blow counts is deviations in hammer energy. Rather than measuring hammer energy directly, Harder and Seed (1986) monitored bounce-chamber pressures and found that uniform combustion conditions (e.g., full throttle with a supercharger) correlated rather well with variations in Becker blow count. From this information, Harder and Seed developed an energy correction procedure based on measured bounce-chamber pressure.

Direct measurement of transmitted hammer energy could provide a more theoretically rigorous correction for Becker hammer efficiency. Sy and Campanella (1994) and Sy et al. (1995) instrumented a small length of Becker casing with strain gauges and accelerometers to measure transferred energy. They analyzed the recorded data with a pile-driving analyzer to determine strain, force, acceleration, and velocity. The transferred energy was determined by time integration of force times velocity. They were able to verify many of the variations in hammer energy previously identified by Harder and Seed (1986), including effects of variable throttle settings and energy transmission efficiencies of various drill rigs. However, they were unable to reduce the amount of scatter and uncertainty in converting BPT blow counts to SPT blow counts. Because the Sy and Campanella procedure requires considerably more effort than monitoring of bounce-chamber pressure without producing greatly improved results, the workshop participants agreed that the bounce-chamber technique is adequate for routine practice.

Friction along the driven casing also influences penetration resistance. Harder and Seed (1986) did not directly evaluate the effect of casing friction; hence, the correlation in Fig. 10(b) intrinsically incorporates an unknown amount of casing friction. However, casing friction remains a concern for depths >30 m and for measurement of penetration resistance in soft soils underlying thick deposits of dense soil. Either of these circumstances could lead to greater casing friction than is intrinsically incorporated in the Harder and Seed correlation.

The following procedures are recommended for routine practice: (1) the BPT should be conducted with newer AP-1000 drill rigs equipped with supercharged diesel hammers to drive plugged 168-mm outside diameter casing; (2) bounce-chamber pressures should be monitored and adjustments made to measured BPT blow counts to account for variations in diesel hammer combustion efficiency—for most routine applications, correlations developed by Harder and Seed (1986) may be used for these adjustments; and (3) the influence of some casing friction is indirectly accounted for in the Harder and Seed BPT-SPT correlation. This correlation, however, has not been verified and should not be used for depths >30 m or for sites with thick dense deposits overlying loose sands or gravels. For these conditions, mudded boreholes may be needed to reduce casing friction, or specially developed local correlations or sophisticated wave-equation analyses may be applied to quantify frictional effects.

MAGNITUDE SCALING FACTORS (MSFs)

The clean-sand base or CRR curves in Figs. 2 (SPT), 4 (CPT), and 10 (V_{s1}) apply only to magnitude 7.5 earthquakes. To adjust the clean-sand curves to magnitudes smaller or larger than 7.5, Seed and Idriss (1982) introduced correction factors termed "magnitude scaling factors (MSFs)." These factors are used to scale the CRR base curves upward or downward on CRR versus $(N_1)_{60}$, q_{c1N}, or V_{s1} plots. Conversely, magnitude weighting factors, which are the inverse of magnitude scaling factors, may be applied to correct CSR for magnitude. Either correcting CRR via magnitude scaling factors, or correcting CSR via magnitude weighting factors, leads to the same final result. Because the original papers by Seed and Idriss were written in terms of magnitude scaling factors, the use of magnitude scaling factors is continued in this report.

To illustrate the influence of magnitude scaling factors on calculated hazard, the equation for factor of safety (FS) against liquefaction is written in terms of CRR, CSR, and MSF as follows:

$$FS = (CRR_{7.5}/CSR)MSF \tag{23}$$

where CSR = calculated cyclic stress ratio generated by the earthquake shaking; and $CRR_{7.5}$ = cyclic resistance ratio for magnitude 7.5 earthquakes. $CRR_{7.5}$ is determined from Fig. 2 or (4) for SPT data, Fig. 4 or (11) for CPT data, or Fig. 9 or (22) for V_{s1} data.

Seed and Idriss (1982) Scaling Factors

Because of the limited amount of field liquefaction data available in the 1970s, Seed and Idriss (1982) were unable to adequately constrain bounds between liquefaction and nonliquefaction regions on CRR plots for magnitudes other than 7.5. Consequently, they developed a set of MSF from average numbers of loading cycles for various earthquake magnitudes and laboratory test results. A representative curve developed by these investigators, showing the number of loading cycles required to generate liquefaction for a given CSR, is reproduced in Fig. 11. The average number of loading cycles for various magnitudes of earthquakes are also noted on the plot. The initial set of magnitude scaling factors was derived by dividing CSR values on the representative curve for the number of loading cycles corresponding to a given earthquake magnitude by the CSR for 15 loading cycles (equivalent to a magnitude 7.5 earthquake). These scaling factors are listed in column 2 of Table 3 and are plotted in Fig. 12. These MSFs have been routinely applied in engineering practice since their introduction in 1982.

Revised Idriss Scaling Factors

In preparing his H. B. Seed Memorial Lecture, I. M. Idriss reevaluated the data that he and the late Professor Seed used to calculate the original (1982) magnitude scaling factors. In so doing, Idriss replotted the data on a log-log plot and suggested that the data should plot as a straight line. He noted, however, that one outlying point had strongly influenced the original analysis, causing the original plot to be nonlinear and characterized by unduly low MSF values for magnitudes <7.5. Based on this reevaluation, Idriss defined a revised set of magnitude scaling factors listed in column 3 of Table 3 and plotted

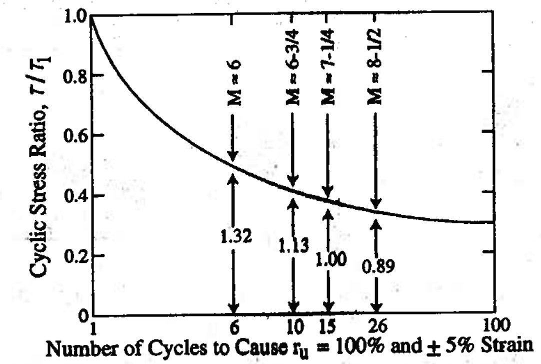


FIG. 11. Representative Relationship between CSR and Number of Cycles to Cause Liquefaction (Reproduced from Seed and Idriss 1982)

TABLE 3. Magnitude Scaling Factor Values Defined by Various Investigators (Youd and Noble 1997a)

Magnitude, *M*	Seed and Idriss (1982)	Idriss[a]	Ambraseys (1988)	Arango (1996)		Andrus and Stokoe (1997)	Youd and Noble (1997b)		
				Distance based	Energy based		$P_L < 20\%$	$P_L < 32\%$	$P_L < 50\%$
5.5	1.43	2.20	2.86	3.00	2.20	2.8	2.86	3.42	4.44
6.0	1.32	1.76	2.20	2.00	1.65	2.1	1.93	2.35	2.92
6.5	1.19	1.44	1.69	1.60	1.40	1.6	1.34	1.66	1.99
7.0	1.08	1.19	1.30	1.25	1.10	1.25	1.00	1.20	1.39
7.5	1.00	1.00	1.00	1.00	1.00	1.00	—	—	1.00
8.0	0.94	0.84	0.67	0.75	0.85	0.8?	—	—	0.73?
8.5	0.89	0.72	0.44	—	—	0.65?	—	—	0.56?

Note: ? = Very uncertain values.

[a] 1995 Seed Memorial Lecture, University of California at Berkeley (I. M. Idriss, personal communication to T. L. Youd, 1997).

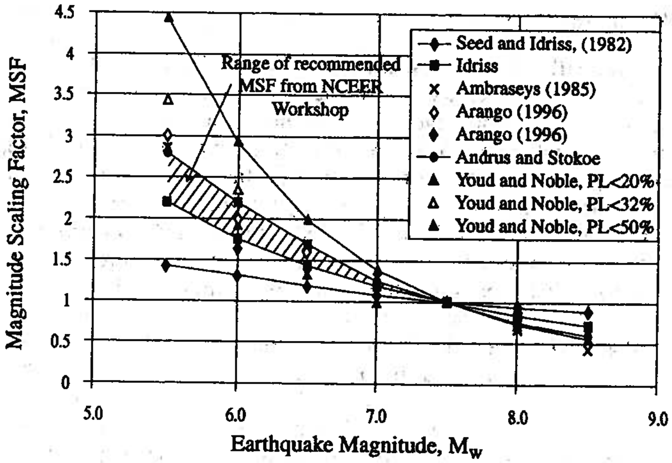


FIG. 12. Magnitude Scaling Factors Derived by Various Investigators (Reproduced from Youd and Noble 1997a)

in Fig. 12. The revised MSFs are defined by the following equation:

$$\mathrm{MSF} = 10^{2.24}/M_w^{2.56} \tag{24}$$

The workshop participants recommend these revised scaling factors as a lower bound for MSF values.

The revised scaling factors are significantly higher than the original scaling factors for magnitudes <7.5 and somewhat lower than the original factors for magnitudes >7.5. Relative to the original scaling factors, the revised factors lead to a reduced calculated liquefaction hazard for magnitudes <7.5, but increase calculated hazard for magnitudes >7.5.

Ambraseys (1988) Scaling Factors

Field performance data collected since the 1970s for magnitudes <7.5 indicate that the original Seed and Idriss (1982) scaling factors are overly conservative. For example, Ambraseys (1988) analyzed liquefaction data compiled through the mid-1980s and plotted calculated cyclic stress ratios for sites that did or did not liquefy versus $(N_1)_{60}$. From these plots, Ambraseys developed empirical exponential equations that define CRR as a function of $(N_1)_{60}$ and moment magnitude M_w. By holding the value of $(N_1)_{60}$ constant in the equations and taking the ratio of CRR determined for various magnitudes of earthquakes to the CRR for magnitude 7.5 earthquakes, Ambraseys derived the magnitude scaling factors listed in column 4 of Table 3 and plotted in Fig. 12. For magnitudes <7.5, the MSFs suggested by Ambraseys are significantly larger than both the original factors developed by Seed and Idriss (column 2, Table 3) and the revised factors suggested by Idriss (column 3). Because they are based on observational data, these factors have validity for estimating liquefaction hazard; however, they have not been widely used in engineering practice.

For magnitudes >7.5, Ambraseys factors are significantly lower and much more conservative than the original (Seed and Idriss 1982) and Idriss's revised scaling factors. Because there are few data to constrain Ambraseys' scaling factors for magnitudes >7.5, they are not recommended for hazard evaluation for large earthquakes.

Arango (1996) Scaling Factors

Arango (1996) developed two sets of magnitude scaling factors. The first set (column 5, Table 3) is based on furthest observed liquefaction effects from the seismic energy source, the estimated average peak accelerations at those distant sites, and the seismic energy required to cause liquefaction. The second set (column 6, Table 3) was developed from energy concepts and the relationship derived by Seed and Idriss (1982) between numbers of significant stress cycles and earthquake magnitude. The MSFs listed in column 5 are similar in value (within about 10%) to the MSFs of Ambraseys (column 4), and the MSFs listed in column 6 are similar in value (within about 10%) to the revised MSFs proposed by Idriss (column 3).

Andrus and Stokoe (1997) Scaling Factors

From their studies of liquefaction resistance as a function of shear wave velocity V_s Andrus and Stokoe (1997) drew bounding curves and developed (22) for calculating CRR from V_s for magnitude 7.5 earthquakes. These investigators drew similar bounding curves for sites where surface effects of liquefaction were or were not observed for earthquakes with magnitudes of 6, 6.5, and 7. The positions of the CRR curves were visually adjusted on each graph until a best-fit bound was obtained. Magnitude scaling factors were then estimated by taking the ratio of CRR for a given magnitude to the CRR for magnitude 7.5 earthquakes. These MSFs are quantified by the following equation:

$$\mathrm{MSF} = (M_w/7.5)^{-2.56} \tag{25}$$

MSFs for magnitudes <6 and >7.5 were extrapolated from this equation. The derived MSFs are listed in column 7 of Table 3, and plotted in Fig. 12. For magnitudes <7.5, the MSFs proposed by Andrus and Stokoe are rather close in value (within about 5%) to the MSFs proposed by Ambraseys. For magnitudes >7.5, the Andrus and Stokoe MSFs are slightly smaller than the revised MSFs proposed by Idriss.

Youd and Noble (1997a) Scaling Factors

Youd and Noble (1997a) used a probabilistic or logistic analysis to analyze case history data from sites where effects of liquefaction were or were not reported following past earthquakes. This analysis yielded the following equation, which was updated after publication of the NCEER proceedings (Youd and Idriss 1997):

$$\text{Logit}(P_L) = \ln(P_L/(1 - P_L)) = -7.0351 + 2.1738M_w - 0.2678(N_1)_{60cs} + 3.0265 \ln \text{CRR} \quad (26)$$

where P_L = probability that liquefaction occurred; $1 - P_L$ = probability that liquefaction did not occur; and $(N_1)_{60cs}$ = corrected equivalent clean-sand blow count. For magnitudes <7.5, Youd and Noble recommended direct application of this equation to calculate the CRR for a given probability of liquefaction. In lieu of direct application, Youd and Noble defined three sets of MSFs for use with the simplified procedure. These MSFs are for probabilities of liquefaction occurrence <20, 32, and 50%, respectively, and are defined by the following equations:

$$\text{Probability } P_L < 20\% \quad \text{MSF} = 10^{3.81}/M^{4.53} \text{ for } M_w < 7 \quad (27)$$

$$\text{Probability } P_L < 32\% \quad \text{MSF} = 10^{3.74}/M^{4.33} \text{ for } M_w < 7 \quad (28)$$

$$\text{Probability } P_L < 50\% \quad \text{MSF} = 10^{4.21}/M^{4.81} \text{ for } M_w < 7.75 \quad (29)$$

New Recommendation by Idriss

I. M. Idriss (TRB 1999) proposed a new set of MSFs that are compatible with, and are only to be used with, the magnitude-dependent r_d that he also proposed. These new MSFs have lower values than the revised MSFs listed in Table 3, but slightly higher values than the original Seed and Idriss (1982) MSFs. Because the proposed r_d and associated MSFs have not been published and the factors have not been independently verified, the workshop participants chose not to recommend the new r_d or MSFs at this time.

Recommendations for Engineering Practice

The workshop participants reviewed the MSFs listed in Table 3, and all but one (S. S. C. Liao) agree that the original factors were too conservative and that increased MSFs are warranted for engineering practice for magnitudes <7.5. Rather than recommending a single set of factors, the workshop participants suggest a range of MSFs from which the engineer is allowed to choose factors that are requisite with the acceptable risk for any given application. For magnitudes <7.5, the lower bound for the recommended range is the new MSF proposed by Idriss [column 3 in Table 3, or (23)]. The suggested upper bound is the MSF proposed by Andrus and Stokoe [column 7 in Table 3, or (26)]. The upper-bound values are consistent with MSFs suggested by Ambraseys (1988), Arango (1996), and Youd and Noble (1997a) for $P_L < 20\%$.

For magnitudes >7.5, the new factors recommended by Idriss [column 3 in Table 3; (25)] should be used for engineering practice. These new factors are smaller than the original Seed and Idriss (1982) factors, hence their application leads to increased calculated liquefaction hazard compared to the original factors. Because there are only a few well-documented liquefaction case histories for earthquakes with magnitudes >8, MSFs in that range are poorly constrained by field data. Thus the workshop participants agreed that the greater conservatism embodied in the revised MSF by Idriss (column 3, Table 3) should be recommended for engineering practice.

CORRECTIONS FOR HIGH OVERBURDEN STRESSES, STATIC SHEAR STRESSES, AND AGE OF DEPOSIT

Correction factors K_σ and K_α were developed by Seed (1983) to extrapolate the simplified procedure to larger overburden pressure and static shear stress conditions than those embodied in the case history data set from which the simplified procedure was derived. As noted previously, the simplified procedure was developed and validated only for level to gently sloping sites (low static shear stress) and depths less than about 15 m (low overburden pressures). Thus applications using K_σ and K_α are beyond routine practice and require specialized expertise. Because these factors were discussed at the workshop and some new information was developed, recommendations from those discussions are included here. These recommendations, however, apply mostly to liquefaction hazard analyses of embankment dams and other large structures. These factors are applied by extending (23) to include K_σ and K_α as follows:

$$\text{FS} = (\text{CRR}_{7.5}/\text{CSR}) \cdot \text{MSF} \cdot K_\sigma \cdot K_\alpha \quad (30)$$

K_σ Correction Factor

Cyclically loaded laboratory test data indicate that liquefaction resistance increases with increasing confining stress. The rate of increase, however, is nonlinear. To account for the nonlinearity between CRR and effective overburden pressure, Seed (1983) introduced the correction factor K_σ to extrapolate the simplified procedure to soil layers with overburden pressures >100 kPa. Cyclically loaded, isotropically consolidated triaxial compression tests on sand specimens were used to measure CRR for high-stress conditions and develop K_σ values. By taking the ratio of CRR for various confining pressures to the CRR determined for approximately 100 kPa (1 atm) Seed (1983) developed the original K_σ correction curve. Other investigators have added data and suggested modifications to better define K_σ for engineering practice. For example, Seed and Harder (1990) developed the clean-sand curve reproduced in Fig. 13. Hynes and Olsen (1999) compiled and analyzed an enlarged data set to provide guidance and formulate equations for selecting K_σ values (Fig. 14). The equation they derived for calculating K_σ is

$$K_\sigma = (\sigma'_{vo}/P_a)^{(f-1)} \quad (31)$$

where σ'_{vo}, effective overburden pressure; and P_a, atmospheric pressure, are measured in the same units; and f is an exponent that is a function of site conditions, including relative density, stress history, aging, and overconsolidation ratio. The workshop participants considered the work of previous investigators and recommend the following values for f (Fig. 15). For relative densities between 40 and 60%, f = 0.7–0.8; for relative densities between 60 and 80%, f = 0.6–0.7. Hynes and Olsen recommended these values as minimal or conservative esti-

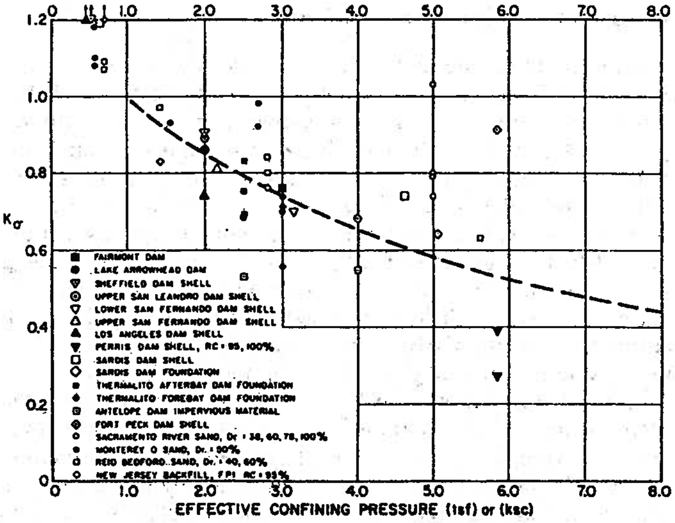


FIG. 13. K_σ-Values Determined by Various Investigators (Reproduced from Seed and Harder 1990)

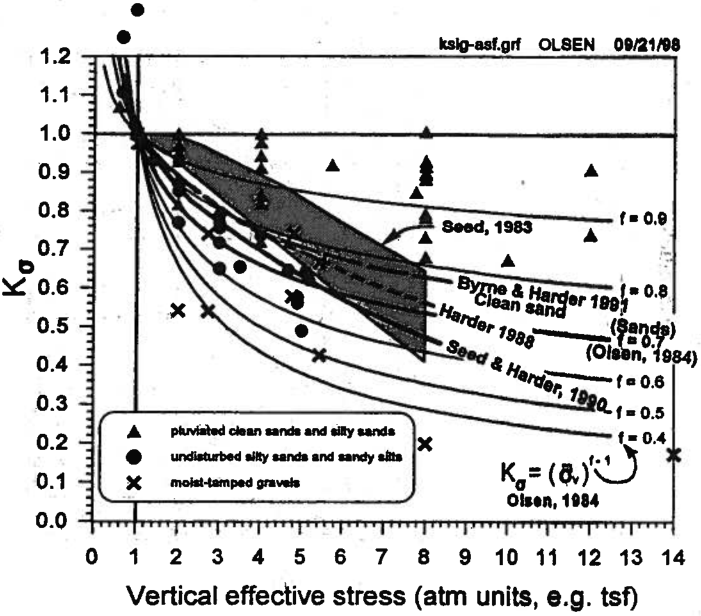


FIG. 14. Laboratory Data and Compiled K_σ Curves (Reproduced from Hynes and Olsen 1999)

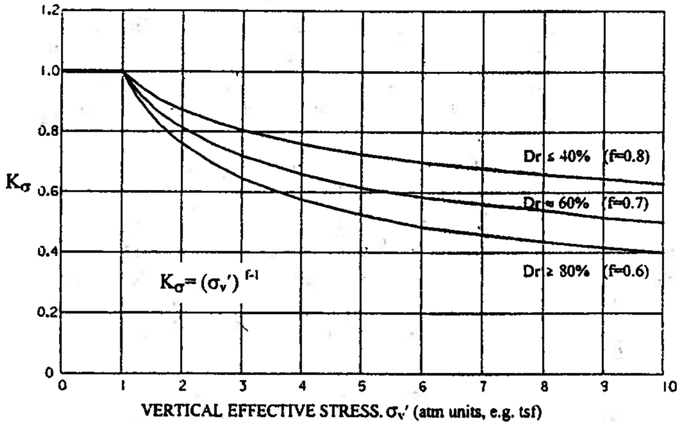


FIG. 15. Recommended Curves for Estimating K_σ for Engineering Practice

mates of K_σ for use in engineering practice for both clean and silty sands, and for gravels. The workshop participants concurred with this recommendation.

K_α Correction Factor for Sloping Ground

The liquefaction resistance of dilative soils (moderately dense to dense granular materials under low confining stress) increases with increased static shear stress. Conversely, the liquefaction resistance of contractive soils (loose soils and moderately dense soils under high confining stress) decreases with increased static shear stresses. To incorporate the effect of static shear stresses on liquefaction resistance, Seed (1983) introduced a correction factor K_α. To generate values for this factor, Seed normalized the static shear stress τ_{st} acting on a plane with respect to the effective vertical stress σ'_{vo} yielding a parameter α, where

$$\alpha = \tau_{st}/\sigma'_{vo} \qquad (32)$$

Cyclically loaded triaxial compression tests were then used to empirically determine values of the correction factor K_α as a function of α.

For the NCEER workshop, Harder and Boulanger (1997) reviewed past publications, test results, and analyses of K_α. They noted that a wide range of K_α values have been proposed, indicating a lack of convergence and a need for continued research. The workshop participants agreed with this assessment. Although curves relating K_α to α have been published (Harder and Boulanger 1997), these curves should not be used by nonspecialists in geotechnical earthquake engineering or in routine engineering practice.

Influence of Age of Deposit

Several investigators have noted that liquefaction resistance of soils increases with age. For example, Seed (1979) observed significant increases in liquefaction resistance with aging of reconstituted sand specimens tested in the laboratory. Increases of as much as 25% in cyclic resistance ratio were noted between freshly constituted and 100-day-old specimens. Youd and Hoose (1977) and Youd and Perkins (1978) noted that liquefaction resistance increases markedly with geologic age. Sediments deposited within the past few thousand years are generally much more susceptible to liquefaction than older Holocene sediments; Pleistocene sediments are even more resistant; and pre-Pleistocene sediments are generally immune to liquefaction. Although qualitative time-dependent increases have been documented as noted above, few quantitative data have been collected. In addition, the factors causing increased liquefaction resistance with age are poorly understood. Consequently, verified correction factors for age have not been developed.

In the absence of quantitative correction factors, engineering judgment is required to estimate the liquefaction resistance of sediments more than a few thousand years old. For deeply buried sediments dated as more than a few thousand years old, some knowledgeable engineers have omitted application of the K_σ factor as partial compensation for the unquantified, but substantial increase of liquefaction resistance with age. For manmade structures, such as thick fills and embankment dams, aging effects are minimal, and corrections for age should not be applied in calculating liquefaction resistance.

SEISMIC FACTORS

Application of the simplified procedure for evaluating liquefaction resistance requires estimates of two ground motion parameters—earthquake magnitude and peak horizontal ground acceleration. These factors characterize duration and intensity of ground shaking, respectively. The workshop addressed the following questions with respect to selection of magnitude and peak acceleration values for liquefaction resistance analyses.

Earthquake Magnitude

Records from recent earthquakes, such as 1979 Imperial Valley, 1988 Armenia, 1989 Loma Prieta, 1994 Northridge, and 1995 Kobe, indicate that the relationship between duration and magnitude is rather uncertain and that factors other than magnitude also influence duration. For example, unilateral faulting, in which rupture begins at one end of the fault and propagates to the other, usually produces longer shaking duration for a given magnitude than bilateral faulting, in which slip begins near the midpoint on the fault and propagates in both directions simultaneously. Duration also generally increases with distance from the seismic energy source and may vary with tectonic province, site conditions, and bedrock topography (basin effects).

Question: Should correction factors be developed to adjust duration of shaking to account for the influence of earthquake source mechanism, fault rupture mode, distance from the energy source, basin effects, etc.?

Answer: Faulting characteristics and variations in shaking duration are difficult to predict in advance of an earthquake event. The influence of distance generally is of secondary importance within the range of distances to which damaging liquefaction effects commonly develop. Basin effects are not yet sufficiently predictable to be adequately accounted for in engineering practice. Thus the workshop participants recommend continued use of the generally conservative relationship between magnitude and duration that is embodied in the simplified procedure.

Question: An important difference between eastern U.S. earthquakes and western U.S. earthquakes is that eastern ground motions are generally richer in high-frequency energy and thus could generate more significant stress cycles and equivalently longer durations than western earthquakes of the same magnitude. Is a correction needed to account for higher frequencies of motions generated by eastern U.S. earthquakes?

Answer: The high-frequency motions of eastern earthquakes are generally limited to near-field rock sites. High-frequency motions attenuate or are damped out rather quickly as they propagate through soil layers. This filtering action reduces the high-frequency energy at soil sites and thus reduces differences in numbers of significant loading cycles. Because liquefaction occurs only within soil strata, duration differences on soil sites between eastern and western earthquakes are not likely to be great. Without more instrumentally recorded data from which differences in ground motion characteristics can be quantified, there is little basis for the development of additional correction factors for eastern localities.

Another difference between eastern and western U.S. earthquakes is that strong ground motions generally propagate to greater distances in the east than in the west. By applying present state-of-the-art procedures for estimating peak ground acceleration at eastern sites, differences in amplitudes of ground motions between western and eastern earthquakes are properly taken into account.

Question: Which magnitude scale should be used for selection of earthquake magnitudes for liquefaction resistance analyses?

Answer: Seismologists commonly calculate earthquake magnitudes using five different scales: (1) local or Richter magnitude M_L; (2) surface-wave magnitude M_s; (3) short-period body-wave magnitude m_b; (4) long-period body-wave magnitude m_B; and (5) moment magnitude M_w. Moment magnitude, the scale most commonly used for engineering applications, is the scale preferred for calculation of liquefaction resistance. As Fig. 16 shows, magnitudes from other scales may be substituted directly for M_w within the following limitations—$M_L < 6$, $m_B < 7.5$, and $6 < M_s < 8$—m_b, a scale commonly used for eastern U.S. earthquakes, may be used for magnitudes between 5 and 6, provided m_b values are corrected to equivalent M_w values. The curves plotted in Fig. 16 may be used for this adjustment (Idriss 1985).

Peak Acceleration

In the simplified procedure, peak horizontal acceleration $a_{\max}$ is used to characterize the intensity of ground shaking. To provide guidance for estimation of $a_{\max}$, the workshop addressed the following questions.

Question: What procedures are preferred for estimating $a_{\max}$ at potentially liquefiable sites?

Answer: The following methods, in order of preference, may be used for estimating $a_{\max}$:

1) The preferred method for estimating $a_{\max}$ is through empirical correlations of $a_{\max}$ with earthquake magnitude, distance from the seismic energy source, and local site conditions. Several correlations have been published for estimating $a_{\max}$ for sites on bedrock or stiff to moderately stiff soils. Preliminary attenuation relationships have also been developed for a limited range of soft soil sites (Idriss 1991). Selection of an attenuation relationship should be based on such factors as region of the country, type of faulting, and site condition.

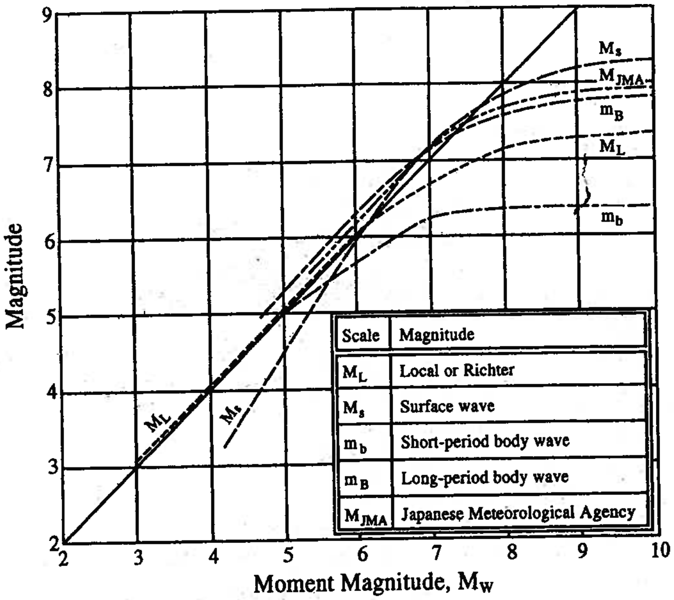


FIG. 16. Relationship between Moment M_w and Other Magnitude Scales (Reproduced from Heaton et al., Unpublished Report, 1982)

2) For soft sites and other soil profiles that are not compatible with available attenuation relationships, $a_{\max}$ may be estimated from local site response analyses. Computer programs such as SHAKE and DESRA may be used for these calculations (Schnabel et al. 1972; Finn et al. 1977). Input ground motions in the form of recorded accelerograms are preferable to synthetic records. Accelerograms derived from white noise should be avoided. A suite of plausible earthquake records should be used in the analysis, including as many as feasible from earthquakes with similar magnitudes, source distances, etc.

3) The third and least desirable method for estimating peak ground acceleration is through amplification ratios, such as those developed by Idriss (1990, 1991) and Seed et al. (1994). These factors use a multiplier or ratio by which bedrock outcrop motions are amplified to estimate surface motions at soil sites. Because amplification ratios are influenced by strain level, earthquake magnitude, and frequency content, caution and considerable engineering judgment are required in the application of these relationships.

Question: Which peak acceleration should be used: (1) the largest horizontal acceleration recorded on a three-component accelerogram; (2) the geometric mean (square root of the product) of the two maximum horizontal components; or (3) a vectorial combination of horizontal accelerations?

Answer: According to I. M. Idriss (oral discussion at NCEER workshop, 1996), where recorded motions were available, the larger of the two horizontal peak components of acceleration was used in the compilation of data used to derive the original simplified procedure. Where recorded values were not available, which was the circumstance for most sites, peak acceleration values were estimated from attenuation relationships based on the geometric mean of the two orthogonal peak horizontal accelerations. In nearly all instances where recorded motions were used, the peaks from the two horizontal records were approximately equal. Thus where a single peak was used, the peak and the geometric mean of the two peaks were about the same value. Based on this information, the workshop participants concurred that use of the geometric mean is consistent with the development of the procedure and is preferred for use in engineering practice. However, use of the larger of the two orthogonal peak accelerations yields a larger estimate of a_{max}, is conservative, and is allowable. Vectorial accelerations are seldom calculated and should not be used. Peak vertical accelerations are generally much smaller than peak horizontal accelerations and are ignored for calculation of liquefaction resistance.

Question: Liquefaction usually develops at soil sites where ground motion amplification may occur and where sediment may soften, reducing motions as excess pore pressure develop. How should investigators account for these factors in estimating peak acceleration?

Answer: The recommended procedure is to calculate or estimate the a_{max} that would occur at the site in the absence of increased pore pressure or the onset of liquefaction. That peak acceleration incorporates the influence of site amplification, but neglects the influence of excess pore-water pressure.

Question: Should high-frequency spikes (periods <0.1 s) in acceleration records be considered or ignored?

Answer: In general, short-duration, high-frequency acceleration spikes are too short in duration to generate significant instability or deformation of granular structures, and should be ignored. By using attenuation relationships for estimation of peak acceleration, as noted above, high-frequency spikes are essentially ignored because few high-frequency peaks are incorporated in databases from which attenuation the relationships were derived. Similarly, ground response analyses programs such as SHAKE and DESRA generally attenuate or filter out high-frequency spikes, reducing their influence. Where amplification ratios are used, engineering judgment should be used to determine which bedrock acceleration is to be amplified.

ENERGY-BASED CRITERIA AND PROBABILISTIC ANALYSES

The workshop considered two additional topics: (1) liquefaction resistance criteria based on seismic energy passing through a liquefiable layer (Kayen and Mitchell 1997; Youd et al. 1997), and probabilistic analyses of case history data (Liao et al. 1988; Youd and Noble 1997b). Although probabilistic or risk analyses have been made for some localities and critical facilities, the workshop participants concluded that probabilistic procedures are still under development and not sufficiently formulated for routine engineering practice. Similarly, new energy-based criteria need to be independently tested before recommendations can be made for general practice. The workshop participants recommend that research and development continue on both of these relatively new and potentially useful procedures.

CONCLUSIONS

The participants in the NCEER workshop reviewed the state-of-the-art for evaluating liquefaction resistance and recommend several augmentations to that procedure. Specific recommendations, including procedures and equations, are listed in each section of this summary paper. Consensus conclusions from the workshop are:

1. Four field tests are recommended for routine evaluation of liquefaction resistance—the cone penetration test (CPT), the standard penetration test (SPT), shear-wave velocity (V_s) measurements, and for gravelly sites the Becker penetration test (BPT). Criteria for each test were reviewed and revised to incorporate recent developments and to achieve consistency between resistances calculated from the various tests. Each test has its advantages and limitations (Table 1). the CPT provides the most detailed soil stratigraphy and robust field-data based liquefaction resistance curves now available. CPT testing should always be accompanied by soil sampling for validation of soil type identification. The SPT has a longer record of application and provides disturbed soil samples from which fines content and other grain characteristics can be determined. Measured shear-wave velocities provide fundamental information on small-strain soil behavior that is useful beyond analyses of liquefaction resistance. V_s is also applicable at sites, such as landfills and gravelly sediments, where CPT and SPT soundings may not be possible or reliable. The BPT test is recommended only for gravelly sites and requires use of rough correlations between BPT and SPT, making the results less certain than other tests. Where possible, two or more test procedures should be applied to assure adequate definition of soil stratigraphy and a consistent evaluation of liquefaction resistance.
2. The magnitude scaling factors originally derived by Seed and Idriss (1982) are overly conservative for earthquakes with magnitudes <7.5. A range of scaling factors is recommended for engineering practice, the lower end of the range being the new MSF recommended by Idriss (column 3, Table 3), and the upper end of the range being the MSF suggested by Andrus and Stokoe (column 7, Table 3). These MSFs are defined by (25) and (26), respectively. For magnitudes >7.5, the new factors by Idriss (column 3, Table 3) should be used. These factors, which are more conservative than the original Seed and Idriss (1982) factors, should be applied.
3. The K_σ factors suggested by Seed and Harder (1990) appear to be overly conservative for some soils and field conditions. The workshop participants recommend K_σ values defined by the curves in Fig. 14 or (31). Because K_σ values are usually applied to depths greater than those verified for the simplified procedure, special expertise is generally required for their application.
4. Procedures for evaluation of liquefaction resistance beneath sloping ground or embankments (slopes greater than about 6%) have not been developed to a level allowable for routine use. Special expertise is required for evaluation of liquefaction resistance beneath sloping ground.
5. Moment magnitude M_w should be used for liquefaction resistance calculations. Magnitude, as used in the simplified procedure, is a measure of the duration of strong ground shaking. The present magnitude criteria are conservative and should not be corrected for source mechanism, style of faulting, distance from the energy source, subsurface bedrock topography (basin effect), or tectonic region (eastern versus western U.S. earthquakes).
6. The peak acceleration a_{max} applied in the procedure is the peak horizontal acceleration that would occur at ground surface in the absence of pore pressure increases or liquefaction. Attenuation relationships compatible with soil conditions at a site should be applied in estimating a_{max}. Relationships based on the geometric mean of the peak horizontal accelerations are preferred, but use of relationships based on peak horizontal acceleration is allowable and conservative. Where site conditions are incompatible with existing attenuation relationships, site-specific response calculations, using programs such as SHAKE or DESRA, should be used. The least preferable technique is application of amplification factors.

ACKNOWLEDGMENTS

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University graduate students Steven Noble, Samuel Gilstrap, and Curt Peterson, assisted in organizing and conducting the workshops.

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NOTATION

The following symbols are used in this paper:

a, b = curve fitting parameters for use with V_s criteria for evaluating liquefaction resistance;
a_{max} = peak horizontal acceleration at ground surface;
C_B = correction factor for borehole diameter;
C_E = correction factor for hammer energy;
C_N = correction factor for overburden pressure applied to SPT;
C_Q = correction factor for overburden pressure applied to CPT;
C_R = correction factor for drilling rod length;
C_S = correction factor for split spoon sampler without liners;
$CRR_{7.5}$ = cyclic resistance ratio for $M_w = 7.5$ earthquakes;
d_c = diameter of CPT tip;
F = normalized friction ratio;
f = exponent estimated from site conditions used in calculation of K_σ;
f_s = sleeve friction measured with CPT;
g = acceleration of gravity;
H = thickness of thin granular layer between softer sediment layers;
I_c = soil behavior type index for use with CPT liquefaction criteria;
K_c = correction factor for grain characteristics applied to CPT;
K_H = thin-layer correction factor for use with CPT;
K_α = correction factor for soil layers subjected to large static shear stresses;
K_σ = correction factor for soil layers subjected to large static normal stresses;
M_L = local or Richter magnitude of earthquake;
M_s = surface-wave magnitude of earthquake;
M_w = moment magnitude of earthquake;
m_B = long period body-wave magnitude of earthquake;
m_b = short period body-wave magnitude of earthquake;
N_m = measured standard penetration resistance;
$(N_1)_{60}$ = corrected standard penetration resistance;
$(N_1)_{60cs}$ = $(N_1)_{60}$ adjusted to equivalent clean-sand value;
n = exponent used in normalizing CPT resistance for overburden stress;
P_a = atmospheric pressure, approximately 100 kPa;
P_L = probability of liquefaction;
Q = normalized and dimensionless cone penetration resistance;
q_{c1N} = normalized cone penetration resistance;
$(q_{c1N})_{cs}$ = normalized cone penetration resistance adjusted to equivalent clean-sand value;
r_d = stress reduction coefficient to account for flexibility in soil profile;
V_s = measured shear-wave velocity;
V_{s1} = overburden-stress corrected shear-wave velocity;
V_{s1}^* = limiting upper value of V_{s1} for liquefaction occurrences;
z = depth below ground surface (m);
α, β = coefficients, that are functions of fines content, used to correct $(N_1)_{60}$ to $(N_1)_{60cs}$;
σ'_{vo} = effective overburden pressure;
τ_{av} = average horizontal shear stress acting on soil layer during shaking generated by given earthquake; and
τ_{st} = static shear stress acting on soil element due to gravitational forces.

ATTACHMENT 3

BORING LOCATION PLAN

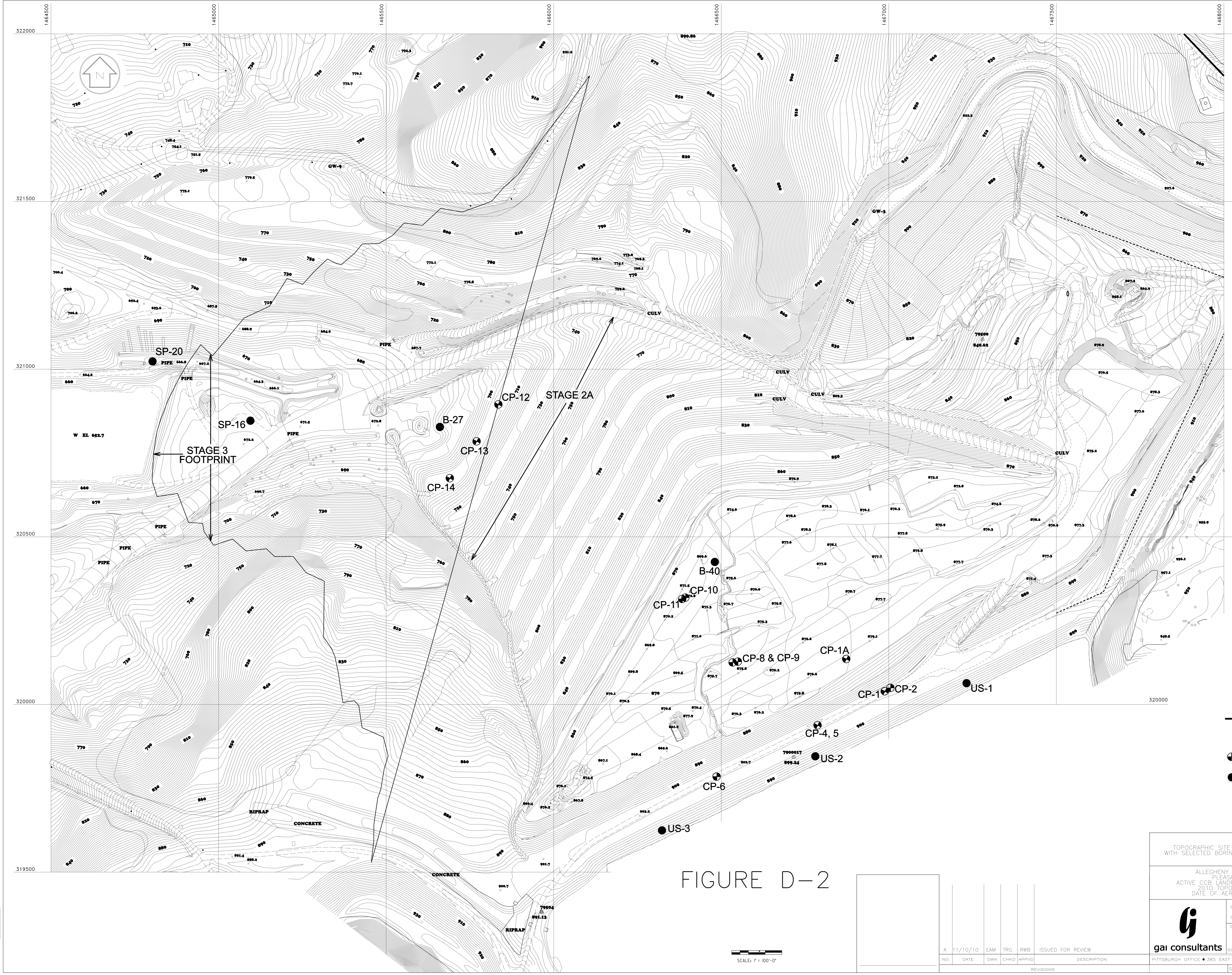

FIGURE D–2

NOTE:

COORDINATES SHOWN ARE BASED ON THE
WEST VIRGINIA STATE PLANE COORDINATE
SYSTEM NORTH ZONE, NAD 83.
406-964 PROPERTY PLAN
Pleasants6_10.dgn LMS CAD FILE
pleas1_10.dgn Cross Sections LMS CAD FILE
pleas2_10.dgn Cross Sections LMS CAD FILE

CONTOUR INTERVAL = 2'

BASED ON PLAN DWG. C79503319 REV. 0
BY ALLEGHENY ENERGY SUPPLY

▬	INDICATES CURRENT PROPERTY BOUNDARY
◕	APPROXIMATE LOCATION OF PIEZOMETER (CP SERIES NUMBERS) NOTE: CP 9, 11, 12, 13, & 14 - FLYASH SAMPLING.
●	APPROXIMATE LOCATION OF EXPLORATION BORING (US SERIES-COMPACTED CLAY) (SP AND B SERIES-ALLUVIAL AND FOUNDATION SOILS)

TOPOGRAPHIC SITE MAP OF STAGE 2A AND STAGE 3
WITH SELECTED BORINGS USED IN LIQUEFACTION ANALYSIS

ALLEGHENY ENERGY SUPPLY CO., LLC
PLEASANTS POWER STATION
ACTIVE CCB LANDFILL AND IMPOUNDMENT FACILITY
2010 TOPOGRAPHIC MAP COMPOSITE
DATE OF AERIAL PHOTOGRAPHY 5–5–10

gai consultants

DRAWN EAM
CHECKED TRG
APPROVED RWB
DATE 11/10/10
DRAWING NUMBER C79506885
SCALE: 1" = 100'
SHT. NO. 1 OF 1
REV A

PITTSBURGH OFFICE • 385 EAST WATERFRONT DRIVE, HOMESTEAD, PA 15120–5005

GAI DRAWING FILE NO. C050268–25–10–G–F001

REVISIONS

NO.	DATE	DWN	CHKD	APPVD	DESCRIPTION
A	11/10/10	EAM	TRG	RWB	ISSUED FOR REVIEW

PLOTTER FILE:

GAI CAD FILE: P:\PIT\2005\2005–268 McElroys\D25 Analyses for EPA Recommendations\C79506885.dgn 11/08/10

ATTACHMENT 5-1

Closure and Post-Closure Plans

McElroy's Run Impoundment Closure and Post-Closure Plans

Allegheny Energy Supply Company, LLC
A FirstEnergy Company
Pleasants Power Station
Pleasants County, West Virginia

October 2016

Rev. 1 November 2020

Prepared for:
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Export, Pennsylvania 15632-1358

Table of Contents

Certification/Statement of Professional Opinion

The Closure and Post-Closure Plan (Plan) for the Pleasants Power Station McElroy's Impoundment was prepared by GAI Consultants, Inc. (GAI). The Plan was based on certain information that, other than for information GAI originally prepared, GAI has relied on but not independently verified. Therefore, this Certification/Statement of Professional Opinion is limited to the information available to GAI at the time the Plan was written. On the basis of and subject to the foregoing, it is my professional opinion as a Professional Engineer licensed in the State of West Virginia that the Plan has been prepared in accordance with good and accepted engineering practices as exercised by other engineers practicing in the same discipline(s), under similar circumstances and at the same time and in the same locale. It is my professional opinion that the Plan was prepared consistent with the requirements of the United States Environmental Protection Agency's "Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments," published in the Federal Register on April 17, 2015 with an effective date of October 19, 2015.

The use of the words "certification" and/or "certify" in this document shall be interpreted and construed as a Statement of Professional Opinion and is not and shall not be interpreted or construed as a guarantee, warranty or legal opinion.

ARICA LEE DITULLIO
21760
Arica L DiTullio

Arica L DiTullio

Arica L. DiTullio, P.E.

Engineering Manager

This closure plan is intended to meet the requirements of 40 CFR § 257 but can be amended at any time [pursuant to § 257.102(b)(3)] due to a number of factors, including but not limited to: specified provisions in 40 CFR § 257, federal or state regulatory changes, and facility operational changes.

1.0 Introduction

The McElroy's Run Impoundment (Impoundment) is located approximately one-half mile east-southeast of the Pleasants Power Station (Station), a coal-fired electric generating station located near the community of Willow Island in Pleasants County, West Virginia (WV). The Impoundment is permitted as a solid waste facility according to the West Virginia Department of Environmental Protection (WVDEP) Permit No. 0079171. The Impoundment receives coal combustion residuals (CCR) in the form of flue gas desulfurization (FGD) scrubber by-product.

The embankment is permitted separately under WV Dam Safety Regulations by the Office of Water Resources. The embankment is currently permitted for operations under Certificate of Approval No. 07302.

2.0 Closure Plan

This plan was prepared in accordance with the applicable requirements of the United States Environmental Protection Agency (USEPA) 40 CFR Part 257, Criteria for Classification of Solid Waste Disposal Facilities and Practices (CCR Rule). This plan sets forth the materials and techniques that will be used to complete closure activities of the Impoundment by placement of a final cover system pursuant to the requirements in §257.102(d).

2.1 McElroy's Run Impoundment Closure Plan Overview

The Closure Plan includes the following:

- Closure Plan narrative;
- Final Cover System description including methods and procedures to install the system, and a description stating how the system will achieve the performance standards set forth by §257.102(d);
- Estimate of the maximum inventory of CCR ever on-site over the active life of the CCR unit;
- Estimate of the largest area of the CCR unit ever requiring final cover at any time over the CCR unit's active life; and,
- Closure Plan schedule for completing all activities necessary to satisfy the closure criteria, including the date by which all closure activities for the CCR unit will be completed.

2.2 Closure Plan Narrative

The Impoundment is to be closed by leaving the CCR in place and installing a final cover system and stormwater collection features. This will be accomplished by meeting the requirements of §257.102 and any additional requirements imposed by the WVDEP.

At final closure, a final cover system and drainage channels will be installed. Prior to the installation of the final cover system, free liquids will be removed, and the remaining waste will be stabilized to support the final cover system. As necessary, additional fill may be used to create positive drainage. The final cover system will be contoured to prevent ponding of stormwater and vegetated.

The closure performance standards stated in §257.102(d) will be achieved in the following manner:

- Free liquid will be removed from the impoundment. The CCR material will be contoured to promote positive drainage and stabilized (as necessary), and the final cover system will be placed over the surface to minimize infiltration of water into the CCR and releases of CCR, leachate, or impacted run-off to the ground or surface waters, as required by §257.102(d)(1)(i);
- The final cover system soil layer will be contoured in order to preclude the probability of future impoundment of water and sediment, as required by §257.102(d)(1)(ii);
- Stability of the final cover system will be provided by stabilizing the CCR (as necessary) prior to final cover system installation, and placement of the engineered cover soil layers during cap construction. Movement or sloughing of the final cover system will be prevented during the closure and post-closure periods by minimizing the slope, as required by §257.102(d)(1)(iii); and
- This design reduces the need for further maintenance through grades that minimize or prevent erosion, and with a vegetation mix that, once well established, forms a thick, self-sustaining layer that minimizes woody plant growth in accordance with the requirements of §257.102(d)(1)(iv).

2.3 Final Cover System

This section provides a description of final cover system components, site preparation, and installation.

2.3.1 Cover Components

The proposed final cover system consists of the following (from the bottom layer to the top layer):

- An infiltration layer composed of eighteen inches of compacted soil (permeability of 1 x 10^{-5} cm/sec or less);
- An erosion layer composed of six inches of cover soil; and,
- Vegetation (mulch, fertilizer, and seed).

The proposed final cover system meets the final cover system design requirements set forth in §257.102(d)(3)(i) and is compliant with the WVDEP regulations (33CSR1). Alternative cap systems that would utilize geosynthetic materials will also be evaluated during closure design.

2.3.2 Site Preparation

Before ceasing receipt of CCR materials, site work will occur to prepare the Impoundment for closure, including the design and construction of various erosion and sedimentation (E&S) and stormwater run-on/run-off controls and initial development of construction staging and soil borrow areas on the disposal facility's property.

2.3.3 Dewatering

Removal of water from the Impoundment is a critical activity with regard to establishing and maintaining closure construction safety and schedule. Dewatering involves removing both "free" water, which is liquid sitting atop the impounded CCRs, and a portion of the "pore" water which is liquid within the pore spaces of the impounded CCRs.

- Free Water Removal. Based on the existing configuration of the Impoundment's outlet works and impounded CCR elevations, discharge via gravity will be the primary means of removing free water once cessation of waste (influent sluicing) occurs. The use of pumps for free water removal is expected to be limited or possibly unnecessary.

- Pore Water Removal. Removal of pore water will occur primarily due to seepage out of the CCR surfaces that become exposed as the Impoundment's pool level (free water) drops. Supplemental dewatering will be assessed and conducted if necessary, to stabilize the upper CCR surface (e.g., upper 10 to 25 feet) so that heavy equipment can safely operate on it to perform any necessary surface contouring and to support the installation of the final cover system.

The discharges associated with both types of dewatering will be routed to the Impoundment's existing National Pollutant Discharge Elimination System (NPDES) Outfall 001 at the Ohio River. The CCR dewatering discharges as well as other impounded water will continue to be subject to the site's NPDES permit requirements. Compliance will be maintained with the permitted analytical parameters and associated discharge limits established by the WVDEP.

Dewatering is scheduled to begin in 2024 after the Impoundment ceases accepting waste. By the 2025 construction season, sufficient dewatering is expected to have occurred to permit contouring of the surface in preparation for installation of the final cover system.

2.3.4 Surface Contouring

As dewatering is completed, the surface of the impounded CCR material may require adjustments to provide positive drainage from the head of the watershed towards the dam to prevent post-closure ponding of stormwater. The contour plan will also include a designed low point to allow stormwater runoff from completed areas in the upstream watershed to flow past the dam and continue down valley. Surface contouring will occur incrementally such that the final cover system installation can be completed by the required deadline.

2.3.5 Final Cover System Installation

The final cover system's compacted soil infiltration layer will be installed directly atop the contoured CCR surface to act as a precipitation infiltration barrier. This will be overlain with an erosion layer capable of supporting vegetative growth and preventing erosion of the infiltration barrier soil. The work is anticipated to proceed incrementally as completion of dewatering and surface contouring provides areas suitable for installation work to commence.

2.3.6 Site Restoration

Site restoration will be performed incrementally as the final cover system installation progresses. Areas to be restored beyond the disposal footprint include access roads developed for construction and final cover installation, soil borrow areas, and construction staging areas. Primary restoration activities include grading disturbed areas, removing temporary E&S and stormwater controls; applying fertilizer, seed and mulch to regraded areas; repairing gravel and asphalt roads adversely affected during construction activities; and upgrading and/or installing necessary site access control measures (e.g., fencing and gates).

2.4 Estimates for Final CCR Volume and Closure Area

This section provides an estimate of the maximum quantity of CCR material expected to be contained during impoundment closure and an estimate of the largest area ever requiring a final cover system.

2.4.1 Maximum CCR Inventory Estimate

The Impoundment is expected to contain 28,000,000 cubic yards of CCRs at full capacity.

2.4.2 Largest Area Requiring Final Cover System

The maximum area to be capped and covered will include the entirety of the impoundment. The maximum area will be approximately 255 acres.

2.5 Estimated Closure Schedule

The construction activities presented above involve varying levels of planning, design, and permitting that will occur prior to construction. Pre-construction activities include the following: a variety of field investigations and studies (e.g., geotechnical characterization of impounded CCRs, soil borrow area delineations, etc.); completing engineering layout, analysis and design; preparing permit application submittals and responding to agency and public review comments; and developing construction drawings, technical specifications and bid documents. Once a construction contract is awarded, construction can commence with mobilization and site preparation, followed by supplemental dewatering activities (which will be an on-going process over the duration of work), annual sequences of concurrent contouring, final cover installation, site restoration activities, construction demobilization/remobilization, and preparation/submission of construction certification record documentation required by WVDEP.

The general sequencing and estimated timing of the activities described in Section 2.3 of this Plan are presented below and are based on reasonable judgement and prior experience with similar projects completed by Allegheny Energy and its contractors. Closure of the Impoundment will include a mix of concurrent and sequential activities in order to safely and efficiently complete all work by the October 2028 deadline:

- Cease receipt of waste / Initiate dewatering: October 2024
- Additional dewatering / Surface Contouring: Incrementally performed, starting in 2025 and continuing through 2026, 2027, and concluding in 2028.
- Final Cover System Installation: Also performed incrementally, starting in 2025 and continuing through 2028.
- Site Restoration: Incrementally performed in accordance with completion of final cover system areas, starting in 2026 and concluding no later than October 17, 2028.

Once the Impoundment closure is complete, a professional engineer will verify and certify that closure has been completed in accordance with the Closure Plan [§257.102(f)(3)]. Within 30 days of completing the Impoundment closure, a notification of closure will be prepared and include the professional engineer's certification of completion [§257.102(h)].

3.0 Post-Closure Plan

This post-closure plan was prepared in accordance with the CCR Rule, and details the maintenance activities to be performed for a period of 30 years, as required by §257.104(d).

3.1 CCR Post-Closure Plan Overview

The post-closure plan, per §257.104(d)(1)(i through iii), must include the following information:

- Description of the monitoring and maintenance activities, including the frequency that activities will be performed;
- Name, address, and telephone number of the person to contact about the facility during the post-closure care period; and,
- Description of the planned use of the property during the post-closure care period.

3.2 Post-Closure Plan Narrative

The major items to be maintained and monitored during the post-closure care period are:

- The final cover system;
- drainage features;
- fencing and gates; and,
- the groundwater monitoring system.

These activities are discussed in detail in the next section. Repairs to the final cover system will be made, as necessary, to mitigate erosion or settlement of the erosion and infiltration soil layers. The final cover system will be inspected at least annually for the 30-year post-closure period. Stormwater drainage features will be de-silted and cleared of debris to maintain capacity, as needed. The groundwater monitoring system will be monitored for the full 30 years of post-closure.

3.3 Monitoring and Maintenance Activities

Following closure of the CCR unit, the owner or operator must conduct post-closure care for 30 years, which consists of at least the following:

- Maintaining the integrity and effectiveness of the final cover system, including making repairs as necessary to correct the effects of settlement, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the final cover; and,
- Maintaining the groundwater monitoring system and monitoring the groundwater in accordance with the requirements of §257.90 through §257.98.

3.3.1 Final Cover Surface

The final cover surface will be visually inspected by a qualified person at least annually during the post-closure period. The site will also be observed during groundwater sampling events. The surface of the Impoundment will be inspected for erosion, thinning vegetation cover, animal burrows, woody vegetation, and cracking in the soil cover which could indicate surface movement. Any observed woody vegetation will be removed. The final cover system will be repaired if any of the aforementioned conditions are observed.

3.3.2 Drainage Features

Stormwater drainage channels will be visually inspected for damage, debris, siltation, and vegetative growth that are reducing capacity. The dam underdrain pipe discharges will be visually inspected for debris, siltation, and evidence of anomalous flow conditions (changes in discharge rate, color, etc.). The drainage features will be cleaned and repaired, if necessary, if any of the aforementioned conditions are observed.

3.3.3 Fencing and Gates

Site access will be controlled during closure and post-closure using the methods approved for use during site operation. The main entrance gate is constructed of a steel frame and posts anchored in concrete. Gates will remain locked at all times when the site is unattended to prevent unauthorized access to the site.

Fencing and gates will be inspected annually for signs of unauthorized entry, damage caused by tree growth or falling limbs/trees, broken or bent posts, and to verify functionality of any gates. Any damage to the access control features observed will be repaired.

3.3.4 Groundwater Monitoring System

Groundwater monitoring will be performed in accordance with the requirements of §257.90 through §257.98 for the duration of the post-closure period.

3.4 Site Contact Information

The operator can be reached during the post-closure period at the following address and phone number:

Environmental Department

FirstEnergy Service Company

On behalf of Allegheny Energy Supply Company, LLC

800 Cabin Hill Drive

Greensburg, PA 15601

(724) 837-3000

An email address is not provided due to potential employee turnover over the 30 year post-closure period.

3.5 Proposed Post-Closure Property Use

The proposed post-closure land use for this facility is anticipated to be for the permanent storage of residual waste and as open green space with controlled access. This is consistent with the surrounding existing and planned use by Allegheny Energy. The site is located in rural Pleasants County in an area that sees little foreseeable need for alternative land uses. There are no support activities needed to achieve the proposed land use. After closure, Allegheny Energy expects the site to be utilized as an "unmanaged wildlife habitat."

4.0 References

United States Environmental Protection Agency (USEPA), 40 CFR Parts 257 and 261, Hazardous and Solid Waste Management Disposal System; Disposal of Coal Combustion Residual from Electric Utilities, Final Rule; April 2015.

Civil & Environmental Consultants, Inc., Application for Renewal, Solid Waste Permit No. WV0079171, McElroy's Run Disposal Facility; February 2007.

GAI Consultants, Inc., Solid Waste/NPDES Permit Application No. WV0079171, Solid Waste Portion, McElroy's Run Disposal Facility; September 1990.

GAI Consultants, Inc., Potential Impact of Draft EPA CCR Regulation, Summary of Findings, McElroy's Run Impoundment; July 2010.

GAI Consultants, Inc., Permit Renewal Application, Solid Waste/National Pollutant Discharge Elimination System Water Pollution Control Permit No. WV0079171; January 2014.

Allegheny Energy Supply Company, LLC, Annual Operation Report 2014, Pleasants Power Station's McElroy's Run Disposal Site; September 2015.