CCR RULE ASSESSMENT OF CORRECTIVE MEASURES (ACM) REPORT

COAL COMBUSTION BYPRODUCT DISPOSAL FACILITY

Pleasants Power Station
Pleasants County, West Virginia

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Tetra Tech Project No. 212C-SW-00070

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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

EPRI, 2010. Arsenic in Coal Combustion Products. Technical Brief No. 1021212. December 2010.

Tetra Tech, 2017. CCR Rule Groundwater Monitoring System Evaluation Report, Pleasants Power Station, Coal Combustion Byproduct Disposal Facility. October 2017.

Tetra Tech, 2018. 2017 Annual CCR Groundwater Monitoring and Corrective Action Report, Coal Combustion Byproduct Disposal Facility, Pleasants Power Station. January 2018.

Tetra Tech, 2019. 2018 Annual CCR Groundwater Monitoring and Corrective Action Report, Coal Combustion Byproduct Disposal Facility, Pleasants Power Station. January 2019.

USEPA, 1999. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. April 21, 1999.

USEPA, 2015. Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule. Federal Register Vol. 80, No. 74, Part II 40 CFR Parts 257 and 261 Hazardous and Solid Waste Management System. April 17, 2015.

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

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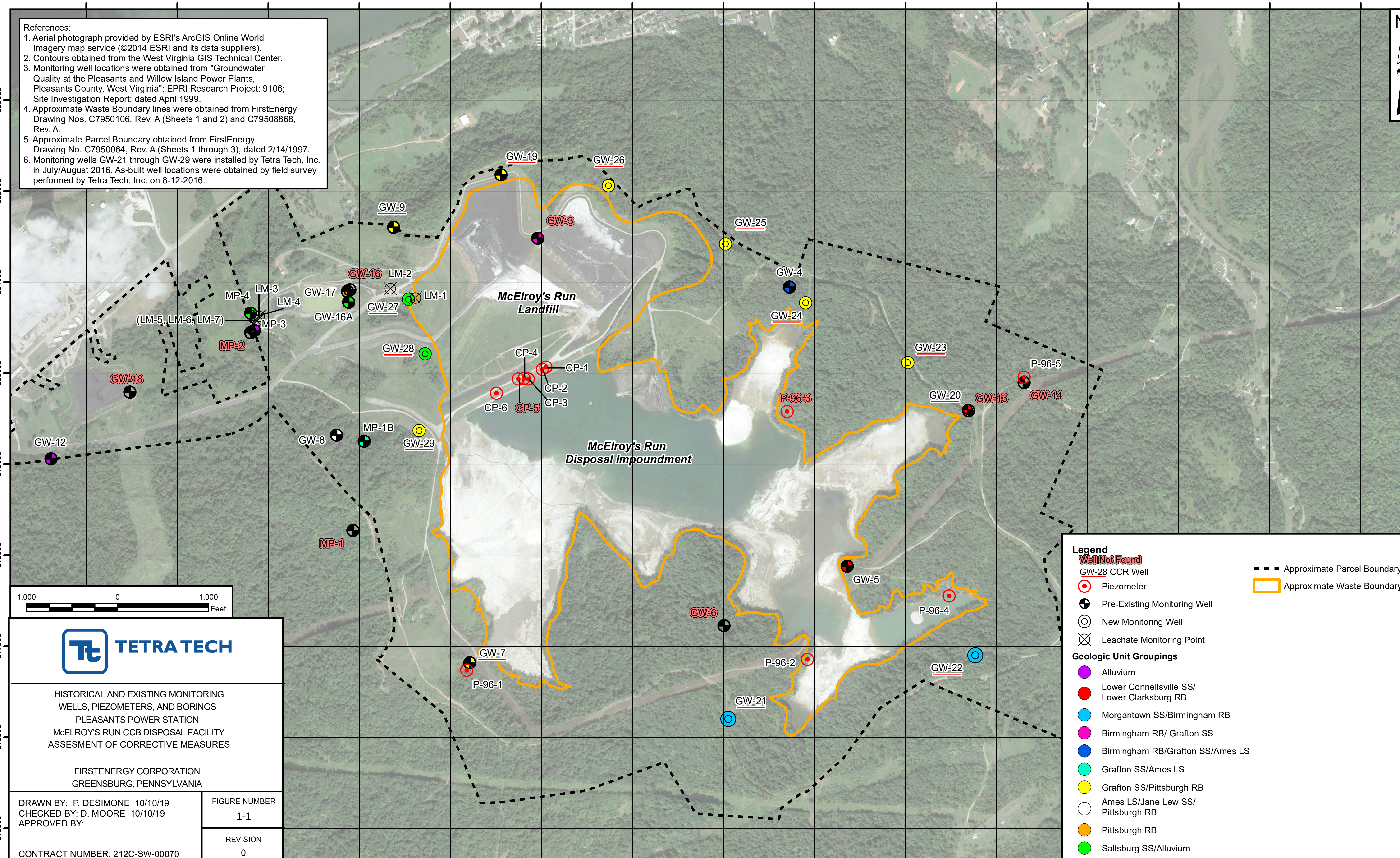

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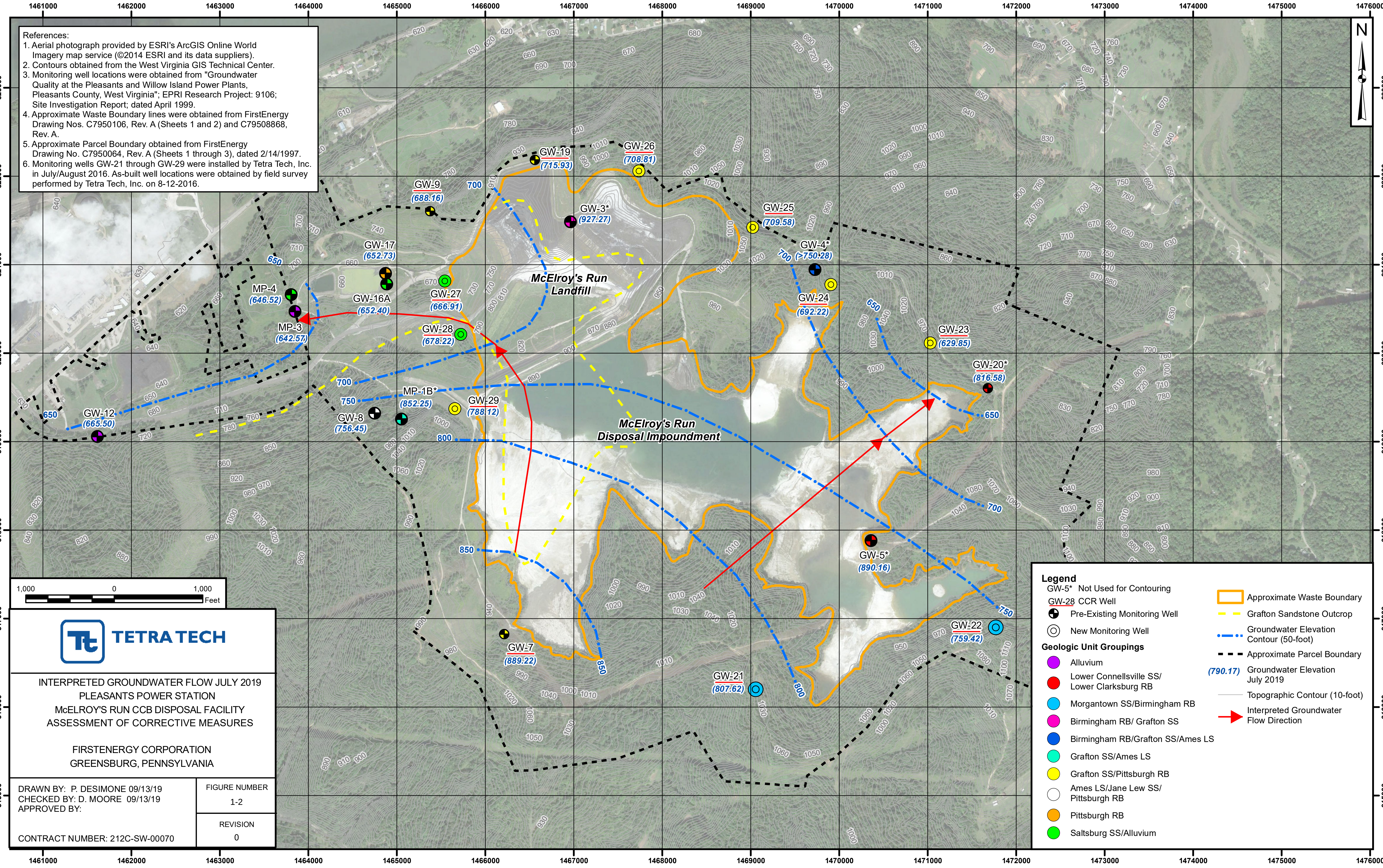

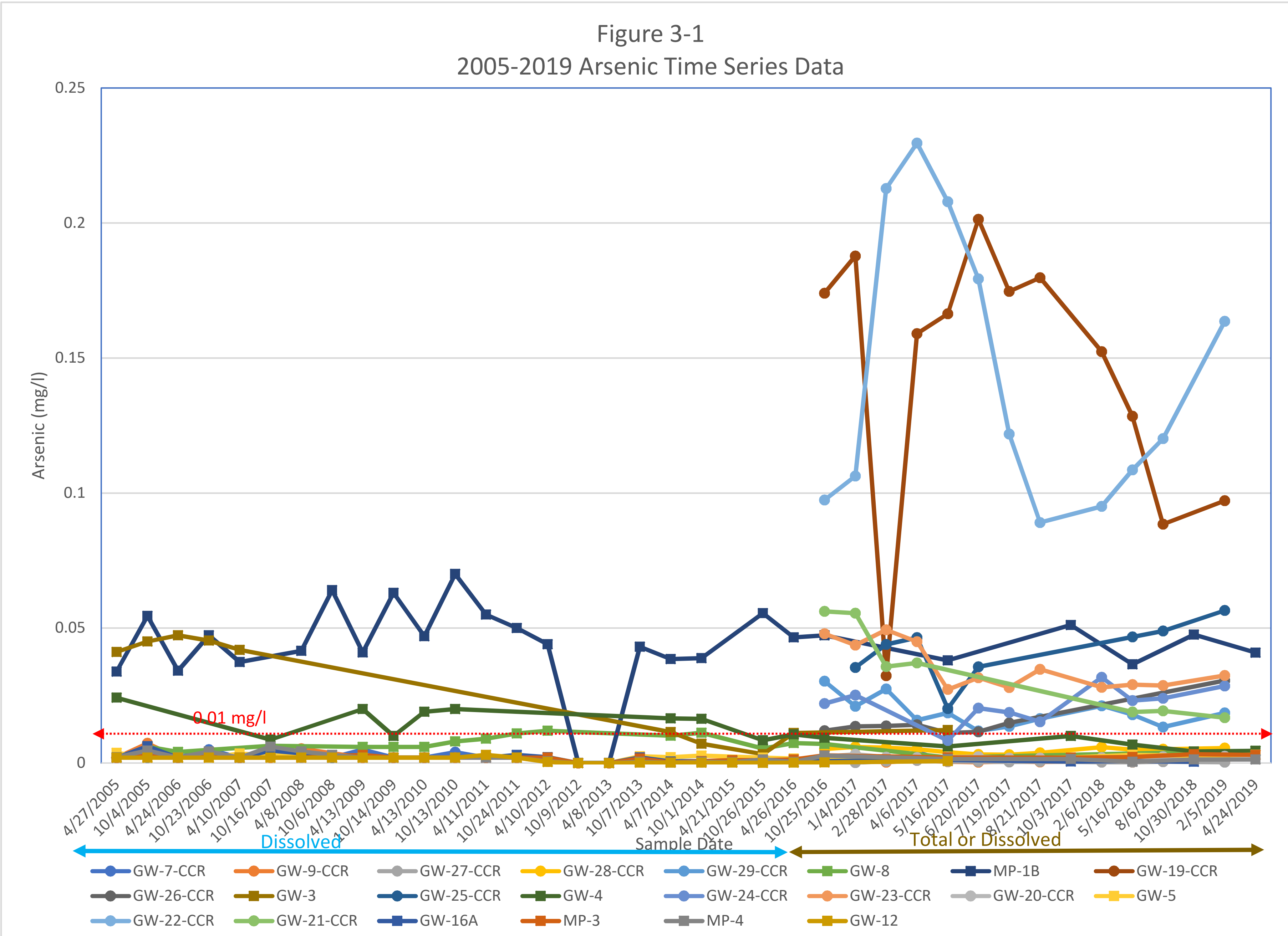

Figure 3-1
2005-2019 Arsenic Time Series Data
Arsenic (mg/l)
0.25
0.2
0.15
0.1
0.05
0
0.01 mg/l
4/27/2005
10/4/2005
4/24/2006
10/23/2006
4/10/2007
10/16/2007
4/8/2008
10/6/2008
4/13/2009
10/14/2009
4/13/2010
10/13/2010
4/11/2011
10/24/2011
4/10/2012
10/9/2012
4/8/2013
10/7/2013
4/7/2014
10/1/2014
4/21/2015
10/26/2015
4/26/2016
10/25/2016
1/4/2017
2/28/2017
4/6/2017
5/16/2017
6/20/2017
7/19/2017
8/21/2017
10/3/2017
2/6/2018
5/16/2018
8/6/2018
10/30/2018
2/5/2019
4/24/2019
Dissolved
Sample Date
Total or Dissolved
GW-7-CCR
GW-9-CCR
GW-27-CCR
GW-28-CCR
GW-29-CCR
GW-8
MP-1B
GW-19-CCR
GW-26-CCR
GW-3
GW-25-CCR
GW-4
GW-24-CCR
GW-23-CCR
GW-20-CCR
GW-5
GW-22-CCR
GW-21-CCR
GW-16A
MP-3
MP-4
GW-12

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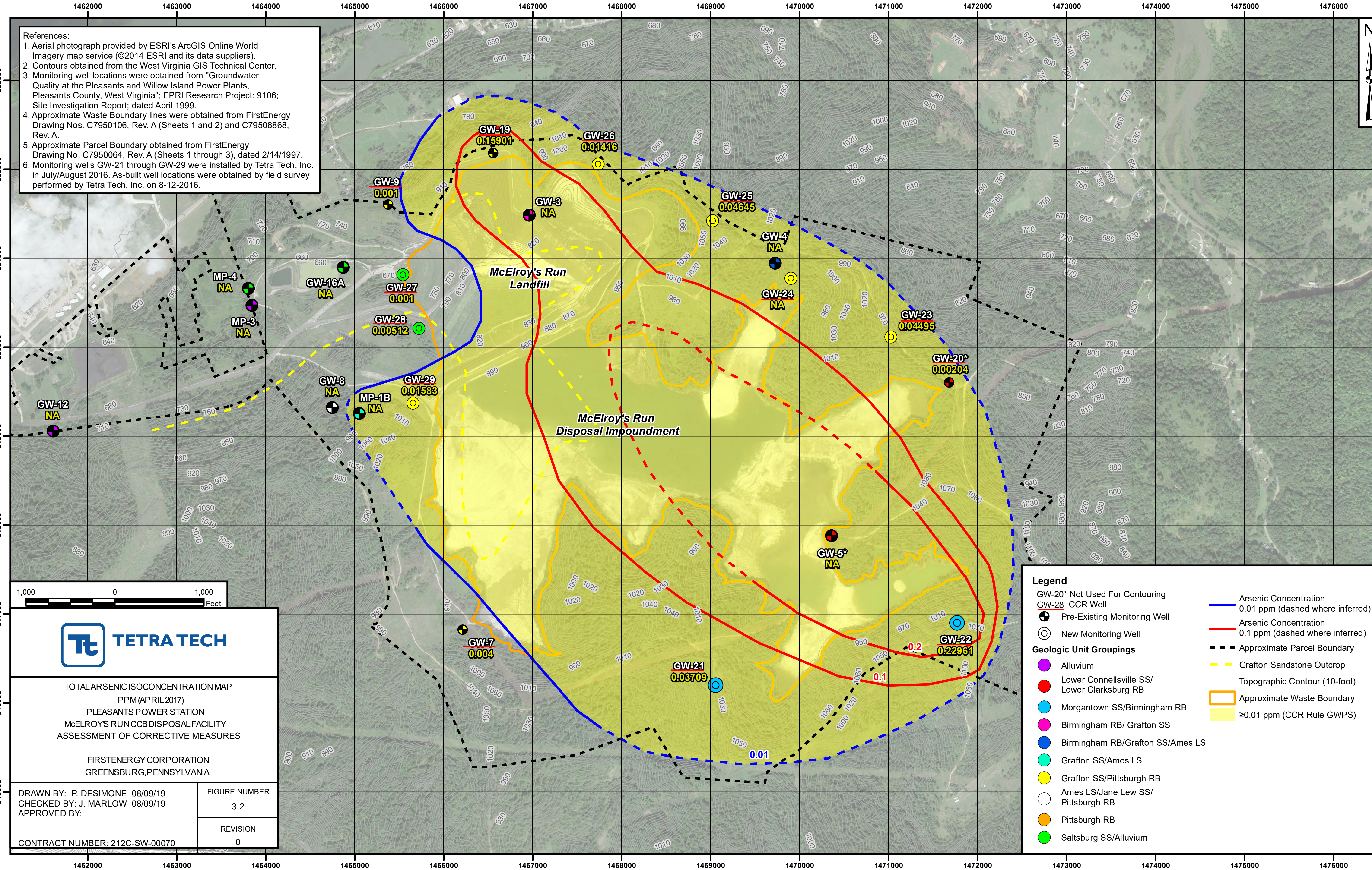

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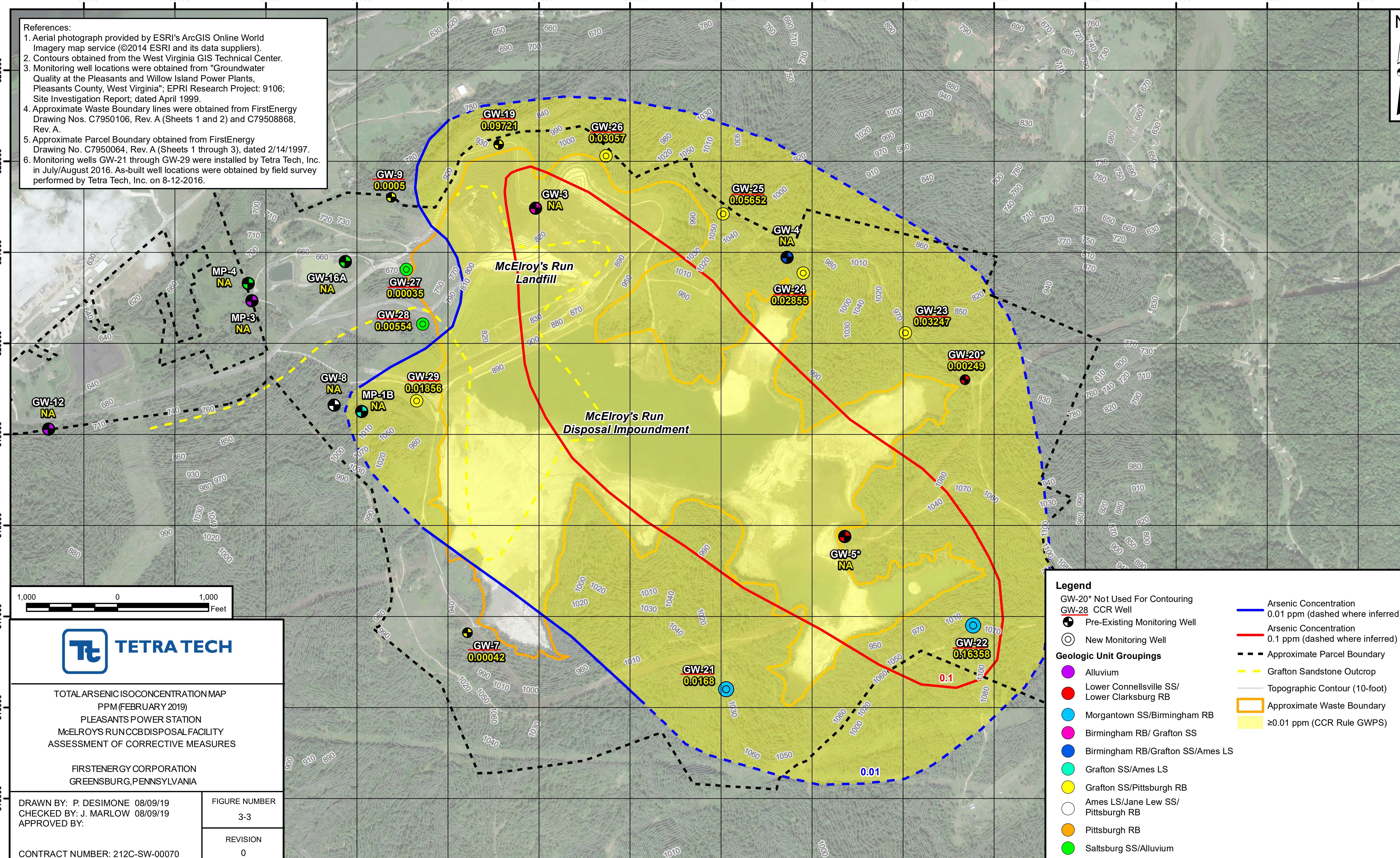


References:
1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (©2014 ESRI and its data suppliers).
2. Contours obtained from the West Virginia GIS Technical Center.
3. Monitoring well locations were obtained from "Groundwater Quality at the Pleasants and Willow Island Power 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.

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:	FIGURE NUMBER 3-3
CONTRACT NUMBER: 212C-SW-00070	REVISION 0

Legend

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

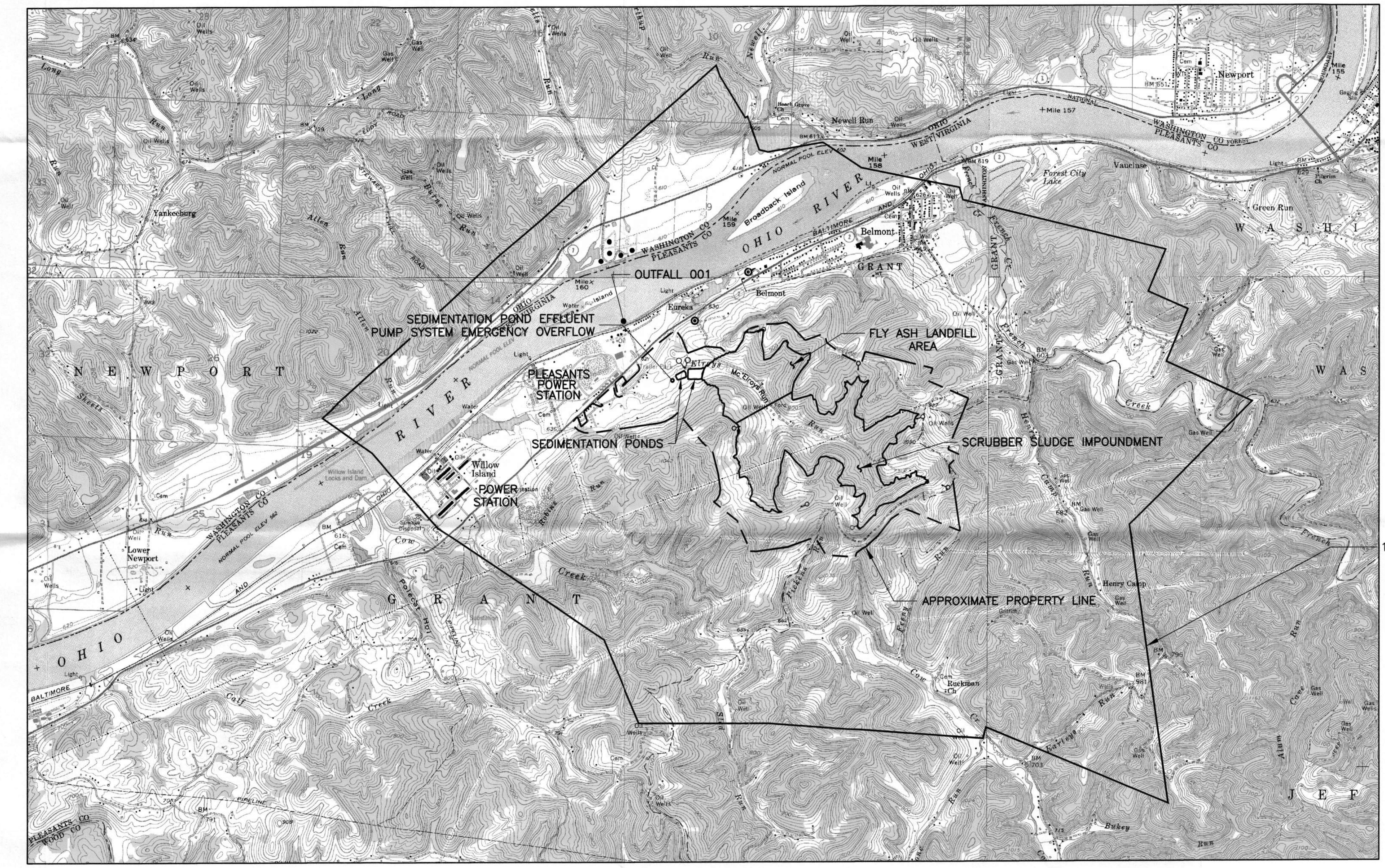
Geologic Unit Groupings

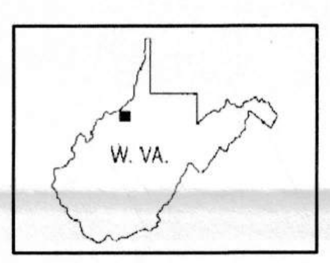
- Alluvium
- Lower Connellsville SS/ Lower Clarksburg RB
- Morgantown SS/Birmingham RB
- Birmingham RB/ Grafton SS
- Birmingham RB/Grafton SS/Ames LS
- Grafton SS/Ames LS
- Grafton SS/Pittsburgh RB
- Ames LS/Jane Lew SS/ Pittsburgh RB
- Pittsburgh RB
- Saltsburg SS/Alluvium

- 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)

FIGURE 4-1 (GROUNDWATER DRINKING WATER SUPPLY WELLS MAP)
PLEASANTS CCBDF - ASSESSMENT OF CORRECTIVE MEASURES

TETRA TECH





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

This drawing was produced with computer aided drafting technology and is supported by electronic drawing files. Do not revise this drawing via manual drafting methods.

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

PITTSBURGH • 570 BEATTY ROAD, MONROEVILLE, PA 15146

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GAI CAD FILE: 99-170-E1001.DWG 1/4/02

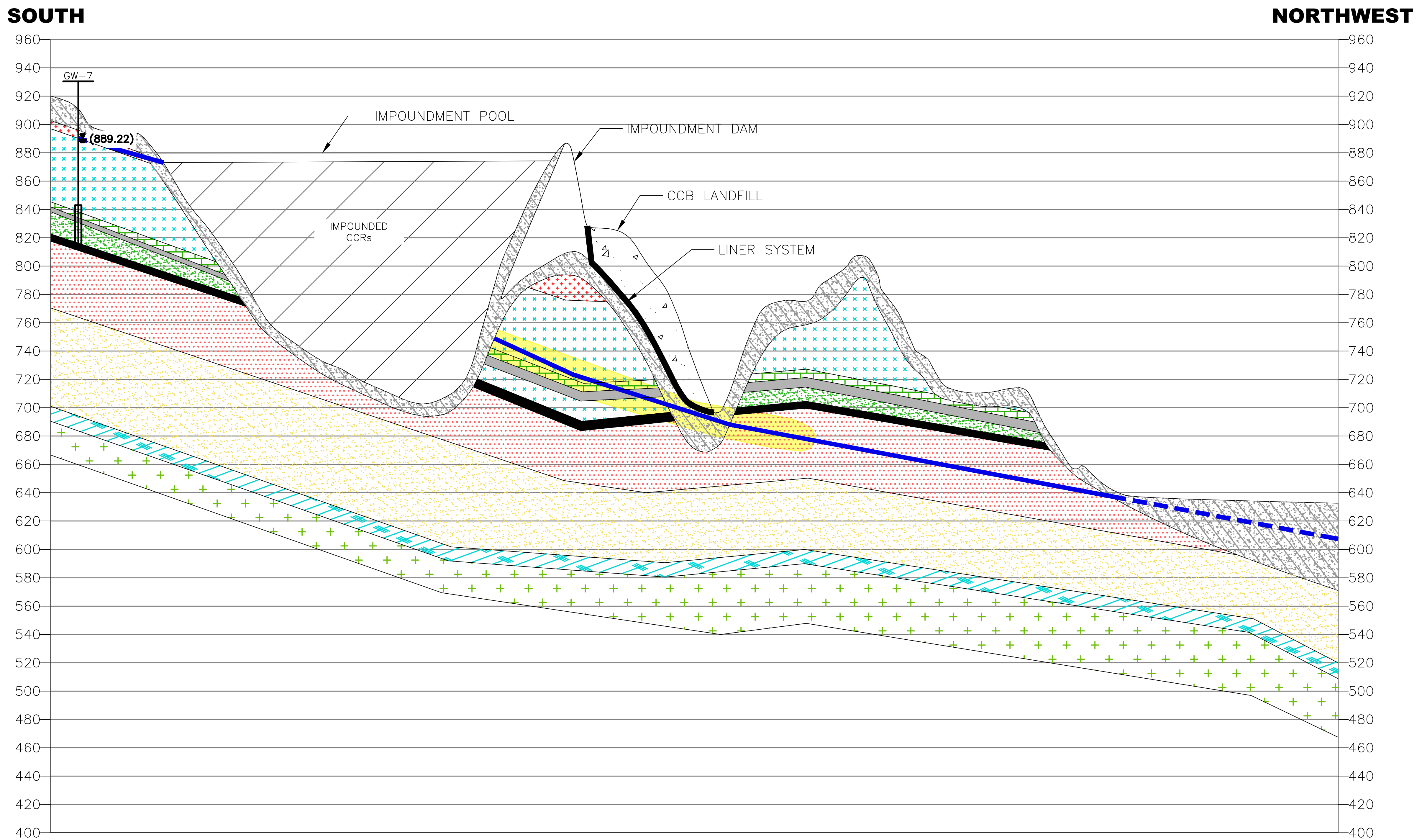
GAI DWG. 99-170-E1001

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 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)
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

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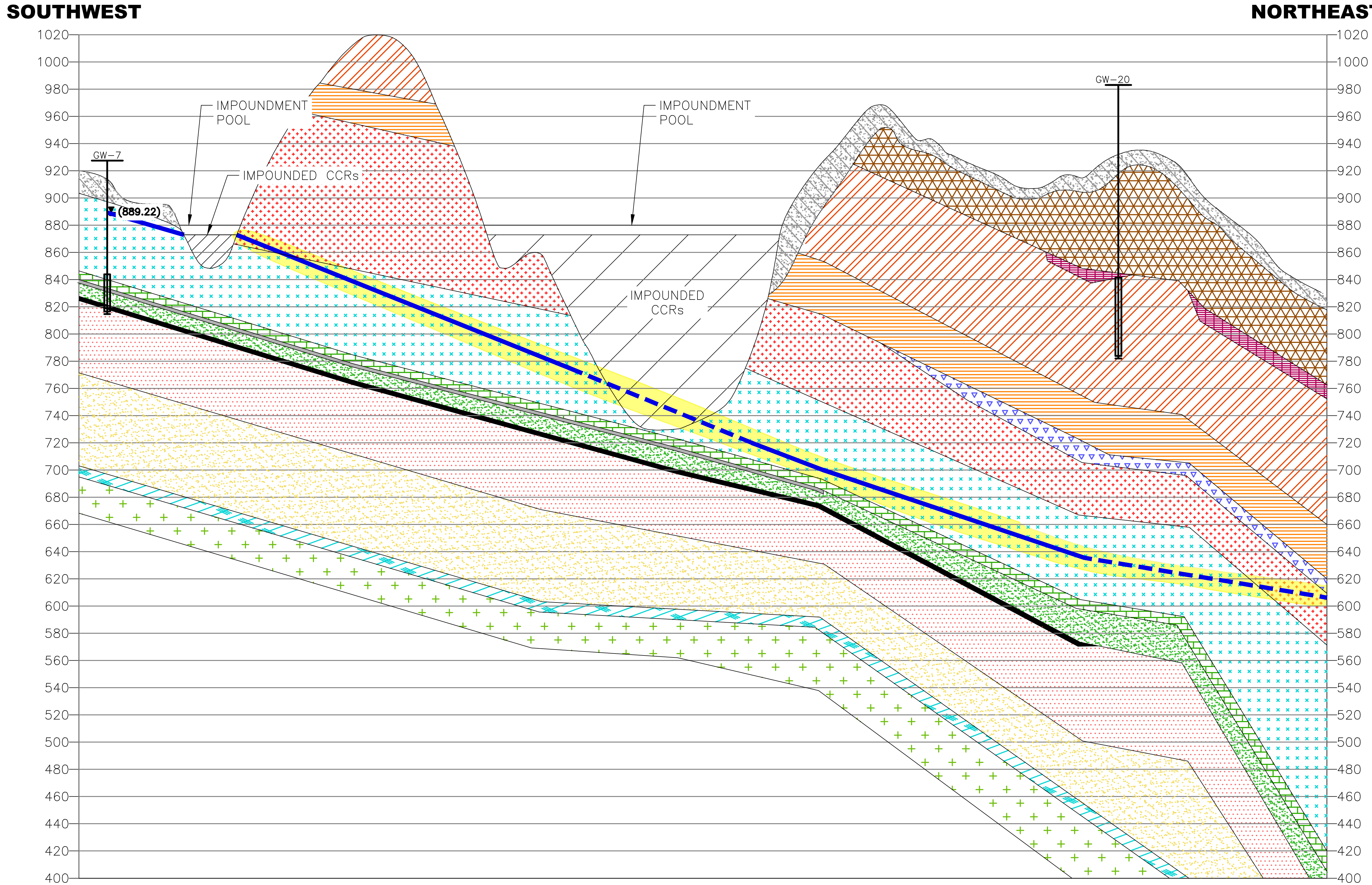

NOTES

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 BEDS
- SALTSBURG SANDSTONE
- CAMBRIDGE LIMESTONE
- BUFFALO SANDSTONE

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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

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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:

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Prepared by:

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Tetra Tech Project No. 212C-SW-00070

October 2019

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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:
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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

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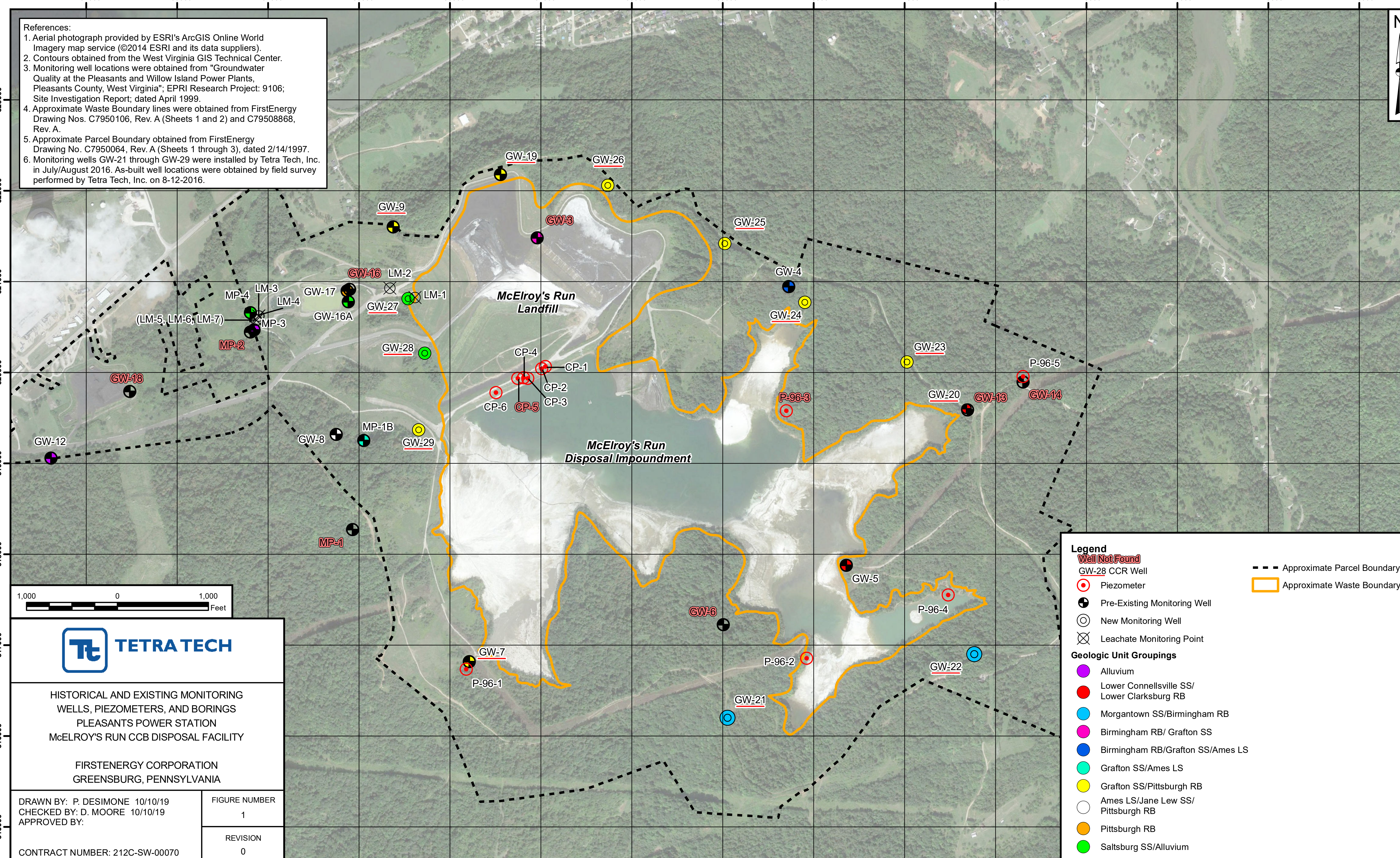

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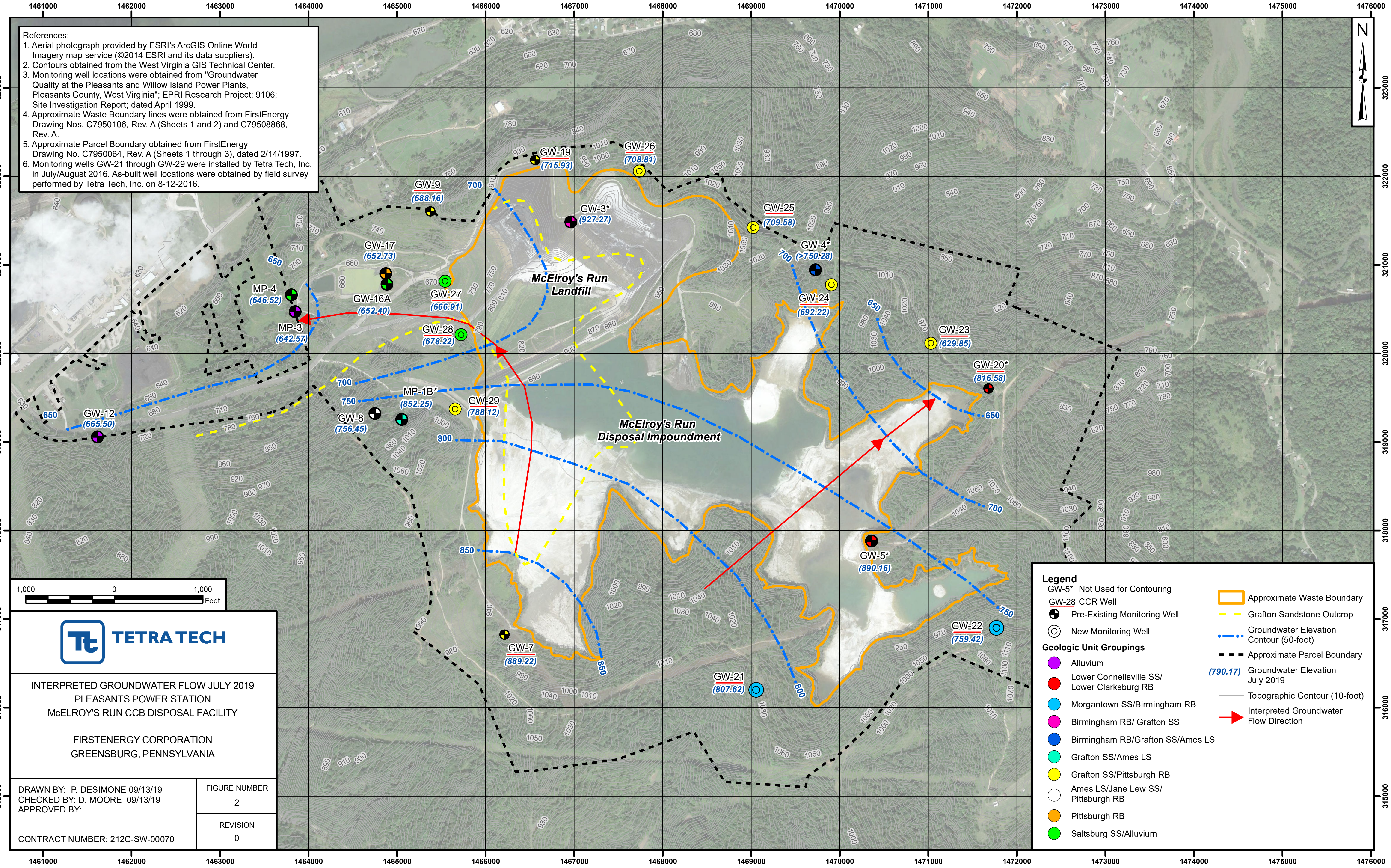

References:
1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (©2014 ESRI and its data suppliers).
2. Contours obtained from the West Virginia GIS Technical Center.
3. Monitoring well locations were obtained from "Groundwater Quality at the Pleasants and Willow Island Power 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.

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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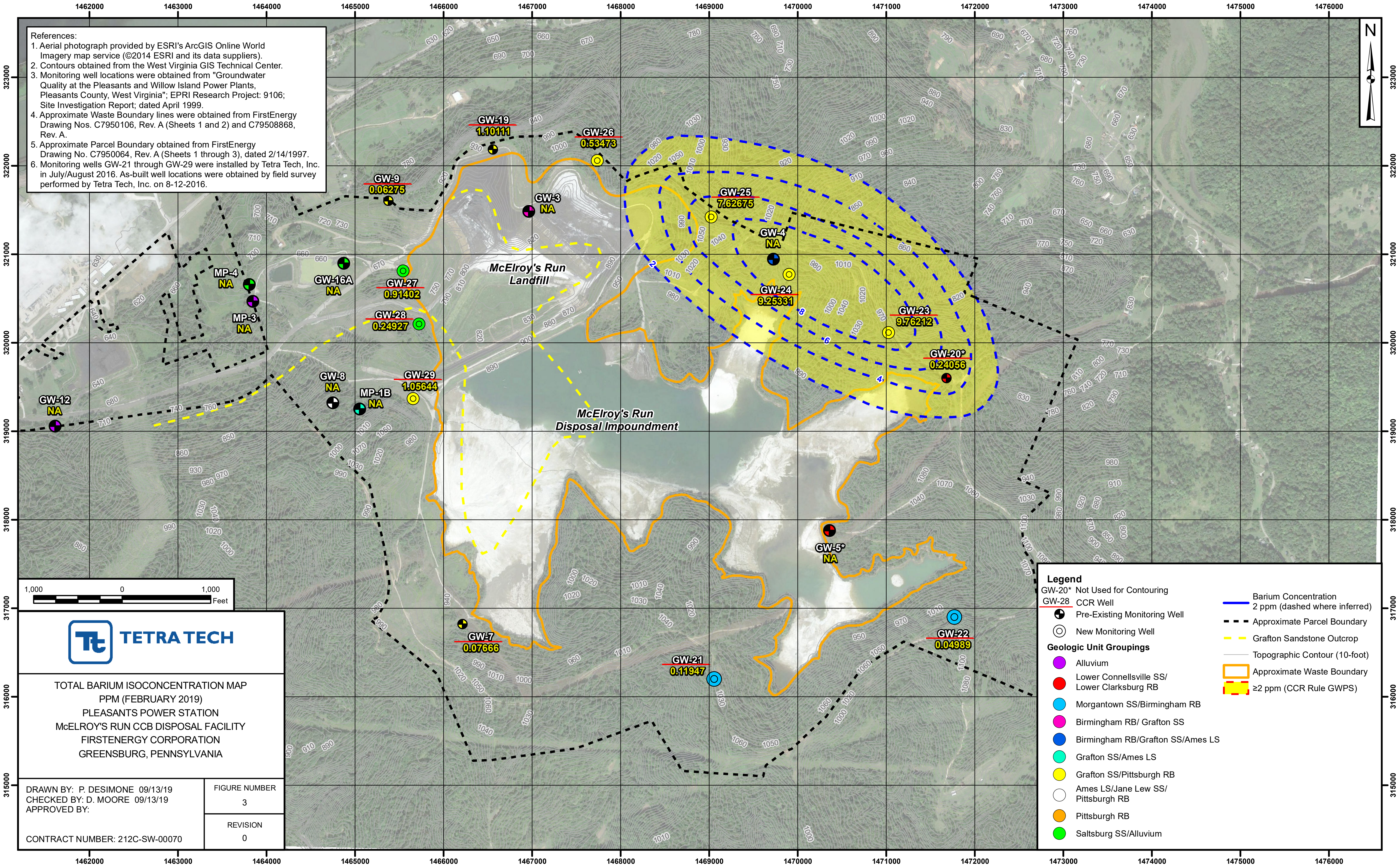

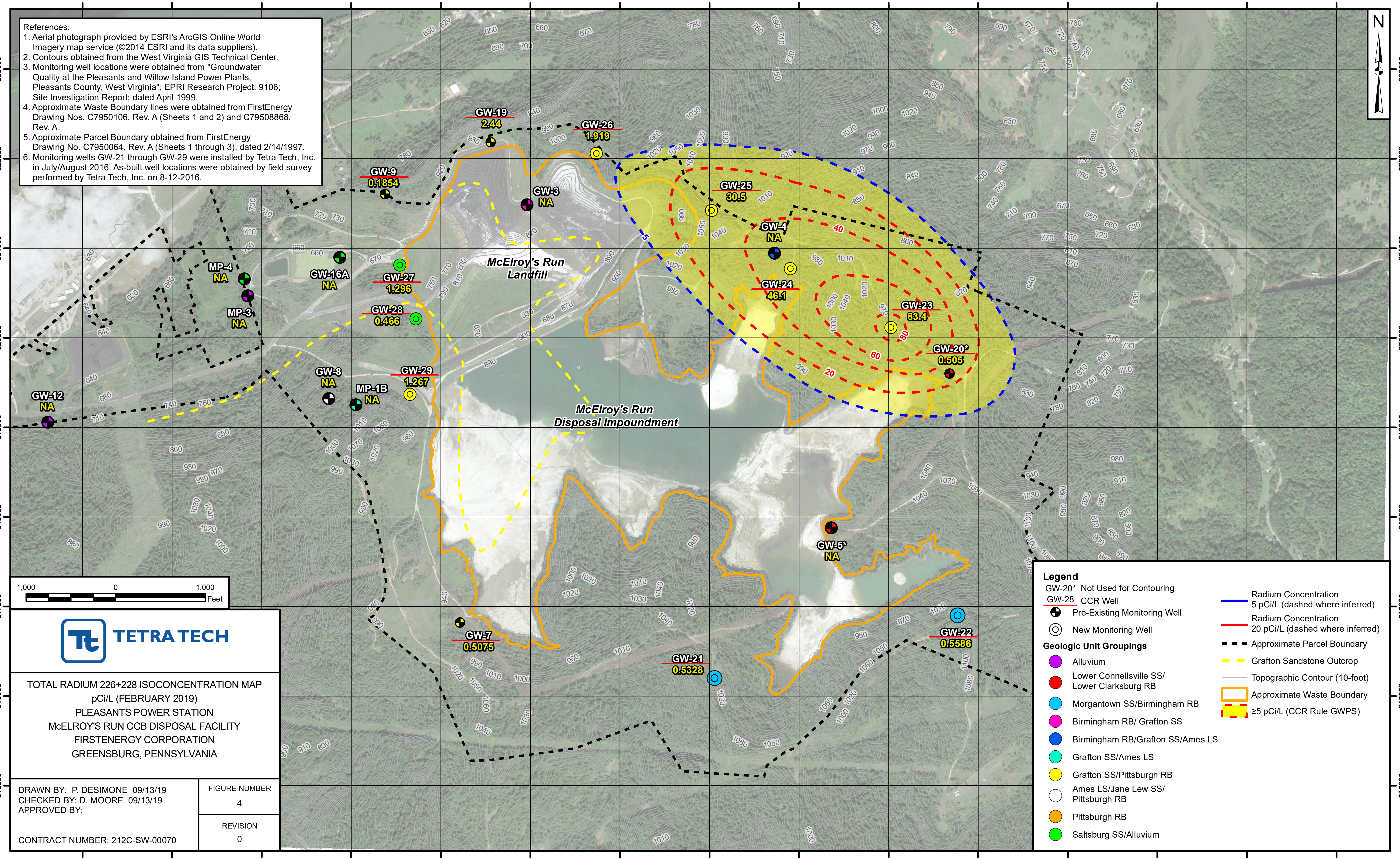

TETRA TECH

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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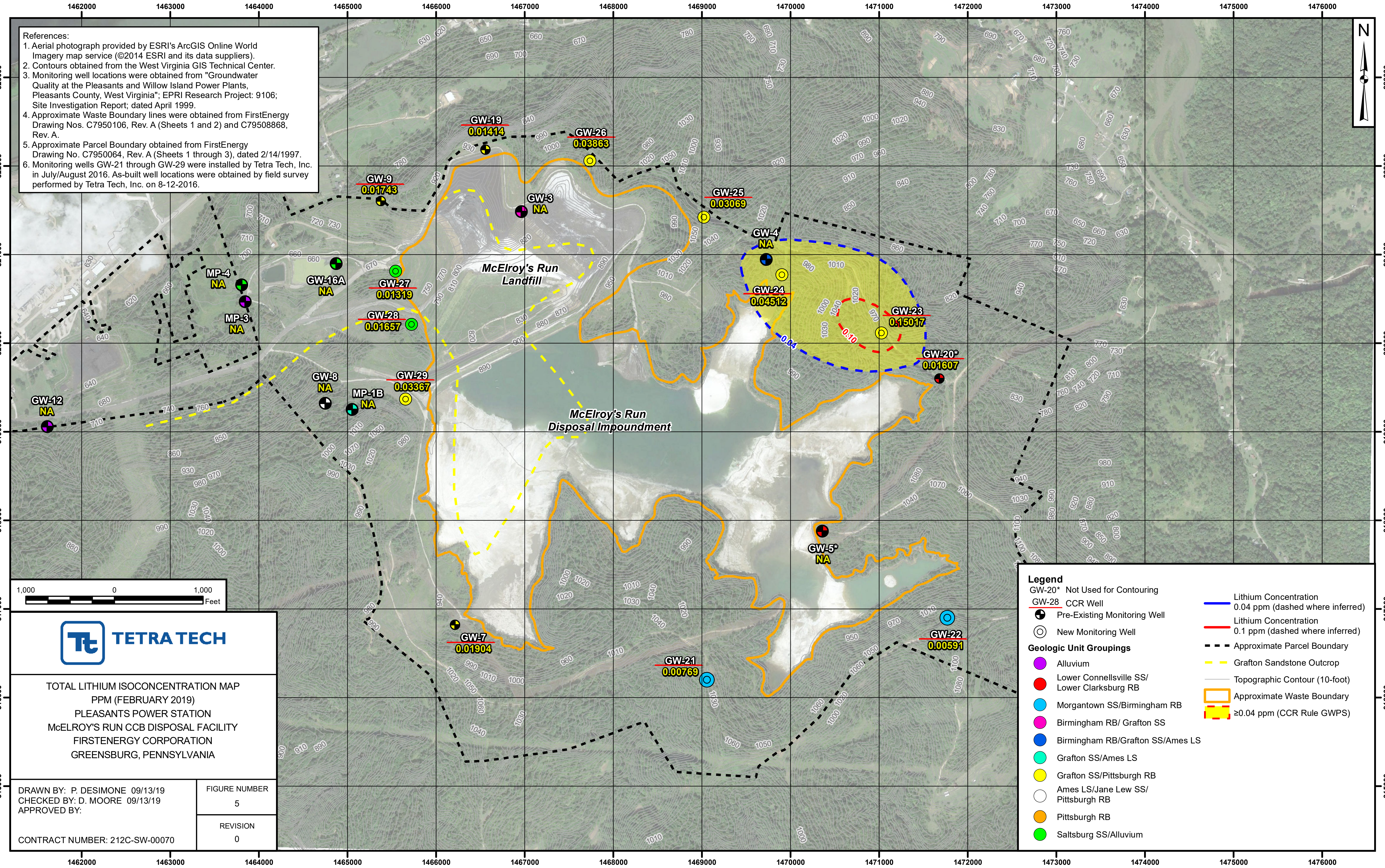

TETRA TECH

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
CONTRACT NUMBER: 212C-SW-00070	REVISION 0

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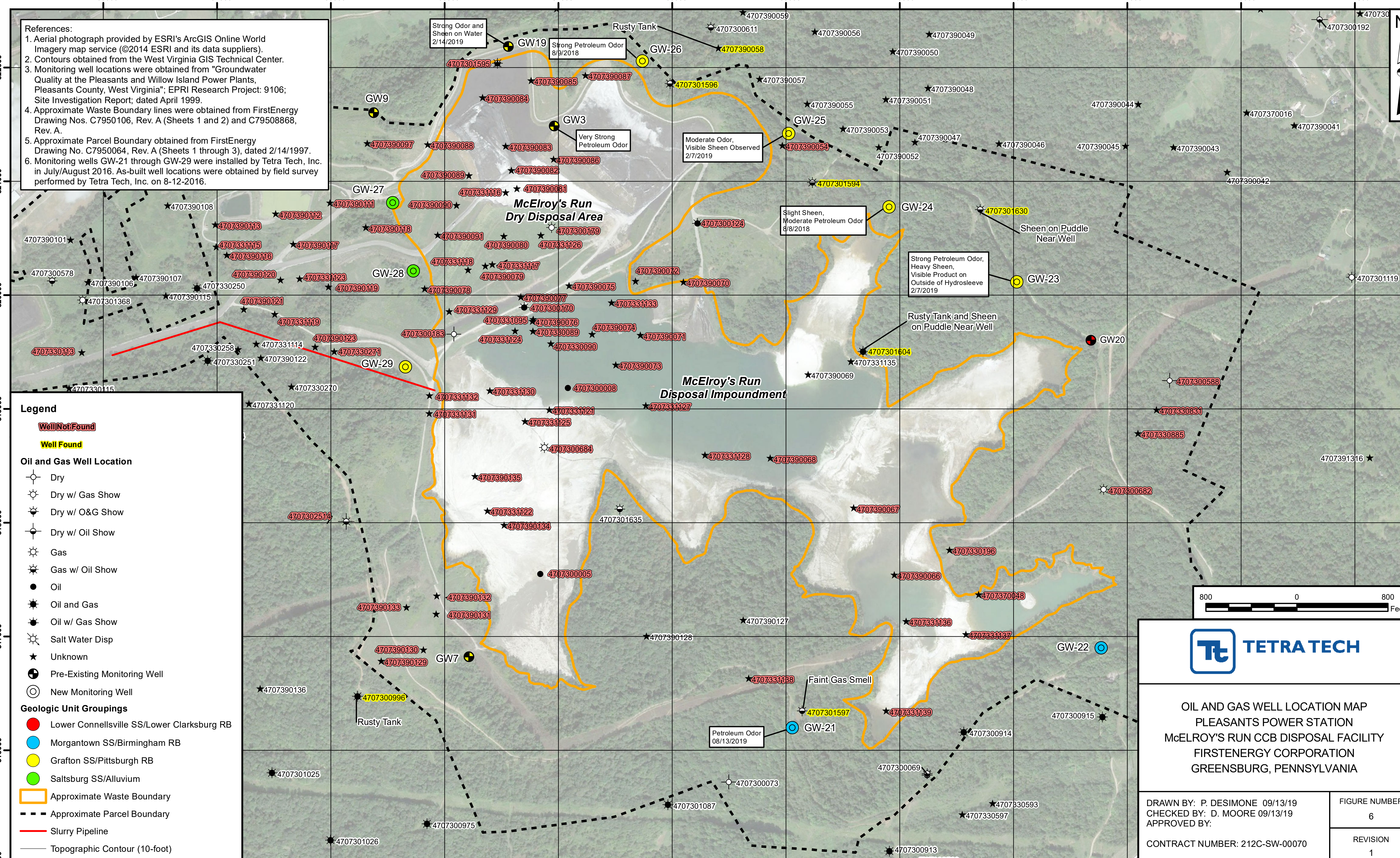

ATTACHMENT A

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 FROM	DEPTH TO	MATERIAL DESCRIPTION					REMARKS
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 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					Driller started adding water @ 61.0'
60.0	69.0	Gry (w/ Tan-Brn Zones) Sandstone					(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 7/8"~~ 13 3/4" 30.0, ~~12 1/4"~~ 10 5/8" 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 FROM	DEPTH TO	MATERIAL DESCRIPTION					REMARKS
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 3/4" ~~13 7/8"~~ 27.0, 12 1/4" ______, 10 5/8" ~~9 7/8"~~ 199.5, 7 7/8" ______, 5 7/8" ______

CASING (LF): 12 3/4" ~~12"~~ 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 FROM	DEPTH TO	MATERIAL DESCRIPTION					REMARKS
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: ______

REMARKS:

Field Classification Sheet for Non-Sampled Borehole

Figur[illegible] 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 FROM	DEPTH TO	MATERIAL DESCRIPTION					REMARKS
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: ______

REMARKS: ______

Field Classification Sheet for Non-Sampled Borehole

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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 FROM	DEPTH TO	MATERIAL DESCRIPTION					REMARKS
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 FROM	DEPTH TO	MATERIAL DESCRIPTION					REMARKS
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 Fossiliferous 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 SEAL: ____ EXPLANATION: ____

REMARKS:

BOREHOLE NO. GW-7

PAGE 1 of 1

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 (%)	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
		9.8/10.0 98%	9.8/10.0 98%		MED. SOFT	GRAY	SILTSTONE (CLAYSTONE 242.2'-243.3' & 243.7'-2[illegible].5')	M	
245.0				244.8	MED. SOFT	GRAY	SANDY SILTSTONE	M	
		10.0/10.0 100%	10.0/10.0 100%						
250.0									
				253.1	MED. HARD	GRAY	SANDSTONE	M	
255.0				254.8					
									RUN SMELLS LIKE OIL
		9.8/10.0 [illegible]%	[illegible]/10.0 [illegible]%						
260.0									
265.0				264.8					ENDED DRILLING ON 5/20/96 AT 264.8'
		10.0/10.0 100%	10.0/10.0 100%						
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 ______ HRS ______ BORING NO. P-96-5
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 (%)	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
					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, 413.1 FT. MID ∠ OPEN FRAC AT 413.2, CRUDE OIL ODOR 411.8 -442.6 FT
414.8									
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	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
					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 + GRAY	CLAYSTONE (PITTSBURGH RED BEDS)	BR	MID ∠ OPEN
444.8									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)	Materials Description
200	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.
205	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.
210	SANDSTONE, N5, medium gray, medium sand grain size, hard, fresh, with quartz, not reactive to dilute HCL. Crude oil odor.
215	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.
220	
225	Same
230	CLAYSTONE, N4, medium dark gray, very soft, fresh, not reactive to dilute HCL.
	Same

Well Completion

2" ID Schedule 40 PVC Screen

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 (%)	Depth (feet)	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

Filter Sand Pack from 193 to 239' BGS (Morie No. 3)

2" ID Schedule 40 PVC Screen

LOG OF BORING GW-24

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					Siltstone, green, soft No HCL reaction	Sltst
70					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					Shaley Siltstone, red, soft No HCL reaction	Sltst
100						

Well construction: Cement/bentonite grout; 2" ID Sch. 40 PVC

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

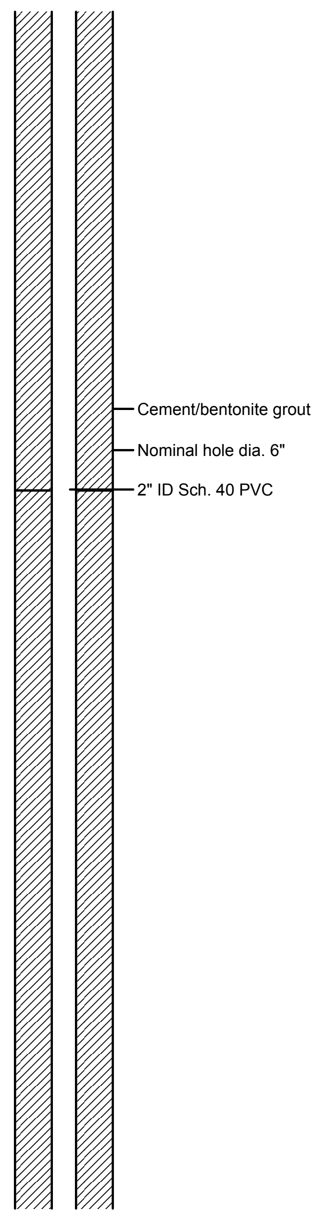
First Energy CCR, Pleasants Power

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
220–250					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.

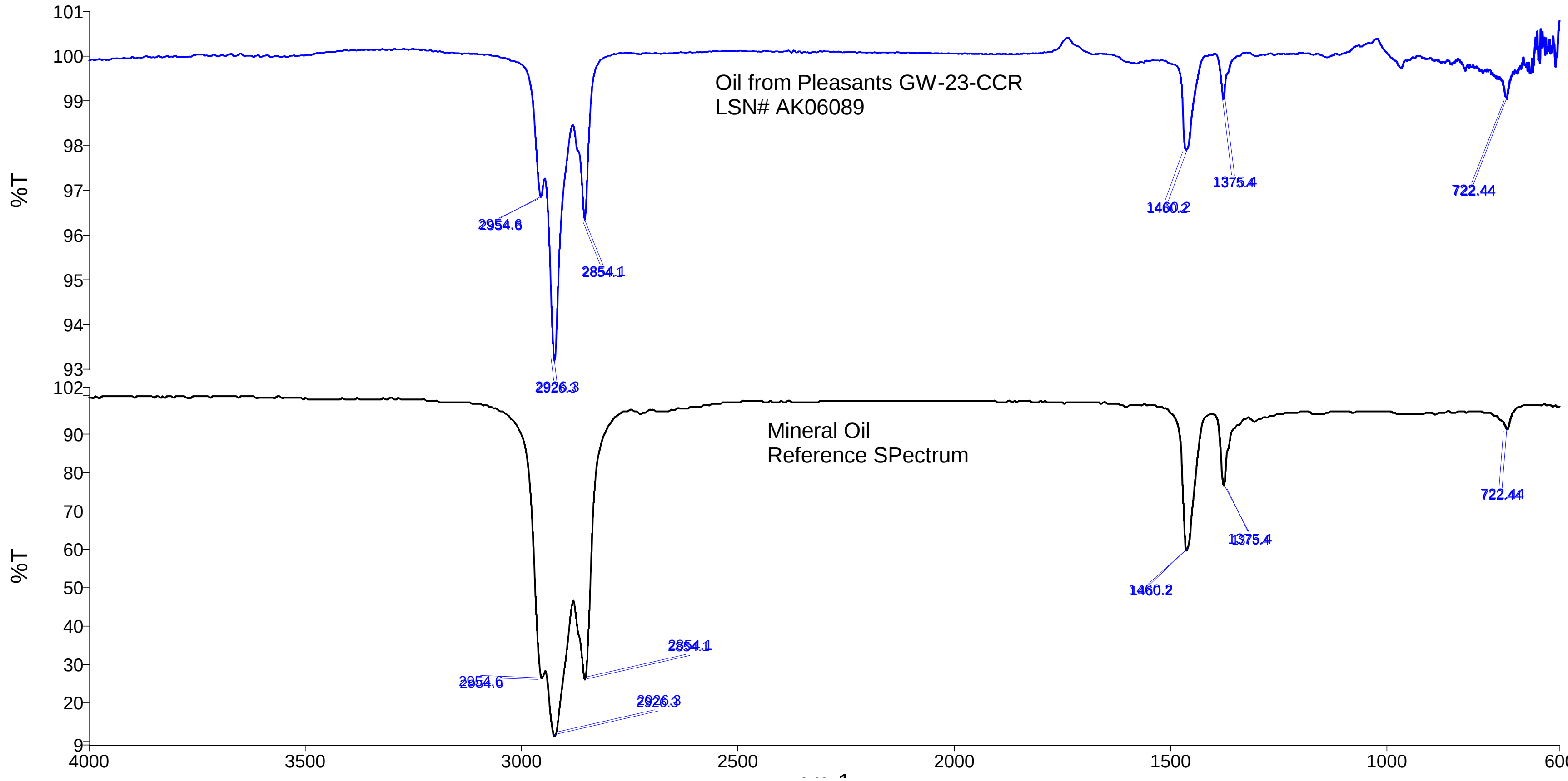
Material Test Equipment

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

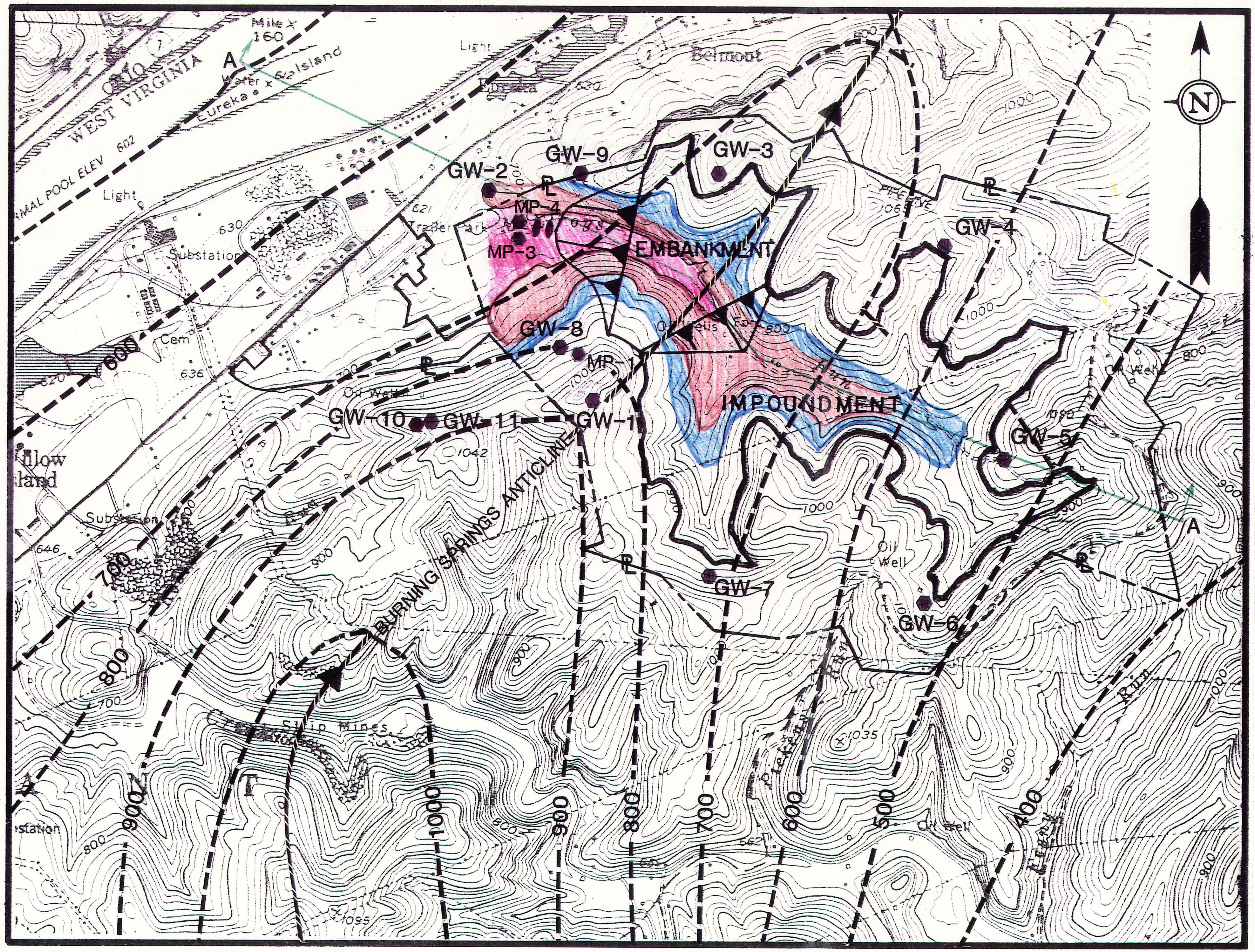
Reviewed By Zance Tay Date 4/28/17

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

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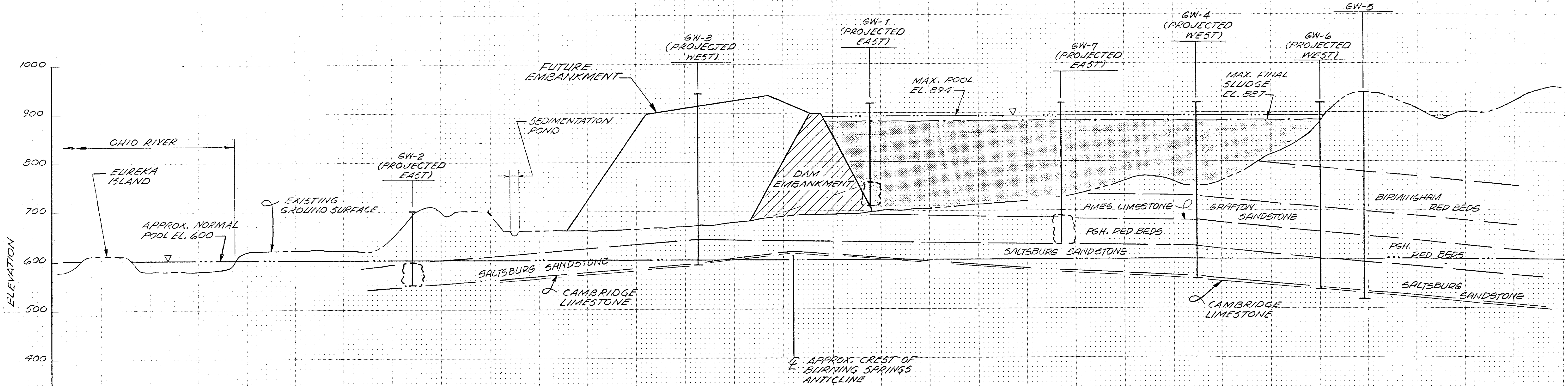
GEOLOGIC MAP, SITE PLAN AND MONITORING WELL LOCATIONS FOR McELROY'S RUN EMBANKMENT AND IMPOUNDMENT AREA

ALLEGHENY POWER SYSTEM
MONONGAHELA POWER COMPANY
PLEASANTS POWER STATION
PLEASANTS COUNTY, W. VA.

DWN. JAL	CHKD.
APPD.	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	2/20/92

REVISIONS

FIGURE 2

GENERALIZED GEOLOGIC SECTION A-A
McELROY'S RUN

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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