Feasibility Study: East Ash Disposal Area

Tennessee Valley Authority

Allen Fossil Plant

Memphis, Tennessee

Prepared for:

Tennessee Valley Authority
Chattanooga, Tennessee

Prepared by:

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REVISION 1

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Abbreviations

ALF	Allen Fossil Plant
ARAP	Aquatic Resource Alteration Permit
ARAR	Applicable or Relevant and Appropriate Requirement
BGS	Below Ground Surface
BTV	Background Threshold Value
CCR	Coal Combustion Residuals
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Constituent of Concern
CSM	Conceptual Site Model
CWA	Clean Water Act
EADA	East Ash Disposal Area
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
FS	Feasibility Study
FT	Feet
GWPS	Groundwater Protection Standards
IRA	Interim Response Action
MCLs	Maximum Contaminant Levels
µg/L	Microgram per Liter
mg/kg	Milligram per Kilogram
MLGW	Memphis Light, Gas, and Water Division
MNA	Monitored Natural Attenuation
MOA	Memorandum of Agreement
MSL	Mean Sea Level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NOI	Notice of Intent
NOT	Notice of Termination

OU	Operable Unit
ORP	Oxidation-Reduction Potential
PCB	Polychlorinated Biphenyl
PEIS	Programmatic Environmental Impact Statement
PP	Proposed Plan
PRB	Permeable Reactive Barrier Wall
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RBSL	Risk-Based Screening Level
ROD	Record of Decision
RI	Remedial Investigation
SARA	Superfund Amendment and Reauthorization Act
SU	Standard Unit
SW-DAF	Surface Water Dilution and Attenuation Factor
SWPPP	Stormwater Pollution Prevention Plan
TBC	To Be Considered
TDEC	Tennessee Department of Environment and Conservation
TVA	Tennessee Valley Authority
USACE	United States Army Corps of Engineers
USGS	United States Geological Society
WADA	West Ash Disposal Area

1.0 INTRODUCTION

This Feasibility Study (FS) documents the development, screening, and detailed analysis of remediation alternatives for the East Ash Disposal Area (EADA), located at the Tennessee Valley Authority (TVA) Allen Fossil Plant (ALF). This FS follows the remedy selection process conducted pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendment and Reauthorization Act (SARA) of 1986, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (EPA, 1994). It follows guidance provided in the document "*Guidance for Conducting Remedial Investigations (RIs) and Feasibility Studies under CERCLA (Interim Final)"* (EPA, 1988) and "*Guide to Selecting Superfund Remedial Actions*" (EPA, 1990). This FS also follows Tennessee Department of Environment and Conservation (TDEC) Division of Remediation, Chapter 0400-15-01 Hazardous Substance Remedial Action, section 0400-15-01-.09(3) Feasibility Study.

The ALF is a non-operational TVA coal-fired power plant in Shelby County, in the southwest corner of the City of Memphis, Tennessee. TVA ceased operations at the power plant in March 2018 and is currently decommissioning the facility. The location of the ALF and its surroundings is presented in **Figure 1-1**. The ALF is located on the south shore of McKellar Lake, on the eastern bank of the Mississippi River, and adjacent to a United States Army Corps of Engineers (USACE) flood-control levee. The local topography is relatively level except for the USACE levee and the Coal Combustion Residuals (CCR) disposal area dikes, which rise approximately 20 to 25 feet (ft) above the surrounding land. A site plan of the ALF showing its major features is presented in **Figure 1-2**.

The land on which the ALF is located is divided into parcels owned by various entities. **Figure 1-3** shows the respective property boundaries of TVA; Memphis Light, Gas, and Water Division (MLGW); and the City of Memphis/Shelby County. Portions of CCR disposal areas are on property leased from MLGW, the City of Memphis, and Shelby County. The property southwest of the ALF is owned by the City of Memphis and MLGW and is occupied by the City of Memphis T.E. Maxson Wastewater Treatment Plant.

1.1 OBJECTIVES

The primary objectives of this FS are to screen applicable remedial technologies, develop a focused list of remedial alternatives to be evaluated against CERCLA evaluation criteria, and make a recommendation for preferred remedies to address two separate but related Operable Units (OUs). The first OU is the EADA, and the second OU is groundwater proximal to the EADA.

1.1.1 OU 1 - East Ash Disposal Area

The EADA is located east of the former coal yard and non-operational power plant, and the USACE levee forms its north dike. The EADA was an active impoundment and is subject to the CCR Rule. The area formerly received plant process flows. Coal burned at the ALF plant generated ash, which was mixed with water and piped to the EADA. Over time, the ash settled to the bottom of the pond, and the water that conveyed it clarified. The EADA is permitted as a single wastewater treatment system that discharges to McKellar Lake under a National Pollutant Discharge Elimination System (NPDES) permit. When the pond water rises to a certain level, the water discharges to McKellar Lake via the NPDES-permitted outfall.

In September 2018, as an interim response action, TVA prepared and submitted a Drawdown and Dewatering Plan to TDEC to remove free water and pore water from the ash. The plan was conditionally approved by TDEC in November 2018, and with modifications received final approved in September 2019. TVA began implementation of the Drawdown and Dewatering Plan in March 2019. Following the completion of the Environmental Impact Statement (EIS), which was required by the National Environmental Policy Act (NEPA) (TVA, 2020a), TVA issued a Record of Decision (ROD) documenting its decision to remove CCR from the ALF (TVA 2020b). This decision to remove the CCR from site has been adopted as the primary remedial technology for OU 1.

1.1.2 OU 2 - Groundwater

During TVA's routine groundwater monitoring around the EADA in 2017, arsenic, lead, and fluoride (constituents of concern, or COCs) were detected in groundwater at concentrations above U.S. Environmental Protection Agency (EPA) maximum contaminant levels (MCLs). Corresponding elevated pH values in groundwater were also observed. In May 2017, TVA voluntarily initiated an investigation to evaluate groundwater conditions on the north and south sides of the EADA where COCs had been detected. TVA subsequently received a letter in July 2017 from TDEC initiating a remedial investigation. The 2017 RI was completed in December 2017, and the draft report was published on March 6, 2018. Shortly after publishing the draft RI report, TVA developed a supplemental scope of work to close data gaps, prepared a Supplemental RI Work Plan for TDEC review and approval, and completed the supplemental RI work scope by December 2018. The updated RI report detailing the results of the supplemental work scope was published on May 31, 2019 (Stantec, 2019).

Since the completion of the RI, TVA has moved forward with the design and installation of a groundwater extraction and treatment system as an interim response action (IRA) for OU 2. TVA selected this IRA to control groundwater during closure of the EADA and begin treating impacted groundwater. The implementation of the IRA was considered in this FS during technology screening, in addition to other remedial technologies that may be more suitable based on the site conditions after closure.

1.2 REPORT ORGANIZATION

The following sections of the report are organized as follows:

- Section 2 (Site Background) presents the site background, description of the ash disposal areas, surrounding land use, site history and operations, description of sewer pipelines, and site regional and environmental setting.
- Section 3 (Conceptual Site Model) presents the Conceptual Site Model and the extent of contamination based on the results of the RI.
- Section 4 (Development of Risk-Based Screening Levels (RBSLs) outlines constituent migration and exposure pathways (post-CCR removal). These form the basis for development of medium-specific screening levels for soil and groundwater at the EADA.
- Section 5 (Source Removal and Closure Approach) describes a performance-based approach for removing CCR from the EADA and achieving CCR unit closure.

- Section 6 (Development of Remedial Action Objectives) presents the Applicable or Relevant and Appropriate Requirements, and the identification and development of Remedial Action Objectives.
- Section 7 (Development of Remedial Alternatives) presents the development of remedial alternatives.
- Section 8 (Analysis of Remedial Alternatives) presents the individual and comparative analysis of remedial alternatives, including recommended alternatives.
- Section 9 (References) lists references utilized in preparation of this FS.
- **Appendix A** provides the soil boring logs for the sampling locations used in the development of background threshold values.
- **Appendix B** provides a statistical evaluation of background groundwater quality near the ALF.
- **Appendix C** provides an evaluation of the geochemical conditions in background groundwater near the ALF.
- **Appendix D** presents the detailed development of RBSLs for soil, groundwater, and surface water.

2.0 SITE BACKGROUND

2.1 ASH DISPOSAL AREAS

The ALF contains two ash disposal areas, the EADA and the West Ash Disposal Area (WADA). Each area is shown in **Figure 1-2** and described in detail below. The focus of this FS is the EADA.

2.1.1 East Ash Disposal Area

The EADA is east of the former coal yard and non-operational power plant, and the USACE levee forms its north dike. The EADA was an active impoundment at the time the CCR Rule was promulgated and is subject to the CCR Rule. The area also received plant process flows, which have been discontinued as part of the decommissioning process. As noted above, TVA issued a ROD documenting its decision to remove CCR from the EADA (i.e., closure-by-removal).

Coal burned at the ALF plant generated ash, which was mixed with water and piped to the EADA. Over time, the ash settled to the bottom of the pond, and the water that conveyed it clarified. The EADA was permitted as a single wastewater treatment system that discharged to McKellar Lake under a NPDES permit. When the pond water reached a certain level, the water discharged to McKellar Lake via the NPDES-permitted outfall. Now that drawdown and dewatering is in progress, the water is treated prior to discharge through a permitted outfall near the power plant.

2.1.2 West Ash Disposal Area (WADA)

The WADA is west of the powerhouse and no longer accepts CCR materials, although it continues to be a NPDES regulated unit. The USACE levee forms its south dike. The WADA is not in use and is exempt from the CCR Rule. It was historically used for intermittent CCR disposal during maintenance and has not received CCR materials since 1992.

Based on the results of the EIS, TVA will close the WADA by removing the CCR material from this unit. This work will be performed concurrently with closure of the EADA. Both areas are subject to TDEC Commissioner’s Order OGC15-0177. The remainder of this document focuses on the EADA.

2.2 SURROUNDING LAND USE

Land use near the ALF is primarily industrial and open space. As shown in **Figure 1-2**, surrounding land use includes McKellar Lake to the north, the Harsco Corporation (Harsco) facility to the west, the City of Memphis T.E. Maxson Wastewater Treatment Plant and associated treatment works to the west and south, respectively, the USACE Ensley Engineering Yard Facility to the east, and T.O. Fuller State Park to the southeast.

2.2.1 Site History and Operations

The ALF was constructed in 1959 by MLGW and consisted of three coal-fired electric generating units. TVA began leasing the plant in 1965. From 1968 through 1978, several improvements were completed at the ALF, including raising the dikes and redeveloping the original West and East Ash Disposal Areas. In 1978, continual plant discharges to the WADA were discontinued.

Following TVA's purchase of the ALF in 1984, ash was excavated from the East and West Ash Disposal Areas for beneficial reuse by USACE from 1991 to 1992. When the EADA was taken off-line during the excavation work, the West Ash Disposal Area was temporarily reopened and began receiving sluiced ash in 1991. In 1992, after excavation activities were completed, the EADA was re-activated, and the WADA stopped receiving sluiced ash (TVA, 1993). The EADA dredge cell and diversion trench were constructed in January 2005. In 2015, the WADA was retrofitted to no longer receive flows and impound water. The EADA ceased receiving sluiced ash in 2018.

2.3 SEWER PIPELINES

Three sewer lines are located at or near the EADA, as shown in **Figure 2-1**. The three sewer lines were constructed during the 1950s and 1970s and are owned and operated by the City of Memphis. Many modifications or repairs have been completed since installation. Leaks and releases from these pipelines have been documented several times, as described in the Updated RI Report (Stantec, 2019). These features are also shown in **Figure 2-2**.

Two of the sewer lines (60-inch and 96-inch gravity sewers) are aligned in an east-west direction, and a 30-inch force main/42-inch gravity sewer is aligned in a north-south direction. **Figure 2-3** depicts a cross-section of the sewer lines with respect to the overlying EADA. The 96-inch sewer and the 30-inch force main/42-inch gravity sewer are both active. The 60-inch sewer is blocked to industrial and sanitary wastewater influent flow from the east at a location west of the EADA. From this blocked location eastward, the 60-inch sewer beneath the EADA is filled with sediment, and this sewer is functionally abandoned beneath the EADA. From the blocked location westward, the sewer remains active.

The wastewater streams transported by the sewer lines include both sanitary and industrial flows, which are discharged to the T.E. Maxson Wastewater Treatment Plant west of the ALF. The 30-inch force main/42-inch gravity sewer carries wastewater from President's Island, an industrial park north of McKellar Lake, and the 96-inch sewer carries wastewater from the southern portion of Memphis.

2.4 SITE AND REGIONAL ENVIRONMENTAL SETTING

2.4.1 Location and Physiography

The ALF is in the southwestern corner of Tennessee within the southwestern city limits of Memphis. The plant is on the south shore of McKellar Lake and the eastern bank of the Mississippi River, on top of the Mississippi Embayment, in the Mississippi Alluvial Plain section of the Gulf Coast Coastal Plain. The Mississippi Embayment is a geologic basin filled with 3,000 ft or more of Cretaceous to Recent age sediments deposited primarily in a Coastal Plain setting. The sedimentary sequence is dominated by unconsolidated sand, silt, and clay with minor lignite (Hosman and Weiss, 1991).

2.4.2 Hydrogeology

Site-specific geologic mapping indicates that the ALF is directly underlain by artificial fill and Quaternary age alluvial deposits. The fill generally consists of alluvium dredged from McKellar Lake, materials from cut and fill excavations from the surrounding floodplain, and possibly windblown silt in certain locations. The fill can range in thickness from a few feet to tens of feet beneath industrial areas in the river floodplain.

The ALF is underlain by two groundwater aquifer zones. The first is the near-surface, unconfined Alluvial aquifer, and the second is the deeper, semi-confined Memphis aquifer. Site-specific observations of the Mississippi River Valley alluvium deposits composing the Alluvial aquifer indicate that this unit is a silty sand with intervals of silts and clay in the upper portion of the unit, and sand and gravel in the lower portion. These observations are consistent with the regional understanding of this stratum (Hosman and Weiss, 1991). Site-specific geological investigations indicate that the Alluvial aquifer is generally underlain by the fine-grained upper Claiborne confining unit, a stratum of low-permeability clay. An east-west cross-section depicting these two strata based on RI borings advanced near the northern boundary of the EADA is presented in **Figure 2-4**. The upper Claiborne confining unit is underlain by the Memphis aquifer, which is characterized by predominantly very fine to very coarse-grained sand with lenses of fine-grained material (Parks and Carmichael, 1990). Deep soil borings advanced during the RI indicate that the upper Claiborne confining unit is not present in the southeastern portion of the EADA, as shown in the east-west cross-section near the southern boundary of the EADA presented in **Figure 2-5**. Groundwater in that vicinity is likely in hydraulic communication between the two aquifers. The missing section of upper Claiborne confining unit in this area is interpreted to be the result of local faulting, displacement, and subsequent erosion.

2.4.3 Regional Water Supply

Current information indicates that the Alluvial aquifer is not used as a drinking water source near the ALF. The City of Memphis obtains its water supply from multiple well fields that withdraw water from the Memphis aquifer. The Memphis and Fort Pillow aquifers are the primary drinking water sources for the surrounding area, including portions of eastern Arkansas and northern Mississippi. Except for the Davis Well Field, the well fields are more than 5.5 miles east of the ALF. The Davis Well Field is approximately two miles south of the ALF. The Memphis aquifer is the most productive aquifer in the region, providing approximately 98% of the total water pumped to the City of Memphis in 1980 (Brahana and Broshears, 2001), and it remains the primary supply of drinking water in the area. Depending on location, the top of the Memphis aquifer is approximately 157-255 ft below surface grade near the ALF based on drilling programs conducted in the area.

2.4.4 Surface Water

2.4.4.1 Mississippi River

The ALF is approximately 2.1 miles east of the Mississippi River. Mississippi River elevations fluctuate up to 40 ft in response to rainfall in the Mississippi, Ohio, and Missouri river basins. Groundwater elevations at the ALF vary widely, corresponding to fluctuations in the Mississippi River level.

2.4.4.2 McKellar Lake

McKellar Lake is an artificial cut-off meander of the Mississippi River and was formerly known as the Tennessee Chute. The lake was created as a deep-water harbor for the City of Memphis in 1948 when USACE began construction of a levee connecting President’s Island to the mainland. The southern and eastern shores of President’s Island have been developed as an industrial area with approximately 148 facilities. Water levels in McKellar Lake can fluctuate up to 40 feet between approximately 180 to 220 feet mean sea level (MSL).

The ALF is within the Horn Lake-Nonconnah watershed. Many of the stream segments in the Horn Lake-Nonconnah watershed and in McKellar Lake have water quality concerns. Water quality data for McKellar Lake and its major tributary creeks indicate present day and historical impacts from organic and inorganic chemicals. TDEC lists McKellar Lake as containing polychlorinated biphenyls (PCBs), dioxins, and chlordane from contaminated sediments. It is also impaired by *Escherichia coli*, low dissolved oxygen, nitrate/nitrite, and sedimentation/siltation from sanitary sewer overflows and separate discharges from municipal storm sewer systems. The nearby Mississippi River and the Horn Lake cutoff are generally listed for similar pollutants from similar sources (TDEC, 2017).

3.0 CONCEPTUAL SITE MODEL

This section describes the current conceptual site model (CSM) for the EADA at the ALF. The CSM is based on historical information and data collected during the RI as detailed in the Updated RI Report (Stantec, 2019).

The EADA is in the eastern portion of the ALF along the shore of McKellar Lake. Existing information shows that the EADA is surrounded by berms or elevated land and that it was developed as an ash storage unit in 1959. Soil borings conducted during geotechnical studies before the RI indicated clay was present at the base of the EADA, but most borings did not penetrate the clay to identify its total thickness. The elevation at the base of the EADA is approximately 210 feet MSL (with clay below). Three sewer lines are located at or near the EADA, as shown in **Figure 2-1**.

Alluvial aquifer groundwater elevations fluctuate with the McKellar Lake stage, but generally range from approximately 180-205 feet MSL. The EADA overlies the upper portion of the alluvium, which tends to consist of interbedded silts, clays, and sands, including a naturally occurring “blue clay” with a base elevation of approximately 165-175 ft MSL, as shown in **Figure 2-3**. Interbedded fine-grained clay, silty clay, clayey silt, silt, and clayey sand define the blue clay interval.

It is postulated that the blue clay interval likely extends beyond the northern and southern boundaries of the EADA; however, the lithologic descriptions in historical borings logs are not specific enough to define the areal extent. Detailed lithologic observations and natural gamma ray logs were used to establish the presence of the blue clay in the two most important areas of interest where the groundwater remedy will be implemented (the north and south areas). The presence of the blue clay interval is further supported by the groundwater elevations in wells ALF-203, PMW-02A, PMW-04A, PMW07A, and EW-N02 (north area), and ALF-202, ALF-212, ALF-215, ALF-217, PMW-10A, PMW-11A, PMW-14A, and EW-S03 (south area), which indicate mounding of groundwater, which is indicative of impeded vertical flow of groundwater. The blue clay can be interbedded with more permeable fine-grained sand in certain locations, so it does not entirely prevent downward groundwater migration like a true confining unit. However, based on the distribution of arsenic and other CCR constituents, the blue clay does appear to limit or impede downward COC movement.

While operational, the EADA held CCR ash, ash pore water, and “free water.” When the pond water reached a certain level, the water discharged to McKellar Lake via the NPDES-permitted outfall. Now that drawdown and dewatering is in progress, free water has been removed and pore water is being removed. The water is treated prior to discharge through a permitted outfall near the power plant. TVA is planning for CCR removal after completion of the EIS.

Elevated concentrations of CCR constituents were detected in ash and ash pore water during the RI. On average, the CCR concentrations in ash were not significantly different from those of ash samples from other coal combustion facilities. However, the concentrations of CCR constituents in the ash pore water were not typical; specifically, arsenic concentrations were found to be unusually elevated. Further analysis suggests that the combination of high pH, low oxidation-reduction potential (ORP), and high carbon content might have produced a geochemical environment that favored arsenic mobility.

The EADA overlies the Alluvial aquifer, which is a thick (approximately 110 to 245 ft) deposit of sand, silt, and clay deposited by the ancestral Mississippi River. Groundwater flow in the aquifer is predominately horizontal, although relatively minor vertical gradients also exist, and flow direction is influenced by the McKellar Lake stage. Below the Alluvial aquifer is the upper Claiborne confining unit, which is a clay layer approximately 30-70 ft thick that when present separates the Alluvial aquifer from the lower Memphis aquifer and is a barrier to downward groundwater flow.

The Memphis aquifer is a source of high-quality drinking water for the City of Memphis. Although the Memphis aquifer is isolated from the Alluvial aquifer under most of the EADA by the intervening upper Claiborne confining unit, an inferred fault underlying the southeastern corner of the EADA has offset (i.e., lowered) the sedimentary sequence of the Alluvial aquifer, the upper Claiborne confining unit, and upper part of the Memphis aquifer to the southeast by varying amounts. The Alluvial aquifer directly overlies the Memphis aquifer in a localized area near monitoring well ALF-202 as a result of the upper Claiborne confining unit having been removed by erosional scouring by a former channel of the Mississippi River that followed a low-lying trough along the fault plane on the downthrown side of the fault. This means that in the southeast corner of the EADA, the Alluvial aquifer and the Memphis aquifer appear to be physically connected. A groundwater pumping test by the United States Geological Survey (USGS) also indicated a discernible hydraulic connection between the Memphis and Alluvial aquifers in the southeastern corner of the EADA, under pumping conditions.

At the ALF, CCR constituents such as arsenic (and to a lesser extent fluoride and lead) have been detected in groundwater samples collected from the Alluvial aquifer proximal to the EADA. Arsenic, fluoride, and lead are considered the primary COCs at the ALF because concentrations in certain locations exceed MCLs. The areas impacted by primary COCs are generally limited to the shallow portion of the Alluvial aquifer near monitoring wells ALF-203 and ALF-204 (the “north area” of OU 2) and ALF-202 and ALF-212 (the “south area” of OU 2). For example, the arsenic concentrations in the shallow monitoring wells near ALF-202 and ALF-203 are generally greater than 200 micrograms per liter (µg/L) and 2,000 µg/L, respectively, compared with the arsenic MCL of 10 µg/L. Concentration maps for RI groundwater data showing arsenic, fluoride, and lead above MCLs are presented in **Figures 3-1 through 3-3**, respectively.

The concentrations of fluoride and lead are substantially lower (relative to their respective MCLs), and the distributions of fluoride and lead in groundwater are within the areas impacted by arsenic. Other CCR-related constituents, such as boron, have been detected in the Alluvial aquifer near the EADA; however, these constituents do not have MCLs and are not considered primary drivers for remedial action. Although the route by which CCR constituents migrated into the Alluvial aquifer from the EADA is not completely understood, the hydrogeological factors controlling COC migration within the Alluvial aquifer have been characterized.

The highest concentrations of COCs in these areas north and south of the EADA were generally encountered in the shallow intervals of the upper Alluvial aquifer (i.e., the upper 50 feet of the aquifer) within and just above a clay/silt layer referred to as the “blue clay.” The blue clay layer marks a transition from shallow fine-grained and interbedded sediments to poorly sorted coarser-grained sands and gravels at depth. The groundwater encountered above and within the blue clay layer is mounded because the low-permeability clay limits downward movement of the groundwater.

Despite the 40 feet of variation in McKellar Lake stage and related reversals in groundwater flow directions in the shallow, intermediate, and deep intervals of the Alluvial aquifer, groundwater flow directions in the blue clay zone are directed away from the EADA and are in limited communication with the lower intervals of the Alluvial aquifer. The blue clay zone aids in the containment of primary COCs (i.e., arsenic, lead, and fluoride) within the shallow portion of the Alluvial aquifer. This is based on the low hydraulic conductivity and adsorptive capacity of the blue clay.

The blue clay is predominantly a mixture of phyllosilicate clay minerals (kaolinite, illite, montmorillonite, etc.), as well as semi-crystalline and amorphous aluminum and iron oxyhydroxides, and iron and manganese oxides (jointly referred to as metal oxyhydroxides). Arsenic (As) in groundwater near the EADA is predominantly observed in the more adsorptive higher arsenate valence state (As(V)) although some of the less adsorptive arsenite (As(III)) is also present. In addition to the form of arsenic present, the groundwater pH also has a strong effect on arsenic adsorption and mobility because pH and mineral adsorption can influence the oxidation of As(III) to As(V) under aerobic conditions. Manning and Goldberg (1997) have also shown that adsorbed As(III) is more readily oxidized to As(V) once adsorbed onto soil minerals improving the adsorption capacity of phyllosilicate and amorphous oxyhydroxide minerals. Maximum adsorption reported by Manning and Goldberg (1997) is also observed within the same pH range as observed in groundwater within the water bearing zone at the ALF (6.5 to 8.5 Standard Units (SU)) above and below the blue clay, suggesting conditions in the blue clay are optimal for arsenic adsorption (greater than 90% adsorption for amorphous iron oxyhydroxides at pH less than 8.5 SU according to Jain et al. (1999), and approximately 90% adsorption for amorphous aluminum oxyhydroxides and illite at pH approximately 6.5 to 8.5 SU according to Manning and Goldberg (1997). Furthermore, Manning and Goldberg (1997) concluded that due to surface catalyzed oxidation of As(III) to As(V), less than half the arsenic adsorbed to amorphous aluminum oxyhydroxides and illite can be desorbed by active extraction with phosphate after adsorption below the ambient pH observed at the ALF (pH less than 8.5). This indicates that once adsorbed, arsenic does not completely desorb, and would therefore be sequestered or naturally attenuated by the blue clay.

This shallow portion of the Alluvial aquifer is the only area where primary COCs are observed with concentrations above MCLs. Other constituents that exhibit greater mobility are present in deeper wells within the Alluvial aquifer. These other constituents do not have MCLs and are not considered primary COCs, but TVA is monitoring groundwater every three months to evaluate concentration trends. Based on groundwater samples from RI, concentrations of constituents in the Memphis aquifer were indicative of natural background conditions unimpacted by CCR. For the underlying sandy intervals of the Alluvial aquifer, during high lake levels groundwater flows south toward the EADA, and during low lake levels groundwater flows north toward McKellar Lake.

A network of groundwater monitoring wells has been installed around the EADA to monitor groundwater at various depth intervals within the Alluvial aquifer. These wells are screened in the shallow, intermediate, and deep intervals of the Alluvial aquifer. Many shallow wells are positioned within and just above the “blue clay” as discussed above. Groundwater samples from the deep wells do not indicate that the primary COCs are present in the deeper intervals of the Alluvial aquifer at elevated concentrations. Vertical groundwater gradients measured during the RI indicate relatively small vertical gradients within the Alluvial aquifer; it appears that COCs in the north and south areas do not tend to move downward in the Alluvial aquifer via groundwater flow. Samples from the Memphis aquifer were also collected during the RI, and CCR constituents were not found at concentrations above their respective MCLs.

3.1 NATURE AND EXTENT OF CONTAMINATION

3.1.1 CCR Material and OU 1

CCR material (ash), ash pore water, and related ash-impacted soil inside the EADA collectively comprise OU 1. These media are subject to the CCR Rule finalized by the EPA in 2015, in addition to other Applicable or Relevant and Appropriate Requirements (ARARs) as discussed in Section 4.0.

OU 1 is a total of approximately 80 acres in size and contains approximately 2,300,000 cubic yards of CCR material (Stantec, 2016). The area is bordered on the north by a 2,200-foot-long USACE flood control levee, and on the east and south by dikes constructed by TVA. The 1,300-foot-long east dike is approximately 20 ft in height and is bordered on the east by wetlands. The 2,300-foot-long south dike has an approximate height of 25 ft and supports a roadway and railroad tracks along its crest. OU 1 is bordered to the west by the Harsco beneficial re-use area and the former coal yard and coal yard runoff pond.

A total of 19 ash samples were collected from five locations within the EADA during the RI and analyzed for COCs, as shown in **Figure 3-4**. These samples were collected from various depths generally less than 20 ft below ground surface (bgs). Concentrations of arsenic observed in ash samples ranged from 1.4-424 milligrams per kilogram (mg/kg), with an average of approximately 85 mg/kg. The average pH associated with ash material was 9.9 SU (Stantec, 2019).

Ash pore water samples were collected from 21 locations within the EADA during the RI, as shown in **Figure 3-5**. Ash pore water is water trapped between CCR particles and is not the same media as groundwater. Samples were collected to a depth of approximately 22.5 ft bgs. Arsenic concentrations in ash pore water ranged from 2.5-13,800 µg/L with an average of 1,624 µg/L. The average pH of ash pore water was 10.3 SU (Stantec, 2019).

During the RI (Stantec, 2019), 27 soil samples from nine borings outside the perimeter of the EADA were collected and analyzed for CCR parameters, as shown in **Figure 3-6**. Analytical results from these samples indicated that ash materials do not extend beyond the boundaries of the EADA. Concentrations of metals in these soil samples were comparable to published background levels in Tennessee soils, including arsenic. The average arsenic concentration in these soil samples was 5.12 mg/kg, and the published background concentration was 10 mg/kg.

Since publication of the RI, background soil samples were collected from locations around the ALF in accordance with the TDEC Order background soil investigation. The investigation was completed in October 2019, and the data were used to develop background threshold values (BTVs) for the purposes of this FS. The soil data from outside the EADA perimeter were compared to the BTVs, and the results are provided in **Table 3-1.** The background soil sampling locations and associated soil boring logs are provided in **Appendix A**.

3.1.2 Groundwater and OU 2

MCLs were used as comparison criteria to evaluate groundwater data. MCLs are standards established by the EPA in National Primary Drinking Water regulations that apply to public water systems. Groundwater from the Alluvial aquifer is not used for drinking water based on currently available information (Stantec, 2019). Groundwater data for the EADA were also compared with site-specific background concentrations. This comparison is provided in **Appendix B**. The wells selected for the background evaluation include: ALF-216 (50 ft), ACC-1A (165.5 ft), ACC-3A (126 ft), ACC-5A (144 ft) and ACC-5B (55 ft). These wells are located hydraulically upgradient of the EADA and did not exhibit constituents at concentrations typically associated with CCR-impacted groundwater (e.g., boron, sulfate). Further information regarding the geochemical evaluation of the background groundwater quality is provided in **Appendix C**.

Based on analytical data from groundwater samples collected during 2017-2018, concentrations of COCs above MCLs have been detected primarily in two areas of groundwater proximal to the EADA (Stantec, 2019). These groundwater areas have been designated the north area and the south area, respectively, and collectively constitute OU 2. The estimated boundaries of OU 2 are shown in **Figure 3-1** and are based on arsenic concentrations above MCLs.

Arsenic, fluoride, and lead were the only constituents detected at concentrations above their MCLs. Elevated pH values (>8 SU) were measured in groundwater, as shown on **Figure 3-7**, and generally corresponded with higher concentrations of arsenic, fluoride, and lead. Arsenic is the primary COC based on its frequency of detection and detected concentrations. Fluoride and lead were detected above their respective MCLs less frequently and were distributed within the arsenic area. By delineating arsenic concentrations above the MCL, fluoride and lead were also delineated.

In the north area, the horizontal extent of arsenic, fluoride, and lead in groundwater is approximately 1,550 ft by 450 ft, as estimated by groundwater sampling locations GP-2 and GP-9 to the west, a point between GP-76 and well ALF-205 to the east, McKellar Lake to the north, and the USACE levee to the south. Vertically within the Alluvial aquifer, the highest concentrations of COCs were found in a zone between approximately 20-50 ft bgs. Arsenic concentrations above the MCL of 10 μg/L extend to a depth of approximately 90 ft bgs, whereas fluoride and lead exceedances extend to depths of approximately 50 ft bgs.

In the south area, the horizontal extent of COCs in groundwater is approximately 1,600 ft by 450 ft, as estimated by well ALF-201 to the west, ALF-212 to the east, ALF-215 to the south, and the dike of the EADA to the north. Vertically, the highest concentrations of COCs were found in a zone between approximately 20-50 ft bgs. Arsenic concentrations above the MCL of 10 μg/L extend to a depth of approximately 80 ft bgs, whereas fluoride exceedances extend to a depth of approximately 50 ft bgs. Lead was not detected above its MCL in the south area.

Groundwater COCs have not been detected above their respective MCLs in samples collected from monitoring wells screened within the deepest interval of the Alluvial aquifer or within the Memphis aquifer.

3.2 SENSITIVE RECEPTOR REVIEW

3.2.1 Regional Water Supply

The City of Memphis obtains its water supply from multiple well fields that withdraw water from the Memphis aquifer. The Memphis and Fort Pillow aquifers are the primary drinking water sources for the surrounding area, including portions of eastern Arkansas and northern Mississippi. Except for the Davis Well Field, the well fields are more than 5.5 miles east of the ALF. The Davis Well Field is approximately two miles south of the ALF. The Memphis aquifer is the most productive aquifer in the region, providing approximately 98% of the total water pumped to the City of Memphis in 1980 (Brahana and Broshears, 2001), and it remains the primary supply of drinking water in the area.

Groundwater samples from the production wells in the Memphis aquifer were collected three times by TVA and once by the USGS. No constituents were detected above EPA drinking water standards. The Memphis aquifer has not been affected by constituents in groundwater detected at the ALF in the Alluvial aquifer (Stantec, 2019).

3.2.2 Surface Water

3.2.2.1 Mississippi River

The ALF is approximately 2.1 miles east of the Mississippi River. Mississippi River elevations fluctuate by up to 40 ft in response to rainfall in the Mississippi, Ohio, and Missouri river basins. Groundwater elevations at the ALF vary widely, corresponding to fluctuations in the Mississippi River level (Stantec, 2019). A USGS monitoring location is approximately 8.5 miles upstream from the ALF. Data from the upstream USGS monitoring location 07032000 show the average water elevation from 2016 to 2018 as approximately 200.8 feet MSL (USGS, 2019).

3.2.2.2 McKellar Lake

McKellar Lake is currently not meeting water quality criteria for its designated uses, including as an industrial water supply, agricultural water supply, aquatic habitat, or for recreational use. TDEC has issued fish consumption advisories for the first 1.8 miles of Nonconnah Creek upstream from McKellar Lake and for the entirety of McKellar Lake for chlordane, other organic chemicals, and mercury (TDEC, 2017). TVA is authorized to discharge water from the EADA to McKellar Lake under a NPDES permit (Stantec, 2019).

4.0 DEVELOPMENT OF RISK-BASED SCREENING LEVELS

Risk-based screening levels (RBSLs) were developed for soil and groundwater at the EADA, as part of TVA's Source Removal Construction Quality Assurance Plan (May 28, 2020). Medium-specific RBSLs are based on the protection of human health and the environment and will be used to assess site conditions following CCR removal. As such, these RBSLs are incorporated into the source removal and closure approach described in Section 5.0. Future use of the property will be for industrial operations. The migration and exposure pathway analysis that serves as the basis for the RBSLs is described in Section 4.1, and the iterative manner in which the RBSLs will be used to assess post-CCR-removal conditions is described in Section 4.2. Details regarding the development of medium-specific RBSLs for the EADA are presented in **Appendix D.**

4.1 MIGRATION AND EXPOSURE PATHWAY ANALYSIS

4.1.1 Soil

Soil remaining after excavation of the EADA is completed may contain residual levels of CCR-derived constituents. Two potentially complete exposure pathways have been identified for post-excavation soil: 1) direct contact by a hypothetical future on-site industrial worker, and 2) direct contact by a hypothetical future on-site construction/utility worker. Both scenarios assume dermal contact, ingestion and particulate inhalation.

4.1.2 Groundwater

In the event that residual concentrations of CCR constituents are present in soil after excavation of the EADA is completed, they may serve as a continuing source of CCR-derived constituents to groundwater through leaching. The Memphis Aquifer is a major regional aquifer and is the source of municipal water for the City of Memphis. However, dissolved CCR constituents would need to move downward through at least 110 ft of alluvium and through 30 to 60 ft of the upper Claiborne confining unit (which is present under most of the EADA), before reaching the Memphis aquifer. In the southeast corner where the upper Claiborne confining unit is offset or missing, constituents would have to move through 225 ft of alluvium before reaching the Memphis aquifer. Also, groundwater flow in the Alluvial aquifer is primarily horizontal, not vertical. Under current conditions, most vertical gradients measured within the Alluvial aquifer are upward or neutral, and the upper Claiborne confining unit serves as a confining layer with a median hydraulic conductivity of 1.39 X 10-9 cm/sec. Therefore, the assumption that CCR constituents in remaining soil could impact a drinking water source (i.e., the Memphis aquifer) through the soil leaching-to-groundwater pathway is conservative. Nevertheless, the Memphis aquifer is an important source of drinking water in the Memphis area, so this potential migration and exposure pathway was evaluated during the development of the RBSLs.

4.1.3 Surface Water

CCR-derived constituents potentially present in groundwater after the excavation is completed may migrate via groundwater to adjacent McKellar Lake. Monitoring wells installed around the EADA indicate that groundwater movement in the Alluvial aquifer immediately beneath the site is generally northward to McKellar Lake. McKellar Lake is designated for industrial water supply, fish and aquatic life, recreation, and navigation designated uses (TDEC, 2013). However, there are water quality concerns with McKellar Lake, and neither McKellar Lake nor the Mississippi River within the vicinity of the ALF are used as source water for potable water supplies. Fish consumption advisories have been issued for McKellar Lake, the Mississippi River and Nonconnah Creek; therefore, human exposures to CCR-derived constituents in surface water through consumption of locally caught fish and aquatic organisms are unlikely.

Other recreational uses of McKellar Lake including swimming and boating which may result in human exposures to CCR-derived constituents in surface water. Aquatic life in McKellar Lake and the Mississippi River within the vicinity of the ALF may be exposed to CCR-derived constituents in surface water. These scenarios were evaluated during the development of the RBSLs.

4.1.4 Sediment

The exposure pathway for sediment was not included because impacts to sediment due to operations at the ALF have not been identified. All discharges from the EADA have been regulated and documented under an NPDES permit. Additionally, McKellar Lake serves as an industrial harbor that is routinely dredged.

4.2 EVALUATION OF FUTURE SITE CONDITIONS

A tiered approach will be used to evaluate site conditions following CCR removal. This approach will generally consist of comparing post-removal soil and groundwater samples with a series of screening levels for each medium. The following comparisons will be performed for each potential pathway.

Soil Direct Contact

1. Comparison of soil data to BTVs developed for background soils
2. Comparison of soil data to U.S. Environmental Protection Agency (EPA, 2019) Industrial Soil RSLs
3. Comparison of soil data to RBSLs developed for a site-specific hypothetical future on-site construction/utility worker exposure scenario.

Soil to Groundwater Migration

1. Comparison of soil data to BTVs developed for background soils
2. Comparison of soil data to RBSLs derived for the potential soil-to-groundwater leaching pathway (based on the use of groundwater as drinking water and protection of surface water for human health and aquatic organisms).

Groundwater

1. Groundwater concentrations will be compared to drinking water values from TDEC and the EPA. This is a conservative screening step as the on-site Alluvial aquifer groundwater is not used as a source of drinking water.
2. Groundwater data will be compared to risk-based surface water screening levels for both ecological receptors and human receptors (based on recreational use of surface water). This is a conservative screening step as the on-site groundwater undergoes significant

dilution and attenuation before entering surface waters, and there is no direct exposure to groundwater by human or ecological receptors.

Groundwater to Surface Water

1. Groundwater data will be compared to surface water chronic and acute ecological screening levels.
2. Surface water dilution and attenuation factors (SW-DAFs) will be used to further evaluate groundwater data relative to surface water screening levels. This evaluation will account for changes in CCR constituent concentrations for groundwater that may flow to McKellar Lake.

5.0 SOURCE REMOVAL AND CLOSURE APPROACH

This section describes the source removal and closure approach for the EADA, which is a performance-based approach wherein the remedial goals presented in Section 8.0 will be met through medium-specific regulatory standards, risk-based criteria, or performance objectives.

5.1 SOURCE REMOVAL APPROACH

TVA's Source Removal Construction Quality Assurance Plan (May 28, 2020) for the EADA outlines the process for CCR removal and post-excavation sampling/testing. The plan specifies removal of CCR using visual observations, followed by removal of an additional 1-foot of underlying soil. Soil samples will be collected at the base of the CCR excavation, and at the base of the additional 1-foot soil excavation. Soil sample analyses will include CCR parameters and percent ash. After soil sampling, clean backfill will be placed in the excavation and graded to promote drainage.

This process was developed by TVA and TDEC, and it is intended to be used for CCR units where closure-by-removal is deemed necessary. This process can be considered a performance-based approach whereby success is achieved by visual removal of CCR and an additional 1-foot of underlying soil. Although post-excavation samples will be collected, no further over-excavation will be performed based on the analytical results. Activities to address residual concentrations of CCR constituents in subsurface will be managed by other means (e.g., groundwater monitoring, groundwater remediation, land-use restriction, subsurface soil management plans, etc.).

The reason for a performance-based approach stems from the inherent risks posed by over-excavation of soil at the EADA. These risks are difficult to quantify and are expected to be challenging to control. The greatest of these risks are as follows:

1. Increased potential for groundwater seepage into the over-excavation area, especially during the rainy and flood-prone season.
2. Management of CCR contact stormwater in the vicinity of over-excavation areas.
3. Maintaining safe CCR slope stability conditions adjacent to over-excavation areas.
4. Undermining existing infrastructure during over-excavation, such as the USACE levee and utilities.

These risks must be managed to successfully remove CCR at the EADA. Analysis by TVA indicates that leaving excavated areas open while awaiting, validating, and interpreting post-excavation analytical data could pose a significant and unacceptable risk to site personnel during removal. The situation is also exacerbated by the size of the EADA, the length of time required for excavation, and changing conditions as the work progresses across the main pond area.

By using the performance-based approach outlined above, TVA will successfully remove the source of CCR constituents in Alluvial aquifer groundwater. In addition, RBSLs were developed for the ALF using a risk-based analysis, as described below. These RBSLs can be used to set target cleanup goals; to compare with data generated in the future; and to guide future site remediation and redevelopment activities.

5.2 PROPOSED TARGET CLEANUP GOALS

Appendix D presents a suite of site-specific RBSLs for CCR constituents in soil and groundwater at the EADA. As stated above, RBSLs can be used to set target cleanup goals; to compare with data generated in the future; and to guide future site remediation and redevelopment activities. Target cleanup goals (i.e., the medium-specific constituent concentrations that will be used to evaluate whether remediation is complete) will be established formally in a ROD issued by TDEC Division of Remediation, which follows the Feasibility Study.

5.2.1 Proposed Soils Target Cleanup Levels

For soils, RBSLs were developed for the following exposure scenarios:

- Industrial site workers who may contact <u>surface or near surface</u> soils
- Construction workers who may contact <u>subsurface</u> soils
- Protection of groundwater used for drinking water (i.e., constituents in <u>subsurface</u> soil that leach to groundwater)
- Protection of surface water used for recreational purposes (i.e., constituents in <u>subsurface</u> soil that leach to groundwater that migrates into surface water)

These RBSLs were then evaluated in conjunction with the closure approach presented in Section 5 to develop proposed target cleanup levels for surface and subsurface soils.

5.2.1.1 Surface Soils

For surface soils, proposed target cleanup goals for industrial site workers will be either EPA RSLs or BTVs, which are applicable to surface or near surface soils (**Table 5-1**). If surface soils exceed the target cleanup goals, action may be required. To date, no data indicates that surface soils in the area of ALF require removal.

5.2.1.2 Subsurface Soils

For subsurface soils, target cleanup goals will not be defined because the CCR removal will take place using the performance-based approach. Instead, actions required after closure-by-removal will be identified using data from post-excavation soil samples and site-specific RBSLs. Activities to address residual concentrations of CCR constituents in subsurface soils above site-specific RBSLs will be managed by other means, such as groundwater monitoring, groundwater remediation, land-use restriction, subsurface soil management plans, etc.

5.2.2 Proposed Groundwater Target Cleanup Levels

Screening levels for groundwater were developed as follows:

- Groundwater used as drinking water
- Groundwater protective of surface water used for recreational purposes

Because the screening levels for drinking water are lower than those protective of surface water, the proposed target cleanup goals for groundwater will be Groundwater Protection Standards

(GWPS). This is consistent with the current Federal CCR Rule and TDEC solid waste regulations. GWPS include TDEC General Water Quality Criteria for Human Health Domestic Water Supply, MCLs, EPA RSLs for Tap Water, and background groundwater concentrations, as appropriate. **Table 5-2** presents the proposed target cleanup goals for groundwater.

TVA's goal is to eventually meet the proposed target cleanup goals for groundwater by continuing or taking the following actions:

- Dewatering and removing CCR from the EADA
- Operating two Alluvial aquifer groundwater extraction and treatment systems in the areas north and south of the EADA
- Monitoring groundwater throughout the Alluvial aquifer every three months
- Evaluating groundwater quality beneath the EADA when it is safe to do so and without interrupting dewatering or removal operations
- Taking further action to address groundwater beneath the EADA as necessary

In the future, it is possible that environmental regulations change such that meeting drinking water standards in the Alluvial aquifer is not required (because the Alluvial aquifer is not used for drinking water purposes). Instead, it may be possible to meet alternative target cleanup goals in the Alluvial aquifer that are still protective of the Memphis aquifer.

6.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES

This section presents the Remedial Action Objectives (RAOs) proposed for the EADA. RAOs are site- and media-specific remediation goals developed to address potential human health and environmental risks and form the basis for evaluating and comparing the effectiveness of the various potential remedial alternatives. Development of RAOs takes into consideration the ARARs, components of the CSM, and potential future use of the site.

Unlike most other TVA power plants, much of the land at the ALF is not owned by TVA but is leased from third parties including the City of Memphis, Shelby County, and MLGW. The leased property will be returned to the third-party owners after the post-closure care period. These parties may consider redevelopment options at that time. The ALF is located in a heavily industrialized area, which means that redevelopment is of particular interest as the land holds significant economic potential for its non-TVA owners due to its location within the Frank C. Pidgeon Industrial Park, as well as its access to the Port of Memphis via McKellar Lake.

6.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

ARARs are federal and state standards, requirements, criteria, or limitations that are either legally applicable, or relevant and appropriate for use at the site, and must be considered in the development and evaluation of the specific remedial alternatives. State ARARs take precedence if they are more stringent than the associated Federal requirements (EPA, 1988).

Chemical-specific ARARs are typically health- or risk-based numerical values that represent cleanup standards (i.e., the acceptable concentration of a chemical at the site). Examples of chemical-specific ARARs include MCLs established under the Safe Drinking Water Act, and water quality criteria established under the Clean Water Act (CWA). As a general rule, if more than one chemical specific ARAR exists for a particular contaminant, the most stringent should be applied.

Location-specific ARARs are restrictions on the concentration of hazardous substances or the conduct of activities in environmentally sensitive areas. An example of a location-specific restriction on the concentration of hazardous substances is the Resource Conservation and Recovery Act (RCRA) land disposal restrictions prohibiting hazardous waste placement into or onto the land (e.g., landfills and salt domes) until waste-specific treatment standards are met. Examples of restrictions on the conduct of activities in environmentally sensitive areas include floodplains, wetlands, and locations where endangered species or historically significant cultural resources are present.

Action-specific ARARs are usually technology- or activity-based requirements or limitations on actions or conditions taken with respect to specific hazardous substances. Examples are: (1) design standards affecting the construction of a remedy; (2) performance standards affecting operation of a remedy, specifically, treatment requirements and management of residuals; and (3) discharge standards for a particular process. On-site CERCLA actions must comply only with the substantive portions of a given ARAR. On-site activities need not comply with administrative requirements, such as obtaining a permit or recordkeeping and reporting. Monitoring requirements are considered substantive requirements. Any improvements to the system must comply with all applicable state rules and regulations.

In addition to the legally binding laws and regulations, there may be criteria, advisories, and guidance that have not been promulgated, and proposed standards that are not legally binding, that may be considered because they provide useful information. These criteria, commonly referred to as “To Be Considered” (TBC), are not potential ARARs and do not have the same status as ARARs but are evaluated for each site to set protective cleanup targets. Potential ARARs for the EADA at the ALF are provided in **Table 6-1.**

6.1.1 CCR Closure Regulations

The EPA published a rule governing the disposal of CCR on April 17, 2015 (Title 40 Code of Federal Regulations [CFR] Part 257 [40 CFR Part 257]). The rule provides that any disposal facilities that received CCRs six months following rule publication were deemed subject to the regulations, which prescribe closure standards. In addition, all applicable state regulatory requirements for management and closure apply to the EADA. In Tennessee, closure is defined as “taking the actions at the termination of a disposal operation that are necessary to finally close the disposal facility or disposal facility parcel” (Rule 0400-11-01-.01(2)). The Tennessee Water Quality Control Act prohibits the discharge of any substance into the waters of the state that could cause damages or pollution to such waters. In addition, the Tennessee Solid Waste Disposal Act further prohibits the placement or deposit of solid waste in waters of the state without TDEC approval. TDEC must be notified of intent to close. Therefore, a Closure Plan that describes the proposed closure strategy, including regulatory consideration, will be submitted by TVA to TDEC. TDEC will review and approve this FS document and the corresponding Proposed Plan (PP) before closure activities can begin.

Additionally, TVA is planning IRAs for EADA drawdown and dewatering and controlling/treating groundwater where elevated arsenic concentrations have been detected, and a NEPA EIS has been completed (see Sections 7.1 and 7.2 for additional details).

6.1.2 Summary of Anticipated Authorizations/Permits

The following list summarizes authorizations or permits that are anticipated in conjunction with EADA closure activities:

- Submittal of documents to facilitate TDEC’s review pursuant to Tennessee Code §68-211-106(j), which states: “(j) The commissioner shall not issue a permit under this section for the disposal of coal ash or for the expansion of an existing coal ash disposal facility unless the plans for the disposal facility include a liner and a final cap; however, this subsection (j) shall not apply to the use of coal ash for fill, to any agricultural use, to any engineered uses as a feedstock for the production of a product, to wastewater treatment units or to the disposal of coal ash in connection with any of these uses, as authorized by the department pursuant to this part.”
- Since more than one acre will be disturbed during the EADA closure activities, a Storm Water Notice of Intent (NOI) to discharge storm water associated with construction activities will be submitted to TDEC Division of Water Resources. A Storm Water Pollution Prevention Plan (SWPPP) will also be submitted as required by TDEC’s Construction Storm Water Individual Permit. Applicable permit fees will be submitted with the NOI. A Notice of Termination (NOT) to terminate the storm water construction permit will be submitted upon completion of the EADA closure and stabilization.

- Storm water management may also require a TDEC NPDES Storm Water Multi Sector General Permit for Industrial Activities, which is a general NPDES permit required for facilities that have significant industrial materials exposed to rainfall and resulting storm water.
- If closure activities will alter or impinge on the USACE levee on the north side of the EADA, then a permit must be obtained in advance according to United States Code Title 33 Section 408, which states: "USACE may grant permission for another party to alter a Civil Works project upon a determination that the alteration proposed will not be injurious to the public interest and will not impair the usefulness of the Civil Works project."
- Section 404 of the CWA requires a permit before dredged or fill material may be discharged into waters of the United States, including wetlands.
- Discharge of treated water to the T.E. Maxson Wastewater Treatment Plant will require a WWTP Permit as per Memphis Code Chapter 33 Sewer User Ordinance.
- If closure activities will result in physical alteration to a stream, river, lake, or wetland, then TDEC requires an Aquatic Resource Alteration Permit (ARAP) be obtained in advance. This approval serves as a CWA §401 Water Quality Certification.

6.2 REMEDIAL ACTION OBJECTIVES

The following performance-based and risk-based RAOs were identified for the EADA.

6.2.1 Performance-Based Remedial Action Objectives

The selected remedial approach for OU 1 should meet the following objective:

- RAO 1 - Soil: During EADA closure, safely remove CCR followed by an additional 1-foot of underlying soil.

6.2.2 Risk-Based Remedial Action Objectives

After CCR removal (i.e., achieving RAO 1), remaining impacts will be addressed through groundwater cleanup, using target clean-up goals. The selected remedial approach for OU 2 should meet the following objective:

- RAO 2 - Alluvial Aquifer Protective of Memphis Aquifer: Use engineering actions to limit the potential migration of COCs from CCR materials into the Alluvial aquifer to concentrations that are protective of the Memphis Aquifer. Protectiveness will be achieved by meeting Remedial Action Goals for Alluvial groundwater that are based on applicable regulatory standards or risk-based concentrations (e.g., MCLs or risk-based concentrations for drinking water based on an acceptable cancer risk range of 1x10-6 to 1x10-4 or noncancer hazard threshold of 1).

- RAO 3 – Alluvial Aquifer Protective of McKellar Lake: Use engineering actions to limit the potential migration of COCs from CCR materials into McKellar Lake to concentrations that are protective of beneficial uses of McKellar Lake. Beneficial uses of McKellar Lake include human recreational uses (e.g., fishing) and aquatic habitat. Protectiveness will be achieved by meeting Remedial Action Goals for Alluvial groundwater that are based on applicable regulatory standards (e.g., surface water quality criteria) or risk-based concentrations for these beneficial uses after dilution and attenuation between Alluvial groundwater and surface water within McKellar Lake are considered (based on an acceptable cancer risk range of 1x10-6 to 1x10-4 or noncancer hazard threshold of 1).

7.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES

The development of potential remedial alternatives must include an evaluation of the following: ARARs, TBCs, site-specific conditions in OU 1 and OU 2, short- and long-term risk reduction for human health and the environment, and potential future industrial land use. The EPA considers the following expectations in developing appropriate remedial alternatives:

- Use treatment to address principal threats wherever practicable;
- Use engineering controls for waste that poses a relatively low long-term threat or when treatment is impracticable;
- Use a combination of methods as appropriate to achieve protection of human health and the environment;
- Use institutional controls to supplement engineering controls as appropriate;
- Consider using innovative technologies; and
- Return usable groundwater to beneficial uses when practicable; when restoration of groundwater is not practicable, prevent further migration, prevent exposure, and evaluate further risk reduction.

7.1 INTERIM RESPONSE ACTION

A groundwater IRA was evaluated in July 2018 (Stantec, 2018) to focus on OU 2, the areas north and south of the EADA where elevated concentrations of arsenic (and to a lesser extent fluoride and lead) are present in groundwater. Groundwater quality in these areas was delineated during the RI, and arsenic was identified as the primarily COC. The objectives of the IRA are to hydraulically control groundwater migration and to reduce the amount of arsenic in groundwater.

The IRA is in the design phase as of the time of this writing. The proposed IRA includes the following elements:

- Installation of a groundwater extraction system and conveyance piping in optimal locations as determined by groundwater modeling simulations;
- Groundwater extraction, aquifer testing, and parameter monitoring to verify the groundwater modeling simulations and identify potential system design enhancements;
- Above-ground (i.e., ex situ) groundwater treatment; and
- Discharge of treated water to the T.E. Maxson Wastewater Treatment Plant.

Discharge of treated water to surface water was considered but eliminated because of the time required to obtain a permit.

Prior to design of the IRA, groundwater extraction tests were performed to verify groundwater extraction rates, and treatability tests were conducted to evaluate groundwater treatment requirements. These activities were completed by late 2018 and the results have been used to inform the IRA design.

The IRA treatment system is to be implemented in both the north and south areas of OU 2 where elevated concentrations of arsenic, fluoride, and lead were detected in shallow Alluvial aquifer groundwater. The target areas were delineated using MCLs as the goal.

The selected IRA includes groundwater removal, ex situ treatment of the groundwater, and discharge of the treated water. Because arsenic has been identified as an indicator of the maximum extent of groundwater impacts, the groundwater extraction system is being designed to hydraulically contain and remove groundwater in areas with elevated arsenic concentrations, which will also encompass locations where fluoride and lead are present at elevated concentrations.

It is anticipated that groundwater treatment will be accomplished using a coagulation/coprecipitation reagent (ferric chloride) and filtration to reduce arsenic concentrations to below limits that allow the treated water to be discharged. The ferric chloride treatment system precipitates arsenic out of groundwater by mixing the water with a ferric chloride reagent to create an insoluble, non-hazardous, precipitate-solid, which can be separated in gravity vessels and finally by a mechanical filter press. After arsenic precipitate removal, treated water will be decanted from the solids and sent through additional filtering prior to discharge. Fluoride and lead are not anticipated to exceed permit limits in extracted groundwater because of their low concentrations and limited extent; however, the arsenic removal treatment will also remove lead from groundwater.

The IRA is designed to be an initial response that will operate during and after dewatering of the EADA (OU 1). Upon completion of actions taken to address OU 1, the groundwater remedy for OU 2 will be evaluated and modified as necessary to adequately address groundwater impacts that may be identified after removal of the CCR materials. At this time, the resulting groundwater remedy is expected to be groundwater extraction and treatment and would be the final remedy for OU 2. For long-term operation, a new NPDES permit for discharge of treated groundwater to surface water may be considered, as an alternative to discharge to the T.E. Maxson Wastewater Treatment Plant.

7.2 ENVIRONMENTAL IMPACT STATEMENTS

In 2016, TVA prepared a programmatic environmental impact statement (PEIS) titled *Final Ash Impoundment Closure Environmental Impact Statement* to address the closure of CCR impoundments at all of TVA's coal-fired power plants. The report consists of two parts: Part I – Programmatic NEPA Review, and Part II – Site-Specific NEPA Review. In Part I, TVA programmatically considered environmental effects of closure of CCR impoundments at all of its coal-fired plants. Part II included a site-specific NEPA Review of closure of the West Ash Pond at the ALF.

On November 30, 2018, TVA published a NOI in the Federal Register to prepare an EIS to specifically address the potential environmental effects associated with long-term management of CCR stored at the ALF. TVA released the Final EIS to the public on March 6, 2020 (TVA, 2020a), and a notice of availability was published in the Federal Register on March 13, 2020. Specifically, the EIS evaluated closure of the surface impoundments at the ALF including the EADA. As a result of internal review and scoping comments, TVA proposed and selected similar alternatives that were evaluated in this FS, which are described in the following sections of this report. Following the completion of the EIS, TVA issued a ROD documenting its decision to remove CCR from the ALF (TVA 2020b).

7.3 ALTERNATIVES FOR OU 1

7.3.1 Alternative 1 – No Action

Under the no action alternative, TVA would not close the EADA. No closure activities (i.e., no excavation) would occur. The no action alternative is inconsistent with TVA's plans to convert all its wet CCR systems to dry systems and is inconsistent with the general direction of the EPA's CCR Rule. In addition, under the no action alternative, the EADA land would not be made available to its owners for future economic development projects in the greater Memphis area. Consequently, this alternative would not satisfy the project purpose and need and is not considered viable or reasonable. It does, however, provide a benchmark for comparing the environmental impacts of implementation of Alternatives 2 and 3.

7.3.2 Alternative 2 – Closure-by-Removal; Disposal of CCR in an Off-site Landfill

Under Alternative 2, TVA would close the EADA via closure-by-removal. Closure-by-removal involves excavating and relocating CCR from the surface impoundments in accordance with federal and state requirements. The final extent of CCR removal will be determined in accordance with a CCR Removal Verification plan prepared by TVA and approved by TDEC.

The EADA contains approximately 2,300,000 cubic yards of CCR. CCR materials would be removed by excavation and transported to an off-site landfill for disposal. The location of the off-site landfill has not been determined at this time. Potential locations of the off-site landfill and potential methods of transport were studied and evaluated in the EIS.

The remaining soil within the EADA would be graded to drain (with borrow fill as needed) and the disturbed areas would be vegetated with native plant species or otherwise stabilized. Alternative 2 would include relocating the 30-inch and 42-inch sanitary sewer force mains and proper abandonment of inactive sewer pipes within the OU 1 footprint.

Removal of the CCR material at OU 1 would precede and support the ongoing IRA remediation of related impacted groundwater at OU 2.

7.3.3 Alternative 3 – Closure-by-Removal; Disposal of CCR Materials in a Beneficial Re-use Process & Off-site Landfill

Under Alternative 3, TVA would close the EADA via closure-by-removal in the same manner as Alternative 2. However, instead of transporting all excavated CCR material to an off-site landfill, most CCR material (ranging from approximately 75 to 95 percent) would be transported to a beneficial re-use facility to be processed for use in concrete and other building materials. Only the remaining percentage of CCR material not suitable for beneficial re-use would be transported to the off-site landfill.

A potential beneficial re-use processing facility and off-site landfill has not been identified. The closest currently identified beneficial re-use processing facility is located approximately 600 miles from the ALF. The anticipated processing capacity of this facility is approximately 200,000 cubic yards or 240,000 tons per year.

The remaining soil within the EADA would be graded to drain (with borrow fill as needed) and the disturbed areas would be vegetated with native plant species or otherwise stabilized. Alternative

3 would include relocating the 30-inch and 42-inch sanitary sewer force mains and proper abandonment of all sewer pipes within the OU 1 footprint.

Removal of the CCR material at OU 1 would precede and support the ongoing IRA remediation of related impacted groundwater at OU 2.

7.4 ALTERNATIVE CONSIDERED BUT ELIMINATED FROM FURTHER DISCUSSION FOR OU 1

TVA considered multiple options for ash impoundment closure at the ALF. This section identifies the alternative that TVA considered but rejected from detailed analysis because it did not meet the purpose and need of the project or was otherwise unreasonable.

7.4.1 Alternative 4 – Closure-in-Place

Under Alternative 4, the CCR material within the EADA would be closed-in-place. Closure-in-place would require waste stabilization followed by filling and grading, and then installation of a low-permeability cap. The top surfaces of the area would be graded to promote positive drainage, and a permanent vegetative cover would be established to reduce erosion. Diversions and/or treatments would be designed for any inflows to the EADA that would continue after closure, including drainage from adjacent yards and sump discharges. TVA would abide by state and federal post-closure monitoring and corrective action requirements.

It is anticipated that stabilizing and capping the CCR material would significantly reduce the leachability of COCs into groundwater. In areas where the concentrations of CCR constituents in groundwater are above MCLs (i.e., OU 2), the groundwater would be extracted, treated, tested, and discharged to surface water in accordance with a NPDES permit. Groundwater extraction near the EADA would control the movement of groundwater, keeping it within the TVA property. The groundwater extraction would continue until test results indicate that groundwater protection standards have been achieved.

TVA carefully considered this alternative and determined that closure-in-place should be eliminated from further consideration due to future land use limitations. Land use limitations associated with closed facilities under Alternative 4 would reduce the type and nature of projects that may be considered in conjunction with re-use of the site. Importantly, unlike other coal facilities, TVA does not own all the property where the EADA is located. TVA intends to leave the property in a re-usable state for the property owners; therefore, Alternative 4 does not meet the purpose and need of making the land available for future economic development projects by the property owners.

7.5 ALTERNATIVES FOR OU 2

Removal of the CCR source material in OU 1 would precede and support the ongoing IRA any of the remedial alternatives for related impacted groundwater in OU 2. Upon completion of actions taken to address OU 1, the groundwater remedy for OU 2 would be evaluated and modified as necessary to adequately address groundwater impacts that may be identified after removal of the CCR materials.

7.5.1 Alternative 1 – No Action

This alternative assumes that no action is taken to remediate the areas of groundwater impact. The no action alternative is inconsistent with the general direction of the EPA’s CCR Rule. Another disadvantage of no action is the potential migration of groundwater COCs to sensitive receptors, such as McKellar Lake and the Memphis aquifer. The no action alternative is not considered viable or reasonable, but it does provide a benchmark for comparing the environmental impacts of implementation of other alternatives.

7.5.2 Alternative 2 – Extraction, Treatment, and Discharge

Under Alternative 2, groundwater would be collected using extraction wells and submersible pumps that would capture groundwater and convey the water through a pipe network connected to an above-grade treatment system. The treatment system, if treatment is required prior to discharge, would likely consist of stage tanks, process pumps, sediment filtration, the addition of ferric chloride and potential acid (using HCl) for arsenic treatment and pH adjustment, controlled with feedback from flow and pH monitoring. The treated groundwater would then be discharged to the T.E. Maxson Wastewater Treatment Plant or to surface water under an NPDES permit. Alternative 2 is effectively a continuation of the proposed IRA for groundwater described in Section 5.1 of this report.

7.6 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM FURTHER DISCUSSION FOR OU 2

TVA considered multiple options for groundwater remediation at the ALF. This section identifies the alternatives that TVA considered but discontinued from detailed analysis for the reasons outlined below. Based on information currently available on groundwater quality, TVA anticipates that the proposed remedy for OU 2 will be suitable for long-term groundwater remediation. In the future, as CCR concentrations decreased and groundwater quality improves, some of the technologies outlined below may accelerate the cleanup process (e.g., chemical oxidation or CO2 sparging) and could be incorporated into the remedial approach. The addition of other treatment would be completed in coordination with TDEC and under applicable regulations.

7.6.1 Alternative 3 – Extraction, Treatment, and Discharge; with Engineered Barrier Wall

Groundwater would be collected using extraction wells complete with submersible pumps, which would pump the captured groundwater through a pipe network connected to an above-grade treatment system. This approach is the same as Alternative 2, except that an engineered barrier wall (e.g., sheet pile wall or slurry wall) would be designed and constructed to reduce the volume of collected groundwater requiring treatment by isolating the targeted treatment areas from non-impacted groundwater. The treatment system consists of staging tanks, process pumps, sediment filtration, addition of ferric chloride and potentially acid (using HCl) for arsenic treatment and pH adjustment, controlled with feedback from flow and pH monitoring. The treated groundwater would then be discharged to the T.E. Maxson Wastewater Treatment Plant or to surface water under a new NPDES permit.

Alternative 3 was eliminated from further consideration because it is substantially similar to Alternative 2 but with several disadvantages. Impacted groundwater extends to 50-90 ft bgs. Installing an engineered barrier wall to that depth increases the design complexity, incurs additional cost, would be more difficult to implement, and creates additional construction-related safety hazards for personnel.

7.6.2 Alternative 4 – Permeable Reactive Barrier Wall

This alternative assumes that a permeable reactive barrier wall (PRB) would be engineered and installed down gradient of the impacted groundwater utilizing deep trenching techniques. A "hanging wall" design would be installed to a depth greater than the depth of impacted groundwater (approximately 50-90 ft bgs). Groundwater remediation occurs as groundwater passively flows through the PRB and is exposed to zero-valent iron.

A PRB wall was eliminated from further consideration as a remedy because of several disadvantages. Installing a PRB wall to the required depth (50-90 ft bgs) requires a high degree of design complexity, has a low degree of implementability, and creates additional construction-related safety hazards for personnel.

7.6.3 Alternative 5 – In Situ Treatment: Chemical Oxidation

This alternative assumes that chemical oxidation can be achieved using potassium permanganate (KMnO4), sodium hypochlorite (NaOCl), or any other suitable oxidant. The oxidant would be introduced to the targeted groundwater area through a series of temporary injection points. Groundwater remediation would occur as a result of oxidation and adsorption of arsenic within the treatment area. Effectiveness would be monitored on a quarterly basis and retreatment with the oxidant would be performed where incomplete treatment is observed.

Alternative 5 was eliminated from further consideration as a remedy because of several disadvantages. In situ treatment, by itself, lacks any means of hydraulic control to limit potential groundwater migration toward sensitive receptors, such as McKellar Lake and the Memphis aquifer. Also, in situ treatment by chemical oxidation may not provide permanent regulatory compliance because it depends upon favorable site-specific groundwater chemistry to immobilize arsenic in aquifer sediments; if groundwater chemistry returns to pre-oxidation conditions or conditions change in the future, arsenic could re-mobilize.

7.6.4 Alternative 6 – In Situ Treatment: CO2 Sparge

This alternative assumes that carbon dioxide (CO_2) would be introduced into the targeted groundwater areas through a series of installed, small diameter injection points. System design includes site-specific calculations regarding the radius of influence of each injection well, CO_2 dosage rate, and pH of the treatment area. Groundwater remediation occurs as a result of acidification by CO_2 within the targeted treatment area, forming precipitates that adsorb or coprecipitate arsenic. System effectiveness would be monitored through a series of installed monitoring points.

Alternative 6 was eliminated from further consideration as a remedy because it has the same disadvantages as Alternative 5. In situ treatment, by itself, lacks any means of hydraulic control to limit potential groundwater migration toward sensitive receptors, such as McKellar Lake and the Memphis aquifer. Also, in situ treatment by CO_2 sparging may not provide permanent regulatory compliance because it depends upon favorable site-specific groundwater chemistry to immobilize arsenic in aquifer sediments; if groundwater chemistry conditions change in the future, arsenic could re-mobilize.

7.6.5 Alternative 7 – Monitored Natural Attenuation (MNA)

MNA is a remedial strategy that involves natural, in situ attenuation/stabilization of COCs. MNA requires the establishment of an assessment program to monitor the physical, chemical, and/or biological processes that exist at a site. These processes can often work to reduce the toxicity, concentration, or mobility of site COCs in a timeframe that may be comparable to other remedial technologies. MNA is a passive remedy that relies upon naturally occurring processes to reduce impact levels and, by itself, does not provide a means to affect change in the subsurface environment. MNA is increasingly used at sites where the source has been controlled, the constituent concentrations are near target levels, and immediate pathways to sensitive receptors do not exist or can be controlled through interim response actions.

MNA was eliminated from further consideration as a stand-alone remedy because it is substantially similar to Alternative 1 – No Action and has many of the same disadvantages. MNA does not actively address the source of COCs, and it does not include measures to control potential migration of impacted groundwater toward sensitive receptors, such as McKellar Lake and the Memphis aquifer. Considering the concentrations of COCs in groundwater, MNA may take decades to reduce elevated arsenic concentrations to levels below the MCL. In the future, MNA may be viable for groundwater after the EADA has been remediated and the source mitigated.

8.0 ANALYSIS OF REMEDIAL ALTERNATIVES

In accordance with CERCLA guidance as well as TDEC Division of Remediation regulations set forth in Rule 0400-15-01-.09(3), the final evaluation of cleanup action alternatives that pass the initial screening shall consider the following factors:

a) Overall protection of human health and the environment, including the degree to which existing risks are reduced, time required to reduce risks, and on-site and off-site risks resulting from implementing the alternative.

(b) Attainment of the remediation goals and compliance with applicable state and federal laws.

(c) Short-term effectiveness, including protection of human health and the environment during construction and implementation of the alternative prior to attainment of the remediation goals.

(d) Long-term effectiveness, including degree of certainty that the alternative will be successful, long-term reliability, magnitude of residual risks, and effectiveness of controls required to manage treatment residues of remaining waste.

(e) Permanent reduction of toxicity, mobility, and volume through treatment, including adequacy of the alternative in treating and managing the hazardous materials, reduction and elimination of hazardous material releases, sources of releases, degree of irreversibility of waste treatment process, and the characteristics and quantity of treatment residuals generated.

(f) The ability to be implemented, including consideration of whether the alternative is technically feasible; availability of needed off-site facilities, services, and materials; administrative and regulatory requirements; scheduling; size; complexity; monitoring requirements; access for construction, operations, and monitoring; and integration with existing facility operations and other current or potential remedial actions.

(g) Cost, including consideration of present and future direct and indirect capital, operation, maintenance and other foreseeable costs.

(h) The degree to which community concerns are addressed.

(i) The degree to which recycling, residue, and waste minimization are employed.

8.1 INDIVIDUAL ANALYSIS OF REMEDIAL ALTERNATIVES

This section provides a detailed analysis of each alternative that was carried through for OU 1 and OU 2 after the screening of alternatives described in Section 5. An evaluation matrix was developed to assess each remedial alternative with respect to the nine TDEC criteria outlined in Section 6.0. After reviewing the conceptual approaches, cost estimates, and pros and cons of each alternative, numeric scores were assigned based on how well the alternative fulfilled each criterion. A weighting factor was then applied to each criterion. The sum of the weighted factors indicates each alternative’s overall score. The evaluation matrix is included as **Table 8-1**.

8.1.1 Individual Analysis of Remedial Alternatives: OU 1

The screening of alternatives for OU 1 in Section 5 resulted in the retention of three alternatives. The individual evaluation of alternatives is presented in **Table 8-1**. Relative cost estimates were developed for the remedial alternatives for OU1 for the purposes of this FS. **Table 8-2** presents a cost summary, and details and assumptions are presented in **Table 8-2a** (Alternative 2) and **Table 8-2b** (Alternative 3).

A summary of the analysis is presented here.

8.1.1.1 No Action

Alternative 1 is the no action alternative. OU 1 would remain “as is” without implementation of remedial action, excavation, institutional controls, monitoring, or any other mitigating actions. The no action alternative was retained throughout the FS as required per EPA CERCLA guidance to provide a comparative baseline against which other alternatives could be evaluated.

(a) Overall protection of human health and the environment

No action would result in no changes to potential risks that OU 1 poses to receptors for both human health and the environment.

(b) Attainment of the remediation goals and compliance with ARARs

A no action alternative would not meet the purpose and need of the remedial action, nor would it comply with ARARs.

(c) Short-term effectiveness

The short-term effectiveness of the no action alternative is essentially zero. No action would be implemented; therefore, no direct change in conditions would occur except for the effect of naturally occurring attenuation processes.

(d) Long-term effectiveness

The long-term effectiveness of the no action alternative is minimal. No action would be implemented; therefore, no direct change in conditions would occur except for the effect of naturally occurring processes. Because control measures and monitoring would not be used, the adequacy and rate of natural attenuation would not be assessed.

(e) Permanent reduction of toxicity, mobility, and volume through treatment

The no action alternative would not implement any form of treatment. Therefore, direct reduction in toxicity, mobility, or volume of CCR material would not occur. It is likely that over time naturally occurring attenuation processes would reduce COCs at OU 1, but the degree to which this may occur would not be monitored.

(f) The ability to be implemented

The no action alternative would leave site conditions unchanged and does not require specific implementation. No construction, operation, maintenance, monitoring, coordination, service, equipment, materials, or technology are required.

(g) Cost

There are no capital, operation, or maintenance costs associated with no action.

(h) The degree to which community concerns are addressed

The no action alternative is likely to be poorly received by the public and the landowners because it does not include any active remediation or mitigation at OU 1. Site conditions, CCR material, and COC impacts would not change. All current, short-term, and long-term concerns would remain. No action does not enable future economic redevelopment of the land.

(i) The degree to which recycling, residue, and waste minimization are employed

The no action alternative does not involve recycling or residue. Waste would be minimized in the sense that no resources would be expended nor would any new waste be generated.

8.1.1.2 Closure-by-Removal: Disposal of CCR Materials in an Off-Site Landfill

Alternative 2 at OU 1 is closure-by-removal and the excavated CCR material would be transported to an appropriate off-site landfill. After excavation and verification sampling, the remaining soil within the EADA would be graded to drain (with borrow fill as needed) and the disturbed areas would be vegetated with native plant species or otherwise stabilized.

(a) Overall protection of human health and the environment

This remedy would eliminate ash in OU 1 in accordance with a CCR Removal Verification plan. Removing the ash would eliminate the source material for COCs affecting groundwater in OU 2. Excavating the ash involves known safety hazards related to operation of heavy equipment, slope stability, and potential worker exposure to ash. Transportation of ash involves hazards related to traffic safety and the possibility of spills or leaks. Ash would be placed into a permitted, engineered landfill approved to manage CCR.

(b) Attainment of the remediation goals and compliance with ARARs

The closure-by-removal action would be designed and conducted to comply with ARARs. Successful completion of this remedy, in conjunction with the remedial action for OU 2, is anticipated to achieve RAO 1.

(c) Short-term effectiveness

The timeframe required to complete this remedial action is estimated at five to seven years and was evaluated in the EIS. The volume of CCR material in OU 1 would decrease throughout the course of the remedy. There would be on-going hazards while operations are in progress. Due to the relatively long estimated time frame for completion of this alternative, short-term effectiveness is low. To address environmental concerns in the short term, TVA has implemented IRAs, namely dewatering and the groundwater IRA.

(d) Long-term effectiveness

Successful completion of this alternative would remove ash from OU 1 in accordance with a CCR Removal Verification plan. Removal of the ash would eliminate the source material for COCs affecting groundwater in OU 2. This remedy action, in conjunction with the remedial action for OU 2, is anticipated to achieve RAO 1, including enabling future economic redevelopment of the land.

(e) Permanent reduction of toxicity, mobility, and volume through treatment

Closure-by-removal would eliminate CCR material at OU 1. The excavated CCR material would be placed into a permitted landfill approved to manage CCR, but toxicity, mobility, and volume of the material would not change.

(f) The ability to be implemented

Closure-by-removal is a proven remedial technique. A preliminary evaluation of site-specific conditions at the ALF did not reveal major obstacles to implementation. The size, shape, depth, and location of OU 1 are amenable to an excavation and offsite disposal operation. Sewer lines within the footprint of OU 1 would need to be rerouted or abandoned. Challenges include ensuring the integrity of adjacent rail lines and the USACE levee are not compromised. Additional details, including a transportation method for the excavated CCR and a specific landfill designated to receive it, were evaluated in the EIS.

(g) Cost

The estimated cost to complete this remedial action $297,709,452.

(h) The degree to which community concerns are addressed

The end result of closure-by-removal is anticipated to be well received by the community. This remedy would eliminate CCR material at OU 1 and enable future economic redevelopment of the land. Potential community concerns may arise regarding the transportation of CCR including noise, dust, traffic volume, specific transportation routes, and the potential for spills or leaks. These and other concerns were addressed in the EIS.

(i) The degree to which recycling, residue, and waste minimization are employed

Closure-by-removal with transportation to an off-site landfill does not include recycling or waste minimization. Excavating and transporting the estimated 2,300,000 cubic yards of CCR material would be labor and resource intensive. Depositing a large volume of CCR at an off-site landfill would hasten the endpoint of the landfill’s operational lifespan.

8.1.1.3 Closure-by-Removal: Disposal of CCR Materials in a Beneficial Re-use Process & Off-site Landfill

Alternative 3 at OU 1 is closure-by-removal with beneficial re-use of the majority of excavated CCR material. CCR unsuitable for beneficial re-use would be transported to an appropriate off-site landfill. After excavation and verification sampling, the remaining soil within the EADA would be graded to drain (with borrow fill as needed) and the disturbed areas would be vegetated with native plant species or otherwise stabilized.

Alternative 3 for OU 1 is similar to Alternative 2 and was scored similarly for many of the TDEC criteria. The main differences are that Alternative 3 employs beneficial re-use of excavated CCR material to the extent practical (estimated at 75-95%) and, therefore, scores higher than Alternative 2 for criterion (e) permanent reduction of mobility, toxicity and volume through treatment and (i) degree to which recycling, residue and waste minimization are employed. Alternative 3 scores lower for criterion (f) ability to be implemented, (g) cost, and (h) degree to which community concerns are addressed, as discussed below.

(a) Overall protection of human health and the environment

This remedy would eliminate ash material in OU 1 in accordance with a CCR Removal Verification plan. Removing the ash would eliminate the source material for COCs affecting groundwater in OU 2. Excavating the ash material involves known safety hazards related to operation of heavy equipment, slope stability, and potential worker exposure to ash material. Transportation of ash material involves hazards related to traffic safety and the possibility of spills or leaks. Ash material would be transported to a beneficial re-use facility to be processed for use in concrete and other building materials. Only the remaining CCR not suitable for beneficial re-use would be transported to an off-site permitted, engineered landfill approved to manage CCR.

(b) Attainment of the remediation goals and compliance with ARARs

The closure-by-removal action would be designed and conducted to comply with ARARs. Successful completion of this remedy, in conjunction with the remedial action for OU 2, is anticipated to achieve RAO 1.

(c) Short-term effectiveness

The timeframe required to complete this remedial action is estimated at 8 to 12 years and was evaluated in the EIS. The volume of CCR material in OU 1 would decrease throughout the course of the remedy. There would be on-going hazards while operations are in progress. The relatively long estimated time frame for completion of this alternative is due to the distance from the ALF to the anticipated processing facility and processing capacity. Therefore, short-term effectiveness is low. To address environmental concerns in the short term, TVA has implemented IRAs, namely dewatering and the groundwater IRA.

(d) Long-term effectiveness

Successful completion of closure-by-removal would eliminate ash material in OU 1 in accordance with a CCR Removal Verification plan. Removal of the ash would eliminate the source material for COCs affecting groundwater in OU 2. This remedy action, in conjunction with the remedial action for OU 2, is anticipated to achieve RAO 1, including enabling future economic redevelopment of the land.

(e) Permanent reduction of toxicity, mobility, and volume through treatment

Closure-by-removal would eliminate CCR material at OU 1. The excavated CCR material would be processed for beneficial re-use to the extent practical with the remainder placed into a permitted landfill approved to manage CCR. Processing would reduce the toxicity, mobility, and volume of the material.

(f) The ability to be implemented

Closure-by-removal operations are a proven remedial technique. A preliminary evaluation of site-specific conditions at the ALF did not reveal any major obstacles to implementation. The size, shape, depth, and location of OU 1 are amenable to a dig and haul operation. Sewer lines within the footprint of OU 1 would need to be rerouted or abandoned. The integrity of adjacent rail lines and the USACE levee must not be compromised. Additional details, including a transportation method for the excavated CCR and a specific beneficial re-use facility designated to receive it, were evaluated in the EIS. The closest currently identified beneficial re-use processing facility is located approximately 600 miles from the ALF. The anticipated processing capacity of this facility is approximately 200,000 cubic yards or 240,000 tons per year. This processing rate and distance from the ALF would significantly increase the estimated time frame as compared to Alternative 2.

(g) Cost

The estimated cost to complete this remedial action is $571,874,222.

(h) The degree to which community concerns are addressed

The end result of closure-by-removal is anticipated to be well received by the community. This remedy would eliminate CCR material at OU 1 and enable future economic redevelopment of the land. Beneficial reuse may be viewed favorably by the public. Potential community concerns may arise regarding the transportation of CCR, including noise, dust, traffic volume, specific transportation routes, and the potential for spills or leaks, and the time frame for Alternative 3 is longer than Alternative 2. These and other concerns were addressed in the EIS.

(i) The degree to which recycling, residue, and waste minimization are employed

Most CCR material would be recycled with Alternative 3. Excavating and transporting the estimated 2,300,000 cubic yards of CCR material would be labor and resource intensive. Beneficial re-use of CCR to the extent practical provides a significant reduction (estimated at 75-95%) in the volume of material deposited into a landfill relative to Alternative 2. Reducing the volume of CCR deposited in a landfill would lengthen the endpoint of the landfill's operational lifespan.

8.1.2 Individual Analysis of Remedial Alternatives: OU 2

The screening of alternatives for OU 2 in Section 5 resulted in the retention of two alternatives. The individual evaluation of alternatives is presented in **Table 8-1**. **Table 8-3** presents a cost summary, and details and assumptions are presented in **Table 8-3a** (Alternative 2).

A summary of the analysis is presented here.

8.1.2.1 No Action

Alternative 1 at OU 2 is a no action alternative. Groundwater in OU 2 would remain "as is" without implementation of remedial action, treatment, hydraulic control, institutional controls, monitoring, or any other mitigating actions. The no action alternative was retained throughout the FS as required per EPA CERCLA guidance to provide a comparative baseline against which other alternatives could be evaluated.

(a) Overall protection of human health and the environment

There are currently no identified unacceptable risks to human health or the environment in OU 2. Groundwater from the Alluvial aquifer is not used for drinking water. The known extent of COC impact does not extend to the Memphis aquifer.

(b) Attainment of the remediation goals and compliance with ARARs

A no action alternative would not meet the purpose and need of the remedial action, nor would it comply with ARARs.

(c) Short-term effectiveness

The short-term effectiveness of the no action alternative is essentially zero. No action would be implemented; therefore, no direct change in conditions would occur except for the effect of naturally occurring processes.

(d) Long-term effectiveness

The long-term effectiveness of the no action alternative is minimal. No action would be implemented; therefore, no direct change in conditions would occur except for the effect of naturally occurring processes. Because control measures and monitoring would not be used, the adequacy and rate of natural attenuation would not be assessed.

(e) Permanent reduction of toxicity, mobility, and volume through treatment

The no action alternative would not implement any form of treatment. Therefore, direct reduction in toxicity, mobility, or volume of impacted groundwater would not occur. It is likely that over time naturally occurring processes would reduce COCs at OU 2, but the degree to which this may occur would not be monitored.

(f) The ability to be implemented

The no action alternative would leave site conditions unchanged and does not require specific implementation. No construction, operation, maintenance, monitoring, coordination, service, equipment, materials, or technology are required.

(g) Cost

There are no capital, operation, or maintenance costs associated with no action.

(h) The degree to which community concerns are addressed

The no action alternative is likely to be poorly received by the community and the landowners because it does not include any active remediation or mitigation at OU 2. Site conditions, COC impacts, and the potential for COC migration would not change. All current, short-term, and long-term concerns would remain. No action would not facilitate future economic redevelopment of the land.

(i) The degree to which recycling, residue, and waste minimization are employed

The no action alternative does not involve recycling or residue. Waste would be minimized in the sense that no resources would be expended, nor would any new waste be generated.

8.1.2.2 Extraction, Treatment, & Discharge

Alternative 2 at OU 2 involves installing a groundwater extraction and treatment system that would discharge treated water to the T.E. Maxson Wastewater Treatment Plant. Groundwater would be pumped from the ground using extraction wells and submersible pumps to capture groundwater and convey the water through a pipe network connected to an above-grade treatment system. The treatment system would likely consist of stage tanks, process pumps, sediment filtration, the addition of ferric chloride and potential addition of HCl for arsenic treatment and pH adjustment, flow meters and pH meters. This alternative may be a continuation of the IRA discussed in Section 5.1, including potential modifications based on the results of remedial work at OU 1.

(a) Overall protection of human health and the environment

Groundwater extraction and treatment systems are a proven technology that have been used successfully at many sites. Such systems are generally protective of human health and the environment and have little off-site risk resulting from implementation. The extraction of groundwater would provide hydraulic control to help minimize the potential for impacted groundwater to migrate toward sensitive receptors, such as McKellar Lake and the Memphis aquifer.

(b) Attainment of the remediation goals and compliance with ARARs

Successful completion of remedial action at OU 1 would eliminate the CCR material that is the source of COCs in groundwater at OU 2. Completion of the OU 1 remedy combined with implementation of an extraction and treatment system at OU 2 is anticipated to comply with ARARs and eventually achieve RAOs. The timeframe necessary for the extraction and treatment system to reduce COC concentrations below MCLs is not known and could exceed 20 years.

(c) Short-term effectiveness

Based on results typically observed with extraction and treatment systems at other sites, short-term results tend to be favorable. The system would be routinely monitored for effectiveness and could be modified to increase its efficacy if warranted, such as by adding additional extraction wells, changing the pumping rates, or adjusting the above-grade treatment system.

(d) Long-term effectiveness

The long-term effectiveness of extraction and treatment systems tends to be favorable, although effectiveness often tapers off as COC concentrations in groundwater decrease over time. The system would be routinely monitored throughout its operational span and could be modified to increase its efficacy if warranted. Alternative 2 is anticipated to eventually reduce COC concentrations below MCLs, although the required timeframe is not known and could exceed 20 years.

(e) Permanent reduction of toxicity, mobility, and volume through treatment

The ex situ treatment system would effectively remove arsenic from groundwater. System performance would be routinely monitored.

(f) The ability to be implemented

Extraction and treatment systems are a proven technology that have been successfully implemented at many environmental sites. The system design and performance could be modified to account for site-specific conditions. A preliminary evaluation of site-specific conditions at the ALF did not reveal any major obstacles to implementation. The size, shape, and depth of the two groundwater plume areas at OU 2 are amenable to an extraction and treatment system. Design plans are currently in progress in the IRA.

(g) Cost

The cost of the extraction and treatment system is estimated at $7,403,066 and includes design, installation, and operation and maintenance (O&M) for the first year

(h) The degree to which community concerns are addressed

Alternative 2 for OU 2 is anticipated to be well received by the community. Extraction and treatment systems are a proven technology that pose little to no off-site risk. This remedy would extract arsenic-impacted groundwater for treatment and provide hydraulic control to minimize the potential for impacted groundwater to migrate to sensitive receptors. Treated water would be discharged to the local T.E. Maxson Wastewater Treatment Plant. The result is anticipated to reduce COC concentrations below drinking water MCLs.

(i) The degree to which recycling, residue, and waste minimization are employed

The extraction and treatment system is anticipated to have an operational capacity of at least 300 to 400 gallons per minute. Treated water would be routed to the T.E. Maxson Wastewater Treatment Plant for additional processing. Insoluble, non-hazardous, precipitate-solid residues would be disposed at an approved landfill.

8.2 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

8.2.1 Comparative Analysis of Remedial Alternatives: OU 1

This section compares the remedial alternatives for OU 1 based on the criteria described in Section 6.0. The alternatives retained for comparative analysis for OU 1 are:

Alternative 1 - No Action

Alternative 2 - Closure-by-Removal: Landfill

Alternative 3 - Closure-by-Removal: Beneficial Re-use & Landfill

Alternative 2 and Alternative 3 for OU 1 are similar in many respects and are comparable to each other for many of the TDEC criteria, with the notable exceptions of: (e) reduction of toxicity, mobility, and volume, (g) cost, (h) community concerns, and (i) recycling and waste minimization.

(a) Overall protection of human health and the environment

Alternative 1 would not implement any direct remediation or mitigation; therefore, the risk levels would remain unchanged.

Alternatives 2 and 3 would eliminate ash material in OU 1 in accordance with a CCR Removal Verification plan. Removing the ash would eliminate the source material for COCs affecting groundwater in OU 2. Excavating the ash material involves known safety hazards related to operation of heavy equipment, slope stability, and potential worker exposure to ash material. Transportation of ash material involves hazards related to traffic safety and the possibility of spills or leaks. Some differentiation of transport-related hazards between Alternatives 2 and 3 were determined during the EIS depending on the specific facilities chosen to receive the ash material (i.e. beneficial re-use vs. landfill) and the resultant distances, routes, and transportation methods involved. Alternative 3 is expected to require more time than Alternative 2, causing safety hazards for several more years. At this time, in the absence of specific details regarding final destinations, Alternatives 2 and 3 are considered almost equal for this criterion.

(b) Attainment of the remediation goals and compliance with ARARs

Alternative 1 would not meet the purpose and need of the remedial action, nor would it comply with ARARs.

For both Alternative 2 and Alternative 3, the closure-by-removal action would be designed and conducted to comply with ARARs. Successful completion of the remedy action, in conjunction with the remedial action for OU 2, is anticipated to achieve RAO 1 and enable meeting RAOs 2 and 3 for OU 1.

(c) Short-term effectiveness

The short-term effectiveness of Alternative 1 is essentially zero. No direct change in conditions would occur except for the minimal effect of naturally occurring attenuation processes.

For both Alternative 2 and Alternative 3, the volume of CCR material in OU 1 would decrease throughout the course of the remedy. There would be similar on-going construction and transportation hazards with both alternatives while operations are in progress. Alternatives 2 and 3 are considered almost equal for this criterion.

(d) Long-term effectiveness

The long-term effectiveness of Alternative 1 is minimal. No direct change in conditions would occur except for the effect of naturally occurring attenuation processes.

For both Alternative 2 and Alternative 3, successful completion of closure-by-removal would eliminate ash material in OU 1 and remove the source material for COCs affecting groundwater in OU 2. Either of these two remedy actions, in conjunction with the remedial action for OU 2, is anticipated to achieve RAO 1, including enabling future economic redevelopment of the land. In addition, both alternatives would enable meeting RAOs 2 and 3 for OU 2. The timeframe required to complete a closure-by-removal remedy is estimated at 5 to 7 years for Alternative 2 and 8 to 12 years for Alternative 3. Because of the shorter timeframe, Alternative 2 is more favorable.

(e) Permanent reduction of toxicity, mobility, and volume through treatment

Alternative 1 would not implement any form of treatment; therefore, no direct reduction in toxicity, mobility, or volume of CCR material would occur. Naturally occurring attenuation might occur over time but would not be monitored.

For both Alternative 2 and Alternative 3, closure-by-removal would eliminate CCR material at OU 1. Removing the CCR would also eliminate the source material for COCs affecting groundwater in OU 2. The excavated CCR would be placed into a landfill or processed for beneficial re-use to the extent practical, under Alternatives 2 or 3, respectively. Alternative 3 is more favorable for this criterion because the toxicity, mobility, and volume of CCR will be improved by processing the material for reuse.

(f) The ability to be implemented

Alternative 1 would leave site conditions unchanged and does not require specific implementation.

For both Alternative 2 and Alternative 3, a preliminary evaluation of site-specific conditions at the ALF did not reveal any major obstacles to implementation of a closure-by-removal remedy relative to the removal process. The size, shape, depth, and location of OU 1 are amenable to an excavation operation. Sewer lines within the footprint of OU 1 would need to be rerouted or abandoned. The integrity of adjacent rail lines and the USACE levee must not be compromised. Additional details, including a transportation method for the excavated CCR and a specific facility designated to receive it, were evaluated in the EIS. The difference between Alternative 2 and Alternative 3 relative to this criterion is transportation and ultimate destination or use. The closest currently identified beneficial re-use processing facility is located approximately 600 miles from the ALF. The anticipated processing capacity of this facility is approximately 200,000 cubic yards or 240,000 tons per year. This processing rate and distance from the ALF would significantly increase the estimated time frame of Alternative 3 as compared to Alternative 2.

(g) Cost

Alternative 1 has no direct cost.

Alternative 2 is estimated to have a total cost of $297,709,452. Alternative 3 has an estimated total cost of $571,874,222 which is almost double.

(h) The degree to which community concerns are addressed

Alternative 1 is likely to be poorly received by the community and the landowners. It does not include any active remediation, mitigation, or monitoring. Site conditions, CCR material, and COC impacts would not change. All short-term and long-term concerns would remain unchanged. Alternative 1 does not enable future economic redevelopment of the land.

The end result of both Alternative 2 and Alternative 3 is anticipated to be well received by the community. Closure-by-removal would eliminate CCR material at OU 1 and enable future economic redevelopment of the land. Although beneficial reuse of the CCR may be viewed as favorable by the public, because the timeframe for Alternative 3 would be longer than Alternative 2, greater community concerns may arise regarding the transportation of CCR including noise, dust, traffic volume, specific transportation routes, and the potential for spills or leaks.

(i) The degree to which recycling, residue, and waste minimization are employed

Alternative 1 does not involve recycling or residue. Waste would be minimized in the sense that no resources would be expended nor would any new waste be generated.

For both Alternative 2 and Alternative 3, closure-by-removal involves excavating an estimated 2,300,000 cubic yards of CCR material and transporting it off-site, which would be labor and resource intensive. Alternative 2 would deposit all the CCR into a landfill with no resultant recycling or waste minimization and shortening the landfill's operational lifespan. Alternative 3 provides a significant reduction (estimated at 75-95%) in the volume of material deposited into a landfill relative to Alternative 2 by utilizing beneficial re-use of CCR to the extent practicable.

8.2.2 Comparative Analysis of Remedial Alternatives: OU 2

This section compares the remedial alternatives for OU 2 based on the criteria described in Section 6.0. The alternatives retained for comparative analysis for OU 2 are:

Alternative 1 – No Action

Alternative 2 – Extraction, Treatment, and Discharge

Alternative 2 would most likely be a continuation of the IRA discussed in Section 5.1, including potential modifications based on the results of remedial work at OU 1.

(a) Overall protection of human health and the environment

There are currently no identified unacceptable risks to human health or the environment in OU 2. Groundwater from the Alluvial aquifer is not used for drinking water, and the known extent of COC impact does not extend to the Memphis Aquifer. Alternative 1 would not implement any direct remediation or mitigation; therefore, the risk levels would remain unchanged.

Alternative 2 would implement an extraction and treatment system to remediate groundwater. Extraction and treatment systems are a proven technology that have been used effectively at many environmental sites. Systems can be designed and modified to account for site-specific conditions. They are generally protective of human health and the environment and have little off-site risk resulting from implementation. The extraction of groundwater would provide hydraulic control to help minimize the potential for impacted groundwater to migrate toward sensitive receptors such as McKellar Lake and the Memphis aquifer.

(b) Attainment of the remediation goals and compliance with ARARs

Alternative 1 would not meet the purpose and need of the remedial action nor would it comply with ARARs.

For Alternative 2, the system's extraction, treatment, and discharge would be designed and monitored to comply with ARARs. Successful completion of the remedy action, in conjunction with the remedial action for OU 1, is anticipated to achieve RAOs 2 and 3.

(c) Short-term effectiveness

The short-term effectiveness of Alternative 1 is essentially zero. No direct change in conditions would occur except for the effect of naturally occurring attenuation processes.

The short-term effectiveness of Alternative 2 is anticipated to be favorable based on results typically observed with extraction and treatment systems at other sites. The system would be routinely monitored for effectiveness and could be modified if warranted, such as by installing additional extraction wells, changing the pumping rates, or adjusting the above-grade treatment process.

(d) Long-term effectiveness

The long-term effectiveness of Alternative 1 is minimal. No direct change in conditions would occur except for the effect of naturally occurring attenuation processes. The effects of natural attenuation would not be monitored.

The long-term effectiveness of Alternative 2 is anticipated to be favorable, although the effectiveness of extraction and treatment systems often tapers off as COC concentrations diminish over time. The system would be routinely monitored throughout its operational span and could be modified to increase its efficiency if warranted. Alternative 2 is anticipated to eventually reduce COC concentrations below MCLs, although the required timeframe is not known and could exceed 20 years.

(e) Permanent reduction of toxicity, mobility, and volume through treatment

Alternative 1 would not implement any form of treatment or hydraulic control; therefore, no direct reduction in toxicity, mobility, or volume of impacted groundwater would occur. Naturally occurring attenuation might occur over time but would not be monitored.

The ex situ treatment system in Alternative 2 would effectively remove arsenic from groundwater. System performance would be routinely monitored. The insoluble, non-hazardous, precipitate-solid residues generated would be disposed at an approved landfill.

(f) The ability to be implemented

Alternative 1 would leave site conditions unchanged and does not require specific implementation.

Extraction and treatment systems such as Alternative 2 have been successfully implemented at many environmental sites. The system design and performance can be modified to account for site-specific conditions. A preliminary evaluation of site-specific conditions at the ALF did not reveal any major obstacles to implementation. The size, shape, and depth of the two groundwater plume areas at OU 2 are amenable to an extraction and treatment system. Design plans are under development for the IRA.

(g) Cost

Alternative 1 has no direct cost.

The initial cost of Alternative 2 is estimated at $7,403,066 and includes design, installation, and operation and maintenance (O&M) of the extraction and treatment system for the first year.

(h) The degree to which community concerns are addressed

Alternative 1 is likely to be poorly received by the community and the landowners. It does not include any active remediation, hydraulic control, or monitoring. Site conditions, COC impacts, and potential COC migration toward sensitive receptors would not change. All short-term and long-term concerns would remain unchanged. Alternative 1 does not support future economic redevelopment of the land.

Alternative 2 is anticipated to be well received by the community. Extraction and treatment systems are a proven technology that pose little to no off-site risk. This remedy would extract arsenic-impacted groundwater for treatment and provide hydraulic control to minimize the potential for impacted groundwater to migrate to sensitive receptors. Treated water would be discharged to the local water treatment plant. The end result is anticipated to reduce COC concentrations below drinking water MCLs.

(i) The degree to which recycling, residue, and waste minimization are employed

Alternative 1 does not involve recycling or residue. Waste would be minimized in the sense that no resources would be expended, nor would any new waste be generated.

The extraction and treatment system in Alternative 2 is anticipated to have an operational capacity of at least 300 to 400 gallons per minute. Treated water would be routed to the T.E. Maxson Wastewater Treatment Plant for additional processing. Insoluble, non-hazardous, precipitate-solid residues would be disposed at an approved landfill.

8.3 RECOMMENDED ALTERNATIVES

The proposed remedial alternatives have been screened, evaluated, and compared as detailed above. An evaluation matrix was developed to assess the retained alternatives with respect to the nine TDEC criteria as shown in **Table 8-1**. Based on the criteria and weighted scores shown in the matrix, the highest scoring alternatives are discussed in the following two sections.

8.3.1 Recommended Remedial Alternative: OU 1

Alternative 2, Closure-by-Removal: Disposal of CCR Materials in an Off-Site Landfill, was the highest scoring remedy and is the preferred action for OU 1. Closure-by-removal with landfilling would removal CCR from the EADA and eliminate the source material for COCs affecting groundwater in OU 2. This remedy can be designed and implemented to comply with all ARARs. Successful completion of this remedy, in conjunction with remedial action at OU 2, is anticipated to achieve RAOs, including enabling future economic redevelopment of the land. The size, shape, depth, and location of OU 1 are amenable to a removal operation. The volume of CCR material in OU 1 would decrease throughout the course of the remedy.

Although beneficial re-use of CCR provides a significant reduction in volume of material deposited in a landfill, the closest viable beneficial re-use processing facility is located approximately 600 miles from the ALF. The anticipated processing capacity of this facility is approximately 200,000 cubic yards or 240,000 tons per year. This processing rate and distance from the ALF would significantly increase the estimated time frame and cost for closure. The extended time frame increases potential risk to human health and the environment, reduces short-term effectiveness and may increase community concerns due to longer time frame of transportation of CCR. For these reasons, CCR disposal in an off-site landfill scored higher and is the recommended alternative.

8.3.2 Recommended Remedial Alternative: OU 2

Alternative 2, Extraction, Treatment and Discharge, was the highest scoring groundwater remedy and is the preferred action for OU 2. This remedy involves groundwater extraction, treatment, and discharge to the T.E. Maxson Wastewater Treatment Plant. The ex situ treatment system would remove arsenic from extracted groundwater. Groundwater extraction would provide hydraulic control to help minimize the potential for impacted groundwater to migrate toward sensitive receptors. Site-specific conditions at the ALF, including the size, shape, and depth of the two groundwater plume areas at OU 2, are amenable to an extraction and treatment system. The system can be designed to comply with ARARs. System performance would be routinely monitored and can be modified if warranted. Short-term effectiveness is anticipated to be favorable, and long-term operation is anticipated to eventually reduce COC concentrations below MCLs. Alternative 2 is anticipated to be well received by the community because extraction and treatment systems are a proven technology that pose little to no off-site risk.

Alternative 2 has a few disadvantages. The effectiveness of all extraction and treatment systems tapers off as COC concentrations diminish over time. The required timeframe to eventually reduce COC concentrations below MCLs is not known and could exceed 20 years. For these reasons, in the future TVA may utilize any or all technologies eliminated from evaluation in this FS to further reduce constituent concentrations or accelerate the cleanup process. This work would be completed in coordination with TDEC and under all applicable regulations.

The system would require routine monitoring and O&M throughout its operational span, which necessitates on-going site access and capital expense. Although there are disadvantages, Extraction, Treatment and Discharge was the only alternative that could immediately control groundwater and begin treatment, making it the recommended alternative.

8.4 CONCLUSION

The primary objectives of this FS were to screen applicable remedial technologies, develop a focused list of remedial alternatives to be evaluated against CERCLA evaluation criteria, and make a recommendation for preferred remedies to address two separate, but related, OUs.

- For OU 1 (the EADA), Alternative 2 – Closure-by-Removal: Disposal of CCR Materials in an Off-Site Landfill was selected as the best alternative based on current conditions and the evaluation criteria.
- For OU 2 (groundwater), Alternative 2 – Extraction, Treatment and Discharge was selected as the best alternative to immediately control and begin remediating groundwater. If this remedial approach results in asymptotic conditions that do not meet the remedial goals, the in-situ alternatives listed in Section 7.6 will be further evaluated and used as necessary in order to accelerate the process.

This FS was based on information available at the time regarding site conditions as presented in the Updated RI Report. A change in any of these conditions, the discovery of additional information related to the extent of impacted soil or groundwater, or changes to the remedial objectives may alter the evaluation and conclusions presented herein.

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TABLES

Table 3-1
Comparison of Soil Sample Results with Background Concentrations
TVA Allen Fossil Plant
Memphis, Tennessee

		Location	**ALF-201-B**	**ALF-201-B**	**ALF-201-B**	**ALF-202-B**	**ALF-202-B**	**ALF-203-B**	**ALF-203-B**	**ALF-204-B**	**ALF-204-B**	**ALF-204-B**
		Sampling Date	**22-Aug-17**	**22-Aug-17**	**22-Aug-17**	**21-Aug-17**	**21-Aug-17**	**21-Aug-17**	**21-Aug-17**	**21-Aug-17**	**21-Aug-17**	**21-Aug-17**
		Depth (ft bgs)	**5.0**	**14.5**	**23.5**	**7.5**	**14.5**	**7.5**	**21.5**	**6.0**	**10.0**	**26.0**
General Chemistry (mg/kg)	**Background (1)**	**BTVs (2)**										
Chloride	NA	5.2	56.1 U	67.0 U	52.7 U	62.0 U	57.6 U	59.9 U	53.8 U	59.4 U	63.0 U	72.0 U
Fluoride	NA	5.8	5.6 U	6.7 U	5.3 U	6.2 U	2.9 J	6.0 U	5.4 U	5.9 U	6.3 U	7.2 U
Sulfate	NA	183	56.1 U	67.0 U	52.7 U	62.0 U	57.6 U	33.7 J	53.8 U	59.4 U	63.0 U	134
Percent Moisture (%)	NA	NA	11.2	25.6	4.9	20.8	13.1	17.1	7.4	16.1	21.4	30.8
Metals (mg/kg)												
Antimony	6.2	0.63	0.55 UJ	0.67 UJ	0.49 UJ	0.60 UJ	0.55 UJ	0.56 UJ	0.52 UJ	0.57 UJ	0.21 J	0.72 UJ
Arsenic	10	9.6	4.3	11.5	4.2	7.1	7.3	5.5	3.5	4.2	8.6	6.8
Barium	144	219	113 J	230 J	58.1 J	137 J	149 J	126 J	65.4 J	95.0 J	248 J	184 J
Beryllium	1	1.1	0.35	1.3	0.23	0.45	0.71	0.47	0.29	0.26	0.87	0.52
Boron	NA	10	5.5 U	3.8 J	4.9 U	1.7 J	3.6 J	1.9 J	5.2 U	5.7 U	6.5	2.9 J
Cadmium	1	0.69	0.12	0.37	0.058 J	0.23	0.26	0.23	0.15	0.14	0.36	0.20
Calcium	NA	20,530	8940	7200	5450	7730	4240	3550	4830	14300	8090	15700
Chromium	20	19	8.6	25.0	6.9	12.4	16.4	11.2	9.1	8.7	22.5	15.3
Cobalt	13	10	5.2	10.8	4.9	7.5	9.2	6.0	5.9	4.7	9.5	9.0
Copper	25	26	5.8	25.9	2.4	10.5	14.9	9.9	5.1	5.1	22.6	12.2
Lead	45	28	7.0	19.0	4.2	10.9	11.3	7.6	5.9	5.5	13.8	9.4
Lithium	NA	17	6.2	19.5	4.3	8.3	11.7	7.5	5.2	5.7	16.8	11.1
Mercury	0.18	0.13	0.014 J	0.031	0.020 U	0.026	0.018 J	0.011 J	0.019 U	0.021 U	0.029	0.017 J
Molybdenum	NA	1.3	0.26 J	0.73	0.16 J	0.43 J	0.58	0.41 J	1.1	0.29 J	0.73	0.42 J
Nickel	18	25	12.5	29.3	10.8	17.5	22.5	14.7	14.0	11.3	24.9	21.3
Selenium	1.2	1.4	0.84	1.9	0.83	1.3	1.8	1.1	1.0	1.0	2.1	1.8
Silver	1.2	1.3	0.55 U	0.67 U	0.49 U	0.60 U	0.55 U	0.56 U	0.52 U	0.57 U	0.59 U	0.72 U
Thallium	1.9	0.57	0.10 U*	0.27 U*	0.057 U*	0.15 U*	0.21 U*	0.17 U*	0.094 U*	0.10 U*	0.33	0.18 U*
Vanadium	32	26	15.0	36.3	11.0	21.3	28.9	19.8	15.0	15.2	37.3	25.2
Zinc	94	89	37.2	103	24.7	46.7	60.4	37.5	31.3	31.4	82.2	53.6
Radium (pCi/g)												
Radium-226	NA	NA	0.886+-0.215	0.649+-0.159	1.748+-0.373	0.989+-0.247	1.425+-0.343	1.092+-0.250	0.846+-0.225	0.853+-0.223	1.917+-0.465	1.084+-0.240
Radium-226+228	NA	NA	2.12+-0.360	1.48+-0.479	3.65+-0.691	2.16+-0.442	3.17+-0.587	2.34+-0.402	2.23+-0.417	1.82+-0.468	3.59+-0.632	2.81+-0.496
Radium-228	NA	NA	1.238+-0.289	0.827+-0.452	1.897+-0.582	1.166+-0.367	1.749+-0.476	1.249+-0.315	1.381+-0.351	0.964+-0.411	1.675+-0.428	1.721+-0.434

Depths reported in feet below ground surface (ft bgs).

mg/kilogram - milligrams per kilogram

pCi/g - picocuries per gram

Radium data reported on a "wet-weight" basis.

U - The analyte was not detected above the indicated reporting limit.

J - The result is estimated.

U* - The analyte was detected in an associated blank.

UJ - The analyte was not detected above the estimated reporting limit.

(1) Hazardous Trace Elements in Tennessee Soils and Other Regions: Naturally occurring background level, Tennessee soils, TN Division of Superfund Survey (2001)

(2) Site-specific Background Threshold Values (BTVs), TVA ALF 2019

NA - Not available

Results above background are shaded.

Results above BTVs are boxed.

Table 3-1
Comparison of Soil Sample Results with Background Concentrations
TVA Allen Fossil Plant
Memphis, Tennessee

		Location	**ALF-210-A**	**ALF-210-A**	**ALF-214-B**	**ALF-214-B**	**ALF-214-B**	**ALF-215**	**ALF-215**	**ALF-216**	**ALF-216**	**GP-51A**
		Sampling Date	**22-Aug-17**	**22-Aug-17**	**22-Aug-17**	**22-Aug-17**	**22-Aug-17**	**05-Sep-17**	**05-Sep-17**	**29-Aug-17**	**29-Aug-17**	**22-Aug-17**
		Depth (ft bgs)	**7.5**	**19.0**	**4.5**	**11.0**	**25.5**	**5.0**	**11.5**	**14.0**	**25.0**	**6.0**
General Chemistry (mg/kg)	**Background (1)**	**BTVs (2)**										
Chloride	NA	5.2	63.5 U	60.5 U	56.1 U	68.9 U	65.0 U	70.3 U	59.9 U	61.1 U	61.2 U	59.1 U
Fluoride	NA	5.8	6.4 U	6.1 U	5.6 U	6.9 U	6.5 U	5.6 J	6.0 UJ	3.3 J	6.1 UJ	4.6 J
Sulfate	NA	183	63.5 U	60.5 U	56.1 U	68.9 U	65.0 U	70.3 U	59.9 U	61.1 U	41.1 J	59.1 U
Percent Moisture (%)	NA	NA	21.6	18.7	11.5	28.9	24.5	29.1	17.1	18.8	18.6	15.9
Metals (mg/kg)												
Antimony	6.2	0.63	0.64 UJ	0.21 J	0.53 UJ	0.28 J	0.62 UJ	0.27 J	0.57 UJ	0.24 J	0.59 UJ	0.56 U
Arsenic	10	9.6	6.7	8.2	5.3	10.2	5.9	11.1	2.8	7.3	2.6	5.1
Barium	144	219	187 J	163 J	114 J	270 J	132 J	275 J	33.4 J	126 J	100 J	126
Beryllium	1	1.1	0.55	0.59	0.38	0.87	0.42	1.2	0.16 J	0.51	0.41	0.45
Boron	NA	10	2.4 J	3.1 J	5.3 U	5.6 J	6.2 U	3.1 J	5.7 U	6.0 U	5.9 U	5.1 U*
Cadmium	1	0.69	0.27	0.25	0.23	0.55	0.15	0.47	0.068	0.45	0.27	0.19
Calcium	NA	20,530	13700	10000	7500	23500	11800	7120	1160	3330	10300	7950
Chromium	20	19	14.1	22.8	9.7	21.0	11.3	26.5	5.4	12.4	11.8	11.0
Cobalt	13	10	7.0	8.0	6.2	11.1	7.1	13.1	3.9	8.4	7.1	6.1
Copper	25	26	13.2	16.4	9.1	24.2	8.8	30.3	2.8	11.5	10.8	9.2
Lead	45	28	9.1	9.6	9.0	14.5	7.8	19.1	3.6	8.1	8.0	9.6
Lithium	NA	17	9.3	9.8	6.2	15.3	7.6	19.3	3.1	8.3	9.8	7.6
Mercury	0.18	0.13	0.023 U	0.013 J	0.023	0.021 J	0.026 U	0.037	0.0096 U	0.015 J	0.010 J	0.022
Molybdenum	NA	1.3	0.54 J	2.2	0.31 J	0.75	0.35 J	0.88	0.17 U	0.83	0.59 U	0.36 J
Nickel	18	25	19.9	22.1	15.0	28.1	17.4	34.8	9.5	27.0	18.7	14.7
Selenium	1.2	1.4	1.6	1.6	1.2	2.2	1.2	2.6	0.79	1.4	2.1	1.3
Silver	1.2	1.3	0.64 U	0.56 U	0.53 U	0.67 U	0.62 U	0.70 U	0.57 UJ	0.60 U	0.59 U	0.56 U
Thallium	1.9	0.57	0.23 U*	0.19 U*	0.11 U*	0.32 U*	0.13 U*	0.33 U*	0.11 U*	0.19 U*	0.15 U*	0.14 U*
Vanadium	32	26	26.0	26.9	17.0	38.5	19.2	43.9	8.8	21.8	18.6	18.5
Zinc	94	89	47.7	52.7	36.0	77.0	41.6	103	18.3	66.0	46.2	42.3
Radium (pCi/g)												
Radium-226	NA	NA	1.248+-0.308	1.266+-0.301	0.972+-0.205	1.249+-0.339	0.989+-0.209	1.392+-0.350	0.465+-0.102	1.032+-0.191	0.914+-0.189	0.895+-0.190
Radium-226+228	NA	NA	2.27+-0.540	2.85+-0.450	2.00+-0.376	2.94+-0.588	2.01+-0.321	3.66+-0.652	1.30+-0.304	2.45+-0.458	1.81+-0.339	2.21+-0.394
Radium-228	NA	NA	1.024+-0.443	1.581+-0.335	1.027+-0.315	1.688+-0.481	1.022+-0.243	2.270+-0.550	0.833+-0.286	1.419+-0.416	0.892+-0.281	1.315+-0.345

Depths reported in feet below ground surface (ft bgs).

mg/kilogram - milligrams per kilogram

pCi/g - picocuries per gram

Radium data reported on a "wet-weight" basis.

U - The analyte was not detected above the indicated reporting limit.

J - The result is estimated.

U* - The analyte was detected in an associated blank.

UJ - The analyte was not detected above the estimated reporting limit.

(1) Hazardous Trace Elements in Tennessee Soils and Other Regions: Naturally occurring background level, Tennessee soils, TN Division of Superfund Survey (2001)

(2) Site-specific Background Threshold Values (BTVs), TVA ALF 2019

NA - Not available

Results above background are shaded.

Results above BTVs are boxed.

Table 3-1
Comparison of Soil Sample Results with Background Concentrations
TVA Allen Fossil Plant
Memphis, Tennessee

Location			GP-51A	GP-51A	GP-51A	GP-51A	GP-51A	GP-51A	GP-51A
Sampling Date			22-Aug-17	22-Aug-17	22-Aug-17	22-Aug-17	22-Aug-17	22-Aug-17	22-Aug-17
Depth (ft bgs)			10.0	14.0	18.0	22.0	26.0	30.0	34.0
General Chemistry (mg/kg)	**Background (1)**	**BTVs (2)**							
Chloride	NA	5.2	56.6 U	59.0 U	63.7 U	61.7 U	62.6 U	66.0 U	63.1 U
Fluoride	NA	5.8	5.7 UJ	5.9 UJ	6.4 UJ	6.2 UJ	6.3 UJ	6.6 UJ	4.6 J
Sulfate	NA	183	36.1 J	40.3 J	41.8 J	33.8 J	62.6 U	37.6 J	50.4 J
Percent Moisture (%)	NA	NA	12.4	15.9	22.3	19.8	20.7	24.3	20.6
Metals (mg/kg)									
Antimony	6.2	0.63	0.55 U	0.56 U	0.61 U	0.59 U	0.60 U	0.61 U	0.58 U
Arsenic	10	9.6	4.6	5.5	10.1	4.4	6.4	8.4	5.8
Barium	144	219	131	147	210	124	185	219	191
Beryllium	1	1.1	0.37	0.41	0.82	0.36	0.65	0.87	0.83
Boron	NA	10	4.4 U*	5.0 U*	6.9 U*	3.8 U*	5.5 U*	9.3 U*	11.5 U*
Cadmium	1	0.69	0.18	0.23	0.31	0.22	0.24	0.38	0.20
Calcium	NA	20,530	8810	8100	8200	7080	9350	6760	4870
Chromium	20	19	10.3	23.0	19.4	9.8	15.0	19.7	20.2
Cobalt	13	10	6.2	7.1	11.8	5.8	8.4	10.9	9.1
Copper	25	26	8.3	11.9	22.4	7.6	16.5	20.5	18.0
Lead	45	28	9.0	10.5	13.7	8.6	14.2	17.7	11.8
Lithium	NA	17	7.2	8.1	14.6	6.3	11.0	15.6	15.4
Mercury	0.18	0.13	0.021 J	0.024	0.026	0.019 J	0.033	0.026	0.026
Molybdenum	NA	1.3	0.26 J	2.0	0.47 J	0.25 J	0.50 J	0.60 J	0.46 J
Nickel	18	25	14.6	17.7	24.6	13.6	19.4	25.7	25.3
Selenium	1.2	1.4	1.2	1.4	2.0	1.2	1.8	2.2	1.6
Silver	1.2	1.3	0.55 U	0.56 U	0.61 U	0.59 U	0.60 U	0.61 U	0.58 U
Thallium	1.9	0.57	0.12 U*	0.15 U*	0.24 U*	0.11 U*	0.20 U*	0.27	0.27
Vanadium	32	26	17.4	19.7	32.7	16.8	25.3	33.5	33.0
Zinc	94	89	38.2	46.2	71.0	38.5	60.7	80.6	73.6
Radium (pCi/g)									
Radium-226	NA	NA	1.012+-0.218	1.253+-0.261	0.980+-0.187	1.021+-0.212	0.892+-0.212	1.148+-0.262	0.978+-0.251
Radium-226+228	NA	NA	2.04+-0.374	2.41+-0.419	1.84+-0.329	1.84+-0.371	2.01+-0.329	2.74+-0.422	1.91+-0.389
Radium-228	NA	NA	1.026+-0.304	1.160+-0.328	0.857+-0.271	0.818+-0.304	1.119+-0.251	1.592+-0.331	0.934+-0.297

Depths reported in feet below ground surface (ft bgs).

mg/kilogram - milligrams per kilogram

pCi/g - picocuries per gram

Radium data reported on a "wet-weight" basis.

U - The analyte was not detected above the indicated reporting limit.

J - The result is estimated.

U* - The analyte was detected in an associated blank.

UJ - The analyte was not detected above the estimated reporting limit.

(1) Hazardous Trace Elements in Tennessee Soils and Other Regions: Naturally occurring background level, Tennessee soils, TN Division of Superfund Survey (2001)

(2) Site-specific Background Threshold Values (BTVs), TVA ALF 2019

NA - Not available

Results above background are shaded.

Results above BTVs are boxed.

Table 5-1
Proposed Soil Target Cleanup Goals
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

Analyte	CAS	Units	Background Threshold Value [a]	Industrial Soil RSL / PRG [b]	Proposed Target Cleanup Goal
Antimony	7440-36-0	mg/kg	0.63	470 [c]	470
Arsenic	7440-38-2	mg/kg	9.6	300	300
Barium	7440-39-3	mg/kg	219	220,000	220,000
Beryllium	7440-41-7	mg/kg	1.1	2,300	2,300
Boron	7440-42-8	mg/kg	10	230,000	230,000
Cadmium	7440-43-9	mg/kg	0.69	980	980
Calcium	7440-70-2	mg/kg	20,528	-	20,528
Chloride	16887-00-6	mg/kg	5.2	-	5.2
Chromium	7440-47-3	mg/kg	19	1,800,000 [d]	1,800,000
Cobalt	7440-48-4	mg/kg	10	350	350
Copper	7440-50-8	mg/kg	26	47,000	47,000
Fluoride	16984-48-8	mg/kg	5.8	47,000	47,000
Lead	7439-92-1	mg/kg	28	800	800
Lithium	7439-93-2	mg/kg	17	2,300	2,300
Mercury	7439-97-6	mg/kg	0.13	350 [e]	350
Molybdenum	7439-98-7	mg/kg	1.3	5,800	5,800
Nickel	7440-02-0	mg/kg	25	22,000 [f]	22,000
Radium-226	13982-63-3	pCi/g	2.5	0.020	2.5
Radium-226+228	13982-63-3/15262-20-1	pCi/g	4.1	0.015 [g]	4.1
Radium-228	15262-20-1	pCi/g	1.9	0.015	1.9
Selenium	7782-49-2	mg/kg	1.4	5,800	5,800
Silver	7440-22-4	mg/kg	1.3	5,800	5,800
Sulfate	14808-79-8	mg/kg	183	-	183
Thallium	7440-28-0	mg/kg	0.57	12 [h]	12
Vanadium	7440-62-2	mg/kg	26	5,800	5,800
Zinc	7440-66-6	mg/kg	89	350,000	350,000

Notes:

"-" - not available
CAS - Chemical Abstracts Service registry number
mg/kg - milligrams per kilogram
pCi/g - picocuries per gram
PRG - preliminary remediation goal
RSL - regional screening level
USEPA - United States Environmental Protection Agency

[a] Background threshold value as presented in Table 3.

[b] November 2019 USEPA RSLs for industrial soil based on a target carcinogenic risk and noncancer hazard quotient (HQ) of $1x10^{-4}$ and 1, respectively. PRGs for radionuclides developed using the PRG calculator for a default composite worker scenario and a target carcinogenic risk of $1x10^{-4}$ as presented in Attachment B of Appendix D.

[c] RSL for antimony (metallic) presented.

[d] RSL for chromium (III) used as a surrogate.

[e] RSL for mercuric chloride used as a surrogate.

[f] RSL for nickel soluble salts presented.

[g] PRG for radium-228 used as a surrogate.

[h] RSL for thallium soluble salts presented.

Table 5-2
Proposed Groundwater Target Cleanup Goals
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

			Drinking Water Standards						
Analyte	CAS	Units	TDEC Domestic Water Supply [a]	USEPA MCL [b]	USEPA Tapwater RSL / PRG [c]	USEPA SMCL [d]	Protection of Surface Water [e]	Background Threshold Value (BTV)	Proposed Target Cleanup Goal [f]
Antimony	7440-36-0	mg/L	0.0060	0.0060	0.0078	-	32	0.0025	0.006
Arsenic	7440-38-2	mg/L	0.010	0.010	0.000052	-	1.7	0.0098	0.010
Barium	7440-39-3	mg/L	2.0	2.0	3.8	-	37	1.14	2.0
Beryllium	7440-41-7	mg/L	0.0040	0.0040	0.025	-	1.8	0.0005	0.004
Boron	7440-42-8	mg/L	-	-	4.0	-	1200	0.24	4.0
Cadmium	7440-43-9	mg/L	0.0050	0.0050	0.0092	-	0.12	0.0004	0.005
Calcium	7440-70-2	mg/L	-	-	-	-	19,000	159	159
Chloride	16887-00-6	mg/L	-	-	-	250	38,000	23	250
Chromium	7440-47-3	mg/L	0.10	0.10	22 [g]	-	12	0.0025	0.10
Cobalt	7440-48-4	mg/L	-	-	0.0060	-	3.2	0.0071	0.0071
Copper	7440-50-8	mg/L	-	1.3 [h]	0.80	1.0	1.5	0.0017	1.3
Fluoride	16984-48-8	mg/L	-	4.0	0.80	2.0	450	0.23	4.0
Lead	7439-92-1	mg/L	0.0050	0.015 [h]	0.015	-	0.42	0.0005	0.005
Lithium	7439-93-2	mg/L	-	-	0.040	-	73	0.034	0.040
Mercury	7439-97-6	mg/L	0.0020	0.0020 [i]	0.0057 [j]	-	0.0085	0.0002	0.0020
Molybdenum	7439-98-7	mg/L	-	-	0.10	-	130	0.002	0.10
Nickel	7440-02-0	mg/L	0.10	-	0.39	-	8.7	0.012	0.10
Radium-226	13982-63-3	pCi/L	-	-	0.00043	-	1,400,000	-	0.0004
Radium-226+228	13982-63-3/15262-20-1	pCi/L	-	5.0	0.0011 [k]	-	1,100,000	3.79	5.0
Radium-228	15262-20-1	pCi/L	-	-	0.0011	-	1,100,000	-	0.0011
Selenium	7782-49-2	mg/L	0.050	0.050	0.10	-	0.25	0.0025	0.050
Silver	7440-22-4	mg/L	-	-	0.094	0.10	0.010	0.0020	0.094
Sulfate	14808-79-8	mg/L	-	-	-	250	-	129	250
Thallium	7440-28-0	mg/L	0.0020	0.0020	0.00020	-	0.078	0.0005	0.0020
Vanadium	7440-62-2	mg/L	-	-	0.086	-	4.5	0.0015	0.086
Zinc	7440-66-6	mg/L	-	-	6.0	5.0	20	0.010	6.0

Notes:

"-" - not available
BTV - Background threshold value
CAS - Chemical Abstracts Service registry number
MCL - maximum contaminant level
mg/L - milligrams per liter
pCi/L - picocuries per liter
PRG - preliminary remediation goal
RSL - regional screening level
SMCL - secondary maximum contaminant level
TDEC - Tennessee Department of Environment and Conservation
USEPA - United States Environmental Protection Agency

[a] Rules of the TDEC Chapter 0400-40-03 General Water Quality Criteria. Criteria for the use of domestic water supply. September, 2019 (Revised). https://publications.tnsosfiles.com/rules/0400/0400-40/0400-40-03.20190911.pdf

[b] USEPA National Primary Drinking Water Regulation MCLs. Accessed September, 2019. https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

[c] November 2019 USEPA tapwater RSLs based on a target carcinogenic risk and noncancer hazard quotient (HQ) of $1x10^{-6}$ and 1, respectively. PRGs for radionuclides developed using the PRG calculator for a default residential tap water scenario and a target carcinogenic risk of $1x10^{-6}$ as presented in Attachment B.

[d] USEPA National Secondary Drinking Water Regulation secondary MCLs. Accessed September 2019. https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals

[e] Protection of surface water levels are based on surface water exposure equal to the target surface water screening levels adjusted with a dilution attenuation factor (DAF) of 166.67 for discharge to McKellar Lake from the East Ash Disposal Area. See Feasibility Study, Appendix D, Table 9.

[f] Target cleanup goal is either the most applicable drinking water standard (e.g., MCL or RSL in the absence of an MCL) or BTV.

[g] Chromium (III) used as a surrogate.

[h] Copper and lead action levels.

[i] MCL for inorganic mercury.

[j] RSL for mercuric chloride used as a surrogate.

[k] PRG for Radium-228 used as a surrogate.

TABLE 6-1 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
ALLEN FOSSIL PLANT – EAST ASH DISPOSAL AREA MEMPHIS, SHELBY COUNTY, TENNESSEE

Chemical-Specific ARARs

Action	Citation	Summary	Analysis
Safe Drinking Water Act, Maximum Contaminant Levels (MCLs) for inorganic contaminants	40 CFR Part 141.62 40 CFR Part 141.66	Legally enforceable drinking water standards that establish maximum contaminant levels (MCLs) for specific contaminants that have been determined to adversely affect human health.	The MCLs are relevant and appropriate based on- constituents present in groundwater at the site.
Safe Drinking Water Act, Secondary MCLs	40 CFR Part 143	Establishes controls for contaminants in drinking water that primarily affect the aesthetic qualities relating to the public acceptance of drinking water which at higher concentrations may have health implications as well as contributing to aesthetic degradation.	The secondary MCLs are relevant and appropriate based on constituents present in groundwater at the site.
Standards for the Disposal of Coal Combustion Residuals (CCRs)	40 CFR Part 257 Appendix III and Appendix IV 40 CFR Part 257.95	Identifies constituents of concern and MCL values for constituents for which MCLs are not established under CFR 141.62 and 141.66.	The MCLs are relevant and appropriate based on constituents present in groundwater at the site.
National Pollutant Discharge Elimination System (NPDES)	40 CFR Parts 122, 125	Identifies maximum concentrations for the discharge of pollutants from any point source into waters of the United States.	Discharge limits would be established for pond dewatering and pore water discharge to surface water at the site.
Ambient Water Quality Criteria	40 CFR Part 131	Requires states to set the ambient water quality criteria (AWQC) for water quality based on use classification and the criteria developed under section 304 (a) of the Clean Water Act.	AWQCs have been developed and may be relevant and appropriate if constituents are present in surface water in the area below the applicable use criteria.
National Pretreatment Standards	40 CFR Part 403.1 US Code Title 33. Section 1317	Sets standards to control pollutants from non- domestic sources that pass through and may interfere with treatment processes in publicly owned treatment works or that may contaminate sewage sludge.	Treated groundwater will be discharged to the T.E. Maxson Wastewater Treatment Plant, therefore, these standards would be relevant and appropriate.
Clean Air Act	Clean Air Act Title V. Section 502 40 CFR Part 70	Establishes air emissions limits from major and nonmajor sources and requires emitters to receive a permit for each regulated pollutant.	Applicable for alternatives involving removal and transport of solid wastes that could result in the discharge of particulates to the atmosphere.
Tennessee General Water Quality Criteria	Title 69, Chapter 3, Part 1 TDEC Rule 0400-40-03	Establishes state ambient water quality criteria (AWQC) based on site specific features to protect groundwater and receiving surface water bodies based on their designated uses. Also requires that any groundwater entering a surface water body must meet the site specific AWQC's for surface water.	The AWQCs specific to the site location are relevant and appropriate based on constituents in groundwater or to be discharged in to surface water.
Tennessee Water Supply Primary and Secondary Drinking Water Standards	Title 69, Chapter 3, Part 1, TDEC Rule 0400-45-01	Established primary and secondary MCLs for specific contaminants that have been determined to adversely affect human health.	The MCLs are relevant and appropriate based on constituents present in groundwater at the site.
Tennessee Air Pollution Control Program	TDEC Rule 1200-03-03	Established air emissions standards for particulates and other air contaminants to prevent significant deterioration of the existing air quality due to industrial or construction activities.	Applicable for alternatives involving removal of solid wastes that could result in the discharge of particulates to the atmosphere if the removal activities are determined to be the predominant particulate emitter.
Tennessee Pretreatment Standards	TDEC Rule 0400-40-14	Established standards to prevent the introduction of pollutants to wastewater facilities which may interfere with the operation of the facility, may be incompatible with the facility treatment operations, and to improve opportunities to recycle and reclaim municipal and industrial wastewater and sludge.	Treated groundwater will be discharged to the T.E. Maxson Wastewater Treatment Plant, therefore, these standards would be relevant and appropriate.
City of Memphis Sewer Use Ordinance	City of Memphis Code Chapter 33	Established standards to prevent the introduction of pollutants to wastewater facilities which may interfere with the operation of the facility, may be incompatible with the facility treatment operations, and to improve opportunities to recycle and reclaim municipal and industrial wastewater and sludge.	Treated groundwater will be discharged to the T.E. Maxson Wastewater Treatment Plant, therefore, these standards would be relevant and appropriate.

TABLE 6-1 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
ALLEN FOSSIL PLANT – EAST ASH DISPOSAL AREA MEMPHIS, SHELBY COUNTY, TENNESSEE

Location Based ARARs

Action	Citation	Summary	Analysis
Location encompassing aquatic ecosystem	40 CFR 230.10(a) and (c)	Restricts discharge of dredged or fill material when practicable alternatives exist that would have less adverse impact or cause less degradation of the waters of the United States.	Action involving addition of fill material into waters of the United States, including wetlands and areas below the high-water mark of McKellar Lake would be subject to these standards.
	TDEC Rule 0400-40-03-.04(4)(b) 40 CFR 230 Section 404(b)(1) Section 230.7	Provides for the discharge of dredge or fill material, wetlands/habitat alterations, or other construction activities which result in the alteration of the waters authorized by an Aquatic Resource Alteration Permit.	
	Clean Water Act Section 401 US Code Title 33. Section 1344	Regulates discharges of fill and dredged material to navigable waters of the United States and provides permitting and protections for wetlands, special aquatic sites and headwaters with high resource value, high vulnerability to filling, and that are not protected by other programs.	
	Executive Order 11988	Requires federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of flood plains to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities.	
	Executive Order 11990	Requires federal agencies to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; and (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.	
Location near a civil work constructed by the U.S.	US Code Title 33. Section 408	Prohibits taking possession of or using for any purpose to build upon, alter, deface, destroy, move, injure, obstruct or in any manner impair the usefulness of any sea wall, dike, levee, or other work built by the United States, constructed for the preservation and improvement of any of its navigable waters or to prevent floods, unless granted a permit by the USACE for the temporary or permanent occupation, use, or alteration of any of the aforementioned public works when such occupation or use will not be injurious to the public interest and will not impair the usefulness.	Work activities near the adjoining Ensley levee may be required; therefore, this standard would be relevant and appropriate.
Location near a navigable channel	US Code Title 33. Section 403 Rivers and Harbors Appropriation Act Section 10 USACE Nationwide Permit	Restricts the creation of any obstruction to the navigable capacity of the waters of the United States or to excavate or fill, or in any manner to alter or modify the course, location, condition, or capacity of any port, roadstead, haven, harbor, canal, lake, harbor of refuge, or enclosure within the limits of any breakwater, or of the channel of any navigable water of the United States, unless the work has been recommended and permitted by the Army Corps of Engineers.	Work activities that include adding fill below the high- water mark of McKellar Lake would be subject to these standards.

TABLE 6-1 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
ALLEN FOSSIL PLANT – EAST ASH DISPOSAL AREA MEMPHIS, SHELBY COUNTY, TENNESSEE

Location Based ARARs

Action	**Citation**	**Summary**	**Analysis**
Location affecting endangered/threatened species habitats	US Code Title 16. Chapter 49. Section 2912 US Code Title 16. Chapter 35. Section Endangered Species Act Section 10	Identifies conservation actions to assure limited effects of environmental changes on endangered migratory nongame birds. Regulates activities affecting endangered and threatened species and the habitats upon which they depend and permits the “take” of endangered species if such taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity, and is accompanied by a habitat conservation plan.	Work activities that may affect, and potentially disturb land on and surrounding the site that includes habitat areas for an endangered migratory non-game bird, therefore, these standards would be relevant and appropriate.
	Tennessee Code 70-8-104	Sets limitations on activities relating to habitat, alteration, taking, possession, transportation, exportation, processing, sale or offer for sale, or shipment as may be deemed necessary to manage endangered nongame wildlife.	
	Tennessee Code 70-8-106	Allows activities deemed necessary to alleviate damage to property or to protect human health and safety that may remove, capture or destroy endangered or threatened species.	

Action Based ARARs

Action	**Citation**	**Summary**	**Analysis**
Activities resulting in discharge of storm water	40 CFR Part 122.26(c)	Requires dischargers of storm water associated with industrial activity to apply for an NPDES permit, and provide the following: (A) A site map showing topography and including the location of drainage areas; (B) An estimate of the total area drained and a description of the control measures, including best management practices, and a list of applicable State and local erosion and sediment control requirement, to reduce pollutants; (C) Certification that storm water discharges are tested or evaluated to minimize the presence of discharges that are not covered by the permit; (D) Information regarding significant leaks and spills of toxic or otherwise hazardous pollutants; and (E) Sample results for pollutants listed on the permit.	Dewatering of the pond and discharge of treated water to the Mississippi River would be subject to this standard. This would include stormwater which will be managed throughout the closure process, including CCR removal.
Activities resulting in discharge of storm water or industrial waters	Tennessee Code 69-3-108(b) TDEC 0400-40-10-.03 NPDES General Permit for Industrial Activities TNR05-0000	Prohibits the following activities: alteration of the physical, chemical, radiological, biological, or bacteriological properties of any waters of the state; the increase in volume or strength of any wastes in excess of the permissive discharges; discharge of sewage, industrial wastes or other wastes into waters; or construction, installation, modification, or operation of any treatment works which may pose a substantial present or potential hazard to human health or the environment. Grants permits authorizing discharges for industrial purposes that impose conditions, including effluent standards and terms of periodic review, and prohibits activities which would cause a condition of pollution either by itself or in combination with others. Requires completion of a storm water pollution prevention plan, including discussions of appropriate controls to limit sediment including particulate filters.	Dewatering of the pond and discharge of treated water to the Mississippi River would be subject to this standard. This would include stormwater which will be managed throughout the closure process, including CCR removal.

TABLE 6-1 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
ALLEN FOSSIL PLANT – EAST ASH DISPOSAL AREA MEMPHIS, SHELBY COUNTY, TENNESSEE

Action Based ARARs			
Action	**Citation**	**Summary**	**Analysis**
Activities resulting in visible dust emissions	TDEC 1200-03-05-.01 (1)	Prohibits the discharge of a visible emission from any air contaminant source with an opacity in excess of twenty (20) percent for an aggregate of more than five (5) minutes in any one (1) hour or more than twenty (20) minutes in any twenty-four (24) hour period.	Removal activities that could result in the discharge of particulates to the atmosphere are subject to this standard.
Activities potentially resulting in fugitive dust emissions migrating offsite	TDEC 1200-03-08-.01	Requires operators to take reasonable precautions to prevent particulate matter from becoming airborne, which may include: use of water or chemicals for control of dust; and application of asphalt, water, or suitable chemicals on dirt roads, material stock piles, and other surfaces which can create airborne dusts. Limits the amount of fugitive visible dust emissions to 5 minutes per hour or 20 minutes per day to produce a visible emission beyond the property line of the property on which the emission originates.	Removal activities that could result in the discharge of particulates to the atmosphere are subject to this standard.
Installation of groundwater monitoring wells	Rules and Regulations of Wells in Shelby County Section 6	Requires all monitoring and recovery wells to be constructed in a manner that will guard against contamination of groundwater aquifers underlying Shelby County and requires a construction permit. Also requires wells to be set such that flood water may not intrude into the well; proper materials are used; and wells are maintained in operable condition.	Installation and maintenance of groundwater monitoring and recovery wells would be subject to this standard.
Installation of soil borings	Rules and Regulations of Wells in Shelby County Section 7	Requires all borings greater than 30 feet deep to be permitted; installed under the supervision of a licensed well driller or a registered professional engineer or geologist; and closed using appropriate materials.	Installation of soil borings would be subject to this standard.
Closure of groundwater monitoring wells	Rules and Regulations of Wells in Shelby County Section 9	Requires wells be restored as nearly as possible to those subsurface conditions which existed before the well was constructed and to be sealed if contamination is present and is a potential source of contamination to the groundwater aquifers underlying Shelby County.	Closure of groundwater monitoring and recovery wells would be subject to this standard.
CCR unit closure	40 CFR 257.102	Requires closure of a CCR landfill, surface impoundment, or lateral expansion of a unit to be completed by leaving the CCR in place and installing a final cover system or through removal of the CCR and decontamination of the CCR unit.	CCR unit closure is subject to this standard.
	40 CFR 257.102 (d)	Establishes closure criteria when leaving CCR in place, which must ensure that the unit is closed in a manner that: controls, minimizes or eliminates, post- closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere; precludes the probability of future impoundment of water, sediment, or slurry; includes measures that provide for major slope stability to prevent the sloughing or movement of the final cover system during the closure and post-closure care period; minimizes the need for further maintenance of the CCR unit; and can be completed in the shortest amount of time consistent with recognized and generally accepted good engineering practices. Also requires elimination of free liquids by removing liquid wastes or solidifying the remaining wastes and residues; and installation of a final cover system that is designed to minimize infiltration and erosion.	Work activities involving closure in place of CCR waste is subject to this standard.

TABLE 6-1 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
ALLEN FOSSIL PLANT – EAST ASH DISPOSAL AREA MEMPHIS, SHELBY COUNTY, TENNESSEE

Action Based ARARs			
Action	**Citation**	**Summary**	**Analysis**
CCR unit closure (continued)	40 CFR 257.102 (c)	Establishes closure criteria by removal of CCR, which must include decontaminating all areas affected by releases from the CCR unit; removing constituent concentrations throughout the CCR unit and in groundwater to levels that do not exceed the groundwater protection standards.	Work activities involving removal of CCR waste is subject to this standard.
Site remediation	TDEC Rule 0400-15-01-.08	Establishes criteria, guidelines, and remediation goals for investigation and remediation of hazardous substances sites.	All activities associated with remediation of on-site media is subject to this standard.
CCR storage	TDEC Rule 0400-11-01-.02(1)(b)	Establishes criteria for storing solid waste that is incidental to its recycling, reuse, reclamation, or salvag provided the waste is stored in a manner that minimizes the potential for harm to the public and the environment.	Work activities involving beneficial reuse of waste materials is subject to this standard.
CCR waste disposal	40 CFR 257.50	Establishes minimum solid waste management criteria that do not pose a reasonable probability of adverse effects on health or the environment for coal combustion residuals generated from the combustion of coal at electric utilities and independent power producers.	Transportation and disposal of CCR waste (non- hazardous) is subject to this standard.
Coal ash disposal	Tennessee Code 68-211-106(J)	Requires coal ash waste to be disposed of at a disposal facility that currently has in place or has plans for a liner and a final cap. Allows for the use of coal ash for fill, agricultural use, or engineered uses as a feedstock for the production of a product.	Transportation and disposal of CCR waste (non- hazardous) is subject to this standard.
Solid waste disposal	TDEC Rule 0400-11-01-.01	Requires generators of special solid wastes to make an application for waste evaluation prior to processiong or disposing of wastes.	Disposal of CCR waste (non- hazardous) is subject to this standard.

TABLE 8-1
ALF EAST ASH DISPOSAL AREA REMEDIAL ALTERNATIVE EVALUATION MATRIX

OU 1 - Alternatives										
OU 1 - Alternative 1 - No Action					OU 1 - Alternative 2 - Closure By Removal: Landfill			OU 1 - Alternative 3 - Closure By Removal: Beneficial Reuse & Landfill		
Decision Criteria	Weighting Factor	Raw Score	Weighted Score	Comments	Raw Score	Weighted Score	Comments	Raw Score	Weighted Score	Comments
Overall protection of human health & environment	20%	0	0	Provides no protection, however there are no currently known risks to human health or environment.	9	1.8	Removes the CCR material and transports it to an appropriate landfill. Potential risks with transportation of CCR and construction risks for excavation worker safety.	9	1.8	Removes the CCR material and transports it for beneficial re-use and landfill. Potential risks associated with transportation of CCR and construction risks for excavation worker safety would increase do to longer time frame.
Attains remediation goals & complies with ARARs	25%	0	0	Does not achieve RAOs. Does not comply with ARARs.	10	2.5	Anticipated to achieve all RAOs and comply with ARARs.	10	2.5	Anticipated to achieve all RAOs and comply with ARARs.
Short-term effectiveness	5%	0	0	There is no active remediation, nor any monitoring.	5	0.25	Excavation and transportation is estimated to take 5-7 years to complete, thus short-term effectiveness is minimal.	4	0.2	Excavation and transportation is estimated to take 8-12 years to complete, thus short-term effectiveness is minimal.
Long-term effectiveness	10%	0	0	There is no active remediation, nor any monitoring.	9	0.9	Removes the CCR material and transports it to an appropriate landfill. Anticipated to achieve all RAOs and comply with ARARs in a shorter period of time than Alternative 3.	9	0.9	Removes the CCR material and transports it for beneficial re-use. Anticipated to achieve all RAOs and comply with ARARs, but requires a longer time period than Alternative 2.
Permanently reduces toxicity, mobility, & volume	10%	0	0	There is no active remediation, nor any monitoring.	3	0.3	Removes the CCR material and transports it to an appropriate landfill. No toxicity or volume reduction is anticipated, although landfilling would control mobility.	9	0.9	Removes the CCR material and transports it for beneficial re-use, which decreases the toxicity, mobility and volume.
Ability to be implemented	10%	10	1	There is nothing to implement.	9	0.9	A removal operation is anticipated to be relatively easy to implement at this site.	2	0.2	A removal operation is anticipated to be relatively easy to implement at this site. However, implementing benificial re-use will be challenging as only one facility with limited processing capability has been identified.
Cost	10%	10	1	There are no direct costs.	5	0.5	The estimated cost for this alternative is $297,710,000	2	0.2	The estimated cost for this alternative is $571,874,000
Community concerns addressed	5%	0	0	Very low due to lack of active remediation, lack of monitoring, lack of compliance with ARARs, and failure to enable future land redevelopment.	7	0.35	Addresses concerns by removing the CCR, but potential concerns may arise regarding transportation of CCR including noise, dust, traffic volume, and transportation routes. Project duration (5-7 years) is shorter than Alternative 3, making it more acceptable.	3	0.15	Addresses concerns by removing the CCR, and beneficial re-use may be viewed as favorable. Potential concerns may arise regarding transportation of CCR including noise, dust, traffic volume, and transportation routes. Project duration (8-12 years), is longer than Alternative 2, making this alternative less desirable.
Recycling, residue, & waste minimization	5%	10	0.5	No waste would be generated.	0	0	Recycling, residue and waste minimization opportunities have not been identified for this alternative.	8	0.4	An estimated 75-95% of CCR can be recycled for beneficial re-use, but only one suitable facility has been identified and it has limited processing capacity.
		Total	**2.5**		**Total**	**7.5**		**Total**	**7.25**	

OU 2 - Alternatives							
OU 2 - Alternative 1 - No Action					OU 2 - Alternative 2 - Extraction, Treatment, & Discharge		
Decision Criteria	Weighting Factor	Raw Score	Weighted Score	Comments	Raw Score	Weighted Score	Comments
Overall protection of human health & environment	20%	1	0.2	Provides no protection, however there are no currently known risks to human health or environment. Naturally occurring degradation processes would provide minimal remediation.	8	1.6	Pump and treat systems are a proven technology that have been used effectively at many sites. Extraction will provide hydraulic control to minimize the migration of impacted groundwater.
Attains remediation goals & complies with ARARs	25%	0	0	Does not achieve RAOs. Does not comply with ARARs.	8	2	Anticipated to achieve all RAOs and comply with ARARs. The time frame required to achieve COC levels below MCLs is unknown.
Short-term effectiveness	5%	1	0.05	Naturally occurring degradation processes would provide minimal remediation. Effectiveness would not be monitored.	8	0.4	Short-term results with pump and treat systems tend to be favorable, although effectiveness often tapers off as COC concentrations diminish over time.
Long-term effectiveness	10%	1	0.1	Naturally occurring degradation processes would provide minimal remediation. Effectiveness would not be monitored.	7	0.7	Long-term results with pump and treat systems tend to be favorable, although the time frame required to achieve COC levels below MCLs is unknown.
Permanently reduces toxicity, mobility, & volume	10%	1	0.1	Naturally occurring degradation processes would provide minimal remediation. However, if local groundwater chemistry changes in the future, COCs could remobilize.	9	0.9	Long-term results with pump and treat systems tend to be favorable. Arsenic and lead will be permanently extracted from groundwater.
Ability to be implemented	10%	10	1	There is nothing to implement.	8	0.8	Pump and treat systems are a proven technology. System performance can be modified to account for site-specific conditions. Design plans are currently in progress in the IRA.
Cost	10%	10	1	There are no direct costs.	7	0.7	The estimated cost is $7,403,000 and includes design, installation, and operation and maintenance (O&M) for the first year.
Community concerns addressed	5%	0	0	Very low due to lack of active remediation, lack of monitoring, lack of compliance with ARARs, and failure to enable future land redevelopment.	8	0.4	Addresses site concerns by permanently extracting COCs from groundwater and providing hydraulic control to minimize potential groundwater migration toward sensitive receptors.
Recycling, residue, & waste minimization	5%	10	0.5	No waste would be generated.	5	0.25	Treated water will be routed to the T.E. Maxson Wastewater Treatment Plant.
		Total	**2.95**		**Total**	**7.75**	

TABLE 8-2
SUMMARY OF ALTERNATIVE COST ESTIMATES
OU 1 EAST ASH DISPOSAL AREA

Operable Unit 1 (OU 1): East Ash Disposal Area Class 5 Cost Estimate			
OU 1 Alternative	**Title**	**Cost**	**Weighted Score**
Alternative 1	No Action	Not Applicable	2.5
Alternative 2	East Ash Disposal Area Closure-by-Removal; Disposal of Coal Combustion Residuals in an Off-site Landfill	$297,709,452	7.65
Alternative 3	East Ash Disposal Area Closure-by-Removal; Disposal of Coal Combustion Residuals Materials in an existing SEFA STAR Beneficial Re-Use Process & Off-site Landfill	$571,874,222	6.3

Notes

1. The values represented above are based on general design concepts and have not been vetted with contractor bids

2. The above estimates include design, construction and transportation costs with a 30% construction risk contingency.

3. The Class 5 Estimate, used for screening or feasibility purposes, has an accuracy range of L:-20% to -50%; H: +30% to +100%

TABLE 8-2a
APPROXIMATE COST: OU 1 EAST ASH DISPOSAL AREA
ALTERNATIVE 2

OU 1 Alternative 2

Closure-by-Removal; Disposal of CCR in an Off-site Landfill - Alternative 2 includes excavation of all CCR within the East Ash pond, transporting the CCR to an off-site landfill, bringing in borrow fill to promote positive drainage to the east (away from the USACE Levee), and stabilizing the site with vegetation.

Action Number	Action	Unit Cost	Units	Quantity	Action Cost	Notes
1	Mobilization	$2,148,000	LS	1	$ 2,148,000	Includes mobilization and Contractor project management. Unit cost based on 5% of all other construction items, excluding hauling and landfill tipping fee.
2	Demolition	$750,000	LS	1	$ 750,000	Includes removal of structures, pipes, and utilities within the unit boundary.
3	Clearing, Grubbing, and Stripping	$11,000	AC	30	$ 330,000	Unit cost based on average Contractor bids for stripping cover soil and similar work at various TVA plants.
4	Sanitary Sewer Relocation	$1,000,000	LS	1	$ 1,000,000	Abandonment and relocation of the sewer lines that run under the ash pond.
5	Excavate, Dry, and Load Saturated CCR	$10	TON	2,208,000	$ 22,080,000	Assumes 80% of CCR at unit is saturated and requires drying before it is suitable for loading into haul truck. Unit cost based on Trans Ash FY12/FY13 Contract w/ TVA, adjusted for additional TVA-required on-site staff and other cost increases.
6	Excavate and Load Dry CCR	$8	TON	552,000	$ 4,416,000	Assumes 20% of CCR at unit has been stacked and requires no moisture conditioning. Unit cost based on Trans Ash FY12/FY13 Contract w/ TVA, adjusted for additional TVA-required Project Management on-site staff and other cost increases.
7	Excavate Soil below CCR	$8	TON	288,000	$ 2,304,000	1 foot of soil excavated from below the CCR. Unit cost based on Trans Ash FY12/FY13 Contract w/ TVA for excavating and loading dry CCR.
8	Transport CCR to Landfill	$19.23	TON	3,048,000	$ 58,613,040	Quantity based on total of saturated and dry CCR and excavated soil beneath CCR. Unit cost based on transporting by truck to the Waste Management Landfill in Tunica, MS (approximately 30 mi. from ALF).
9	CCR Disposal	$25	TON	3,048,000	$ 76,200,000	Unit cost based on quote provided by Waste Management in September 2017 for disposal of CCR at its Camden TN Landfill.
10	Grading	$9	CY	53,000	$ 477,000	Utilize onsite soils to grade the Stilling Pond after CCR removal. Unit cost based on Contractor bids from previous TVA project.
11	Borrow Soil	$16	CY	3,255,500	$ 52,088,000	Backfill to pre-removal conditions. Unit cost based on "Potential Borrow Site at the TVA Allen Fossil Plant to Support East and West Pond Closure" by Stantec (2015).
12	Stormwater Management	$18,000	MO	72	$ 1,296,000	Unit cost based on "Closure Evaluation and Cost Estimate For Closure-by-Removal with On-Site Disposal Ash Pond Complex and NRS" by AECOM.
13	Erosion & Sediment Control and Site Stabilization	$7,000	AC	108	$ 756,000	Stabilization includes soil amendments, seed, mulch, and fertilizer. Unit cost based on Contractor bids from previous TVA project.
				Construction Subtotal	**$ 222,458,040**	
				30% Construction Risk	**$ 66,737,412**	
				Construction Subtotal with Risk	**$ 289,195,452**	
14	Engineering Design	$2,088,000	LS	1	$ 2,088,000	Phase 1 and 2 Engineering costs provided by Stantec November 16 2017.
15	Construction Support	$126,000	MO	72	$ 5,292,000	Unit cost based on TVA's estimate using both internal and external partners, based on 100% coverage per month by duration of project.
16	Project Management	$27,000	MO	72	$ 1,134,000	Unit cost based on TVA's estimate using both internal and external partners, based on 100% coverage per month by duration of project.
				Project Support Subtotal	**$ 8,514,000**	
				Total Cost of Closure	**$ 297,709,452**	

TABLE 8-2b
APPROXIMATE COST: OU 1 EAST ASH DISPOSAL AREA
ALTERNATIVE 3

OU 1 Alternative 3

Closure-by-Removal; Disposal of CCR Materials in a Beneficial Re-Use Process & Off-site Landfill - Alternative 3 includes excavation of all CCR within the East Ash pond, excavating and screening CCR, hauling screening rejects to an offsite landfill, then hauling the screened CCR to an existing SEFA STAR Beneficial Re-Use plant (Lexington, South Carolina). After CCR removal, closure work includes bringing in borrow fill to promote positive drainage to the east (away from the USACE Levee) and stabilizing the site with vegetation

Action Number	Action	Unit Cost	Units	Quantity	Action Cost	Notes
1	Mobilization	$2,510,000	LS	1	$ 2,510,000	Includes mobilization, Contractor project management, truck scales and screening equipment. Unit cost based on 5% of all other construction items, excluding hauling, disposal fees, and borrow soil.
2	Demolition	$750,000	LS	1	$ 750,000	Includes removal of structures, pipes, and utilities within the unit boundary.
3	Clearing, Grubbing, and Stripping	$11,000	AC	30	$ 330,000	Unit cost based on average Contractor bids for stripping cover soil and similar work at various TVA plants.
4	Sanitary Sewer Relocation	$1,000,000	LS	1	$ 1,000,000	Abandonment & relocation of the sewer lines that run under the ash pond.
5	Excavate, Dry, Screen, and Load Saturated CCR	$12	TON	2,208,000	$ 26,496,000	Assumes 80% of CCR at unit is saturated and requires drying before it is suitable for loading into haul truck. Unit cost based on Trans Ash FY12/FY13 Contract w/ TVA, adjusted for additional TVA-required on-site staff and other cost increases. Screening costs based on 2018 RSMeans.
6A	Excavate, Screen, and Load Dry CCR	$10	TON	552,000	$ 5,520,000	Assumes 20% of CCR at unit has been stacked and requires no moisture conditioning. Unit cost based on Trans Ash FY12/FY13 Contract w/ TVA, adjusted to account for additional TVA-required Project Management on-site staff and other cost increases. Screening costs based on 2018 RSMeans.
6B	Excavate Soil below CCR	$8	TON	288,000	$ 2,304,000	1 foot of soil excavated from below the CCR. Unit cost based on Trans Ash FY12/FY13 Contract w/ TVA for excavating and loading dry CCR.
7A	Haul Screening Rejects and Soil to Offsite Landfill	$19.23	TON	978,000	$ 18,806,940	Quantity based on 25% of the total of saturated and dry CCR and excavated soil beneath CCR. Unit cost based on transporting by truck to the Waste Management Landfill in Tunica, MS (approximately 30 mi. from ALF).
7B	Haul Screened CCR to existing SEFA STAR	$105	TON	2,070,000	$ 216,315,000	Quantity based on 75% of the total of saturated and dry CCR. Assumes using 20 ton capacity trucks ($110/hour, provided by Trans Ash), hauling 1200 miles roundtrip (19 hours). Estimated SEFA STAR (existing facility in Lexington, South Carolina) capacity capped at 240,000 ton/year.
8A	Screening Rejects and Soil Disposal	$25	TON	978,000	$ 24,450,000	CCR screening rejects will be hauled and placed in an off-site landfill located within 20 miles of the plant. The landfill disposal fee used in this cost estimate ($25/ton) was provided by Waste Management in September 2017 for disposal of CCR and coal fines at its existing Camden TN Landfill.
8B	SEFA Tipping Fee	$35	TON	2,070,000	$ 72,450,000	A tipping fee of $35/ton will be applied when the CCR is delivered to the existing SEFA STAR plant. This rate has been provided by TVA.
9	Grading	$9	CY	53,000	$ 477,000	Utilize onsite soils to grade the Stilling Pond after CCR removal. Unit cost based on Contractor bids for grading on another TVA project.
10	Borrow Soil	$16	CY	3,255,500	$ 52,088,000	Quantity is to backfill to pre-removal conditions. Unit cost based on "Potential Borrow Site at the TVA Allen Fossil Plant" by Stantec (2015).
11A	Stormwater Management	$18,000	MO	104	$ 1,863,000	Unit cost based on "Closure Evaluation and Cost Estimate For Closure-by-Removal with On-Site Disposal Ash Pond Complex and NRS" by AECOM.
11B	Erosion & Sediment Control and Site Stabilization	$7,000	AC	108	$ 756,000	Stabilization includes soil amendments, seed, mulch, and fertilizer. Unit cost based on Contractor bids from previous TVA project.
Construction Subtotal					**$ 426,115,940**	
30% Construction Risk					**$ 127,834,782**	
Construction Subtotal with Risk					**$ 553,950,722**	
12	Engineering Design	$2,088,000	LS	1	$ 2,088,000	Phase 1 and 2 Engineering costs provided by Stantec November 16 2017.
13	Construction Support	$126,000	MO	104	$ 13,041,000	Unit cost based on TVA's estimate using both internal and external partners, based on 100% coverage per month by duration of project. Months governed by SEFA STAR capacity of 240,000 ton/year
14	Project Management	$27,000	MO	104	$ 2,794,500	Unit cost based on TVA's estimate using both internal and external partners, based on 100% coverage per month by duration of project.
Project Support Subtotal					**$ 17,923,500**	
Total Cost of Closure					**$ 571,874,222**	

TABLE 8-3
SUMMARY OF ALTERNATIVE COST ESTIMATES
OU 2 GROUNDWATER

Operable Unit 2 (OU 2): Groundwater Class 5 Cost Estimate		
OU 2 Alternative	**Title**	**Cost**
Alternative 1	No Action	Not Applicable
Alternative 2	Extraction, Treatment and Discharge to the City of Memphis WWTP	$7,403,066

Notes

1. The values represented above are based on general design concepts and have not been vetted with contractor bids

2. Permit fees (Well and City) have been based on previous experience and may not be consistent with local permit fees

3. The above estimate value percentage variation (-30% - +70%) of actual costs after application of contingency (25%)

4. The above estimates include design, construction and operation and maintenance costs (1 year)

5. The Class 5 Estimate, used for screening or feasibility purposes, has an accuracy range of L:-20% to -50%; H: +30% to +100%

TABLE 8-3a
APPROXIMATE COST: OU 2 GROUNDWATER
ALTERNATIVE 2

OU 2 Alternative 2

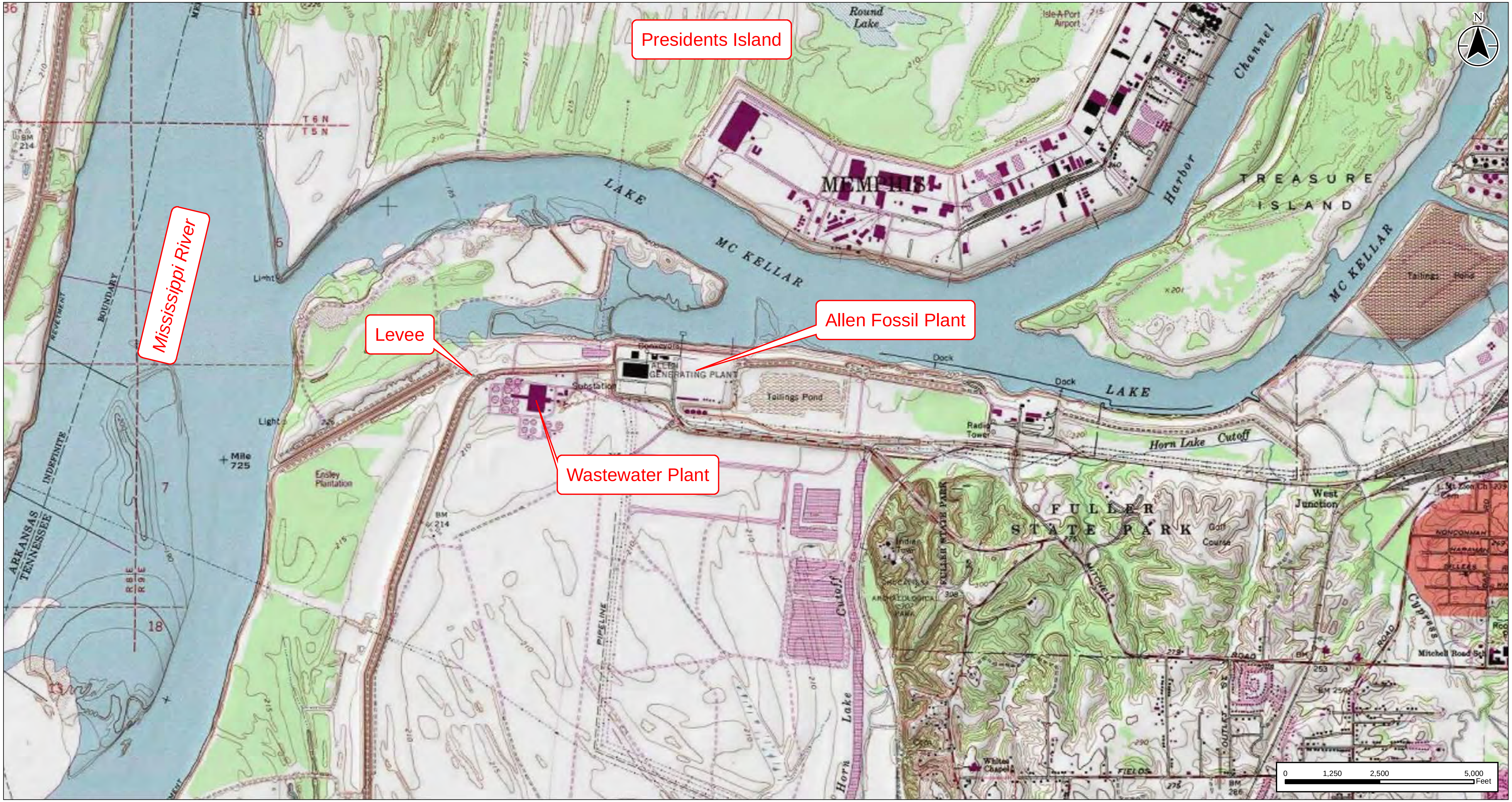
Extraction, Treatment and Discharge to the City of Memphis WWTP - Groundwater will be collected using extraction wells and down well pumps, which capture groundwater and pass the water through a pipe network connected to an above-grade treatment system. The treatment system will consist of stage tanks, process pumps, sediment filtration, the addition of ferric chloride and potential HCl for arsenic treatment and pH adjustment, flow meters and pH meters. Treated groundwater will be discharged to the City of Memphis Waste Water Treatment Plant (WWTP).

Action Number	Action	Unit Cost	Units	Quantity	Action Cost
1	Design and Construction Oversight Services	$538,973	LS	1	$538,973
2	Quality Assurance and Project Management Services	$47,608	LS	1	$47,608
3	Mobilization	$1,200	EA	5	$6,000
4	Well Drilling	$10,000	EA	8	$80,000
5	Well Pump Purchase	$1,500	EA	57	$85,500
6	Treatment System Installation	$1,955,000	LS	1	$1,955,000
7	Treatment System Components (Filtration System and Electrical Infrastructure)	$2,340,000	LS	1	$2,340,000
8	Treatment System Chemicals (40% FeCL Solution)	$750	TN	14	$10,730
9	Laboratory Analytical	$5,000	EA	2	$10,000
10	Hazardous Material Disposal	$2,000	DM	8	$16,000
11	Well Installation and Treatment System Markup (10%)				$450,323
12	Permit Fees (Wells and City)	$43,500	LS	1	$43,500
13	Treated Groundwater Discharge Fee	$0.005	GAL	60,812,600	$304,063
14	Permitting and Discharge Fee Markup (10%)				$34,756
				Subtotal	$5,922,453
				Contingency (25%)	$1,480,613
				Total (1 year of operation)	**$7,403,066**

Alternative Assumptions:

1	Costs shown are approximate within 25% of actual costs
2	Does not include installation of additional monitoring wells to monitor system effectiveness
3	10% markup included on Subconsultant costs
4	Approximate Costs estimated here based on industry experience
5	Vertical well installation and drilling will be performed over a one month period.
6	Stantec reporting includes one final report covering installation and first year of operation
7	Costs include 1 year of operation and maintenance fees

FIGURES



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Revised: 2017-12-18 By: ltrujillo

December 2017

Stantec

Notes
1. Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
2. Topographic data: ESRI Online

Client/Project
Tennessee Valley Authority
Allen Fossil Plant
Memphis, Shelby County, Tennessee

Figure No.
1-1

Title
Allen Fossil Plant and Surrounding Area Location Map

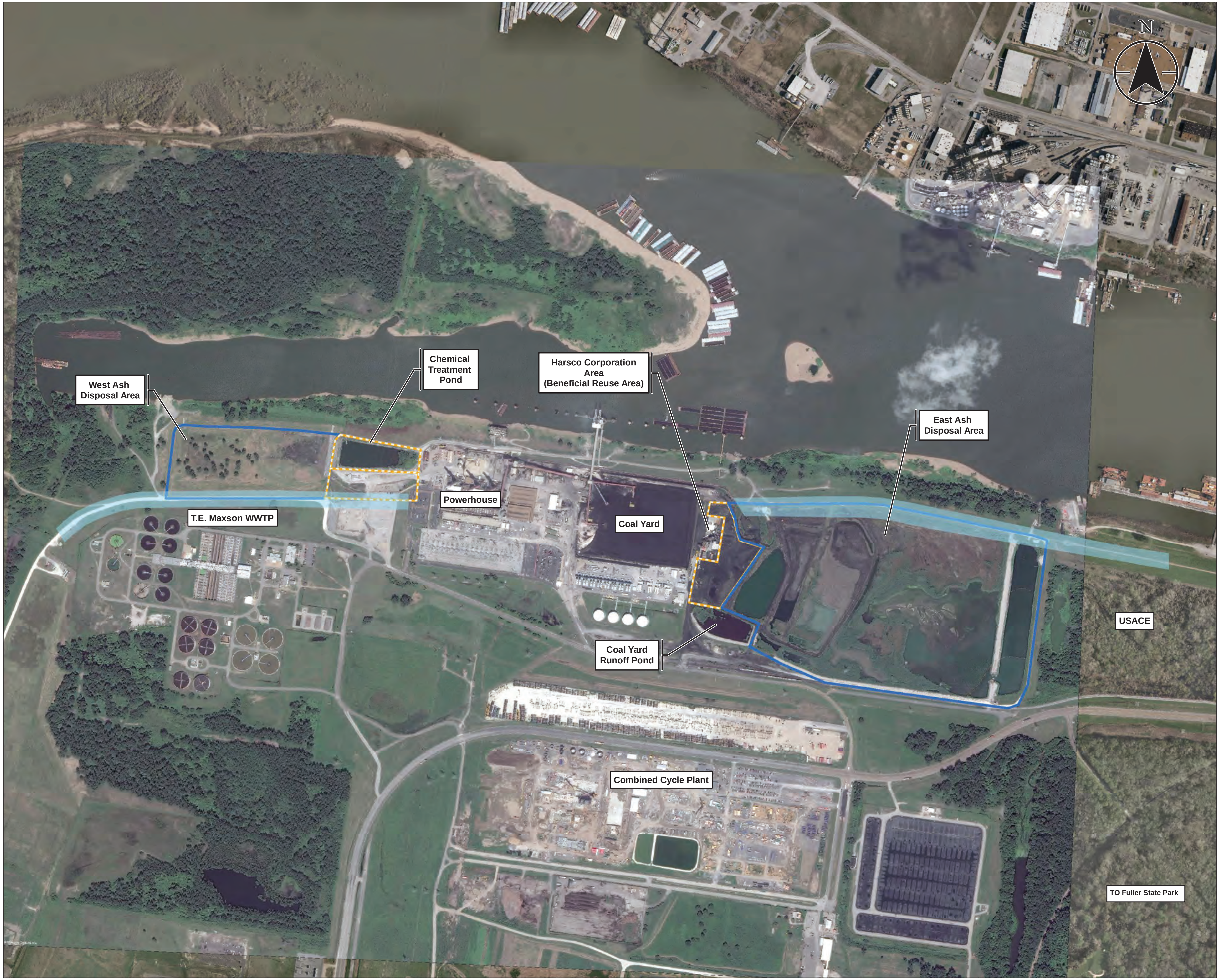

Figure No.

1-2

Title

Allen Fossil Plant Site Plan

Client/Project

Tennessee Valley Authority
Allen Fossil Plant

Project Location

Memphis, Tennessee

175577013
Prepared by LT on 2019-02-07
Technical Review by JJ on 2019-02-07

0 400 800 1,200 1,600 Feet
1:4,800 (At original document size of 22x34)

Legend

🟦	Levee
▭	Current Impoundment (Approximate)
⬚	Former Disposal Area (Approximate)

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by Terraserver (2016) & TVA (2015)
3. The West Ash Disposal Area does not impound water; therefore, a water surface elevation is not applicable to the West Ash Disposal Area.
4. The water surface elevation for the East Ash Disposal Area is referenced to the National Geodetic Vertical Datum of 1929.
5. TVA property boundary is referenced from TVA Drawing 421 P 504 Allen Fossil Plant Reservation.

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Figure No.
1-3

Title

Allen Fossil Plant Property Boundaries

Client/Project

Tennessee Valley Authority
Allen Fossil Plant

Project Location
Memphis, Tennessee

175577013
Prepared by LT on 2017-12-21
Technical Review by JJ on 2017-12-21

0 400 800 1,200 1,600 Feet
1:4,800 (At original document size of 22x34)

Legend

🟦	Levee
▨	TVA Property Boundary

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by Terraserver (2016) & TVA (2015)
3. The West Ash Disposal Area does not impound water; therefore, a water surface elevation is not applicable to the West Ash Disposal Area.
4. The water surface elevation for the East Ash Disposal Area is referenced to the National Geodetic Vertical Datum of 1929.
5. TVA property boundary is referenced from TVA Drawing 421 P 504 Allen Fossil Plant Reservation.

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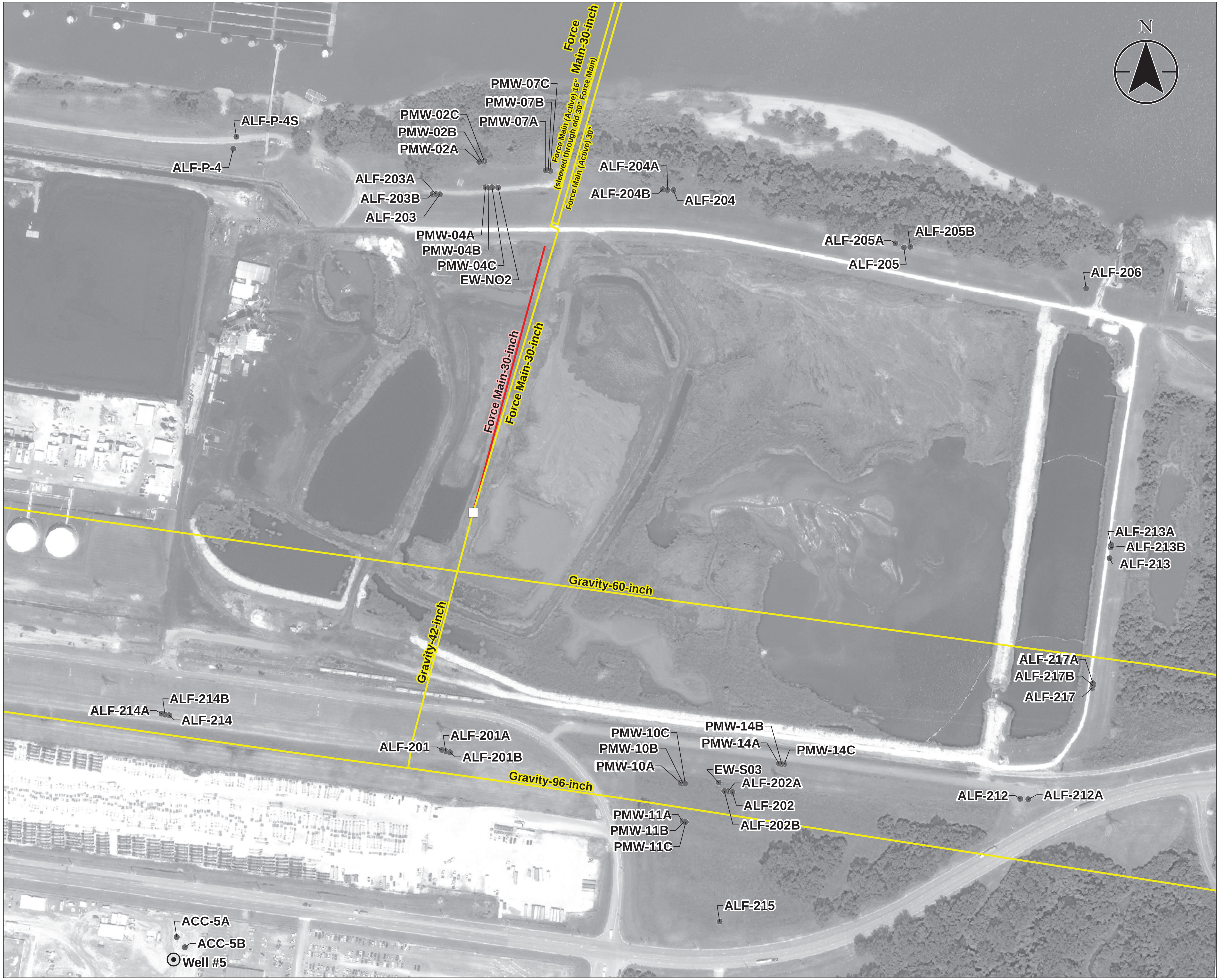

Figure No.
2-1

Title

Location of Sewer Lines Underlying East Ash Disposal Area

Client/Project
Tennessee Valley Authority
Allen Fossil Plant

Project Location
Memphis, Tennessee

175577013
Prepared by LT on 2019-01-30
Technical Review by JJ on 2019-01-30

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1:1,800 (At original document size of 22x34)

Legend

● Monitoring Well, Extraction Well (EW) or Performance Monitoring Well (PMW)

⊙ Production Well (Memphis Sand)

— Active Sewer

— Inactive Sewer

☐ Sewer Manhole Location of Force Main Transition to Gravity

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TerraServer (2016)

U:\TVA-EIP\175567295\gis\mxds\ACC\ALF_2-3_Location_of_Sewer_Lines_East_Ash_Pond.mxd Revised: 2019-01-30 By: mbough

Figure No.
2-2

Title

Geologic Cross Section Location Map – East Ash Disposal Area

Client/Project

Tennessee Valley Authority
Allen Fossil Plant

Project Location

Memphis, Tennessee

175578046
Prepared by MB on 2020-08-25
Technical Review by BT on 2020-08-25

0 350 700 1,050 1,400 Feet
1:4,200 (At original document size of 22x34)

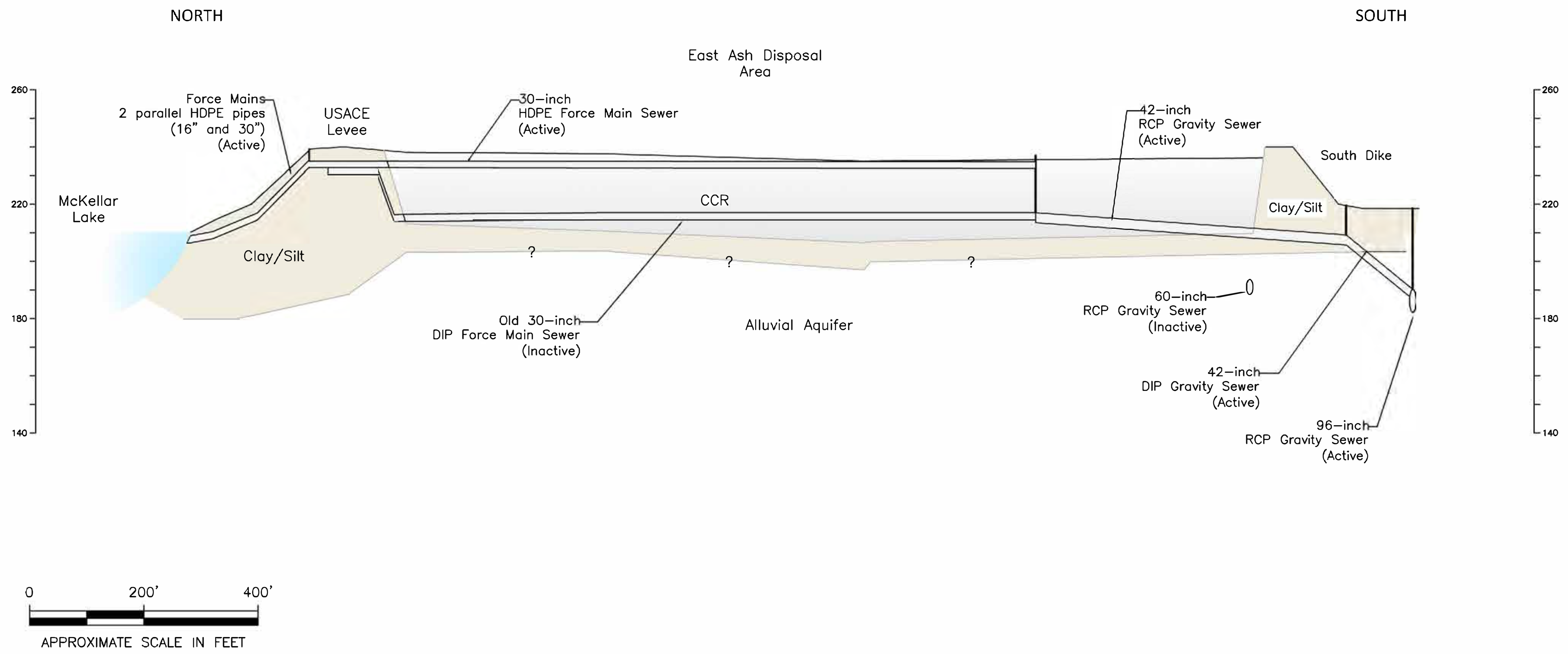
Legend

●	Extraction Well (EW) or Performance Monitoring Well (PMW)
●	Deep Stratigraphic Boring
⊙	Production Well (Memphis Sand)
C-C' D-D'	Cross Section East-West
⊕	Shallow Well
⊕	Intermediate Well (B-Series)
⊕	Deep Well (A-Series)
☐	Sewer Manhole Location of Force Main Transition to Gravity
☐	2019 Imagery Boundary

Notes
1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2018-03-15 and 2019-06-04)

Stantec TVA

U:\TVA-EIP\175567295\gis\mxds\ACC\ALF_2_2_Geologic_CrossSection_Location_EADA.mxd Revised: 2020-08-25 By: mbough



Legend

▭ CCR
▭ Clay/Silt – Observed lean to fat clay; silt
▭ Alluvial Aquifer – Sand, gravel, silt and clay

Notes

Sewer pipe elevations and locations are projected and approximate.

Stantec

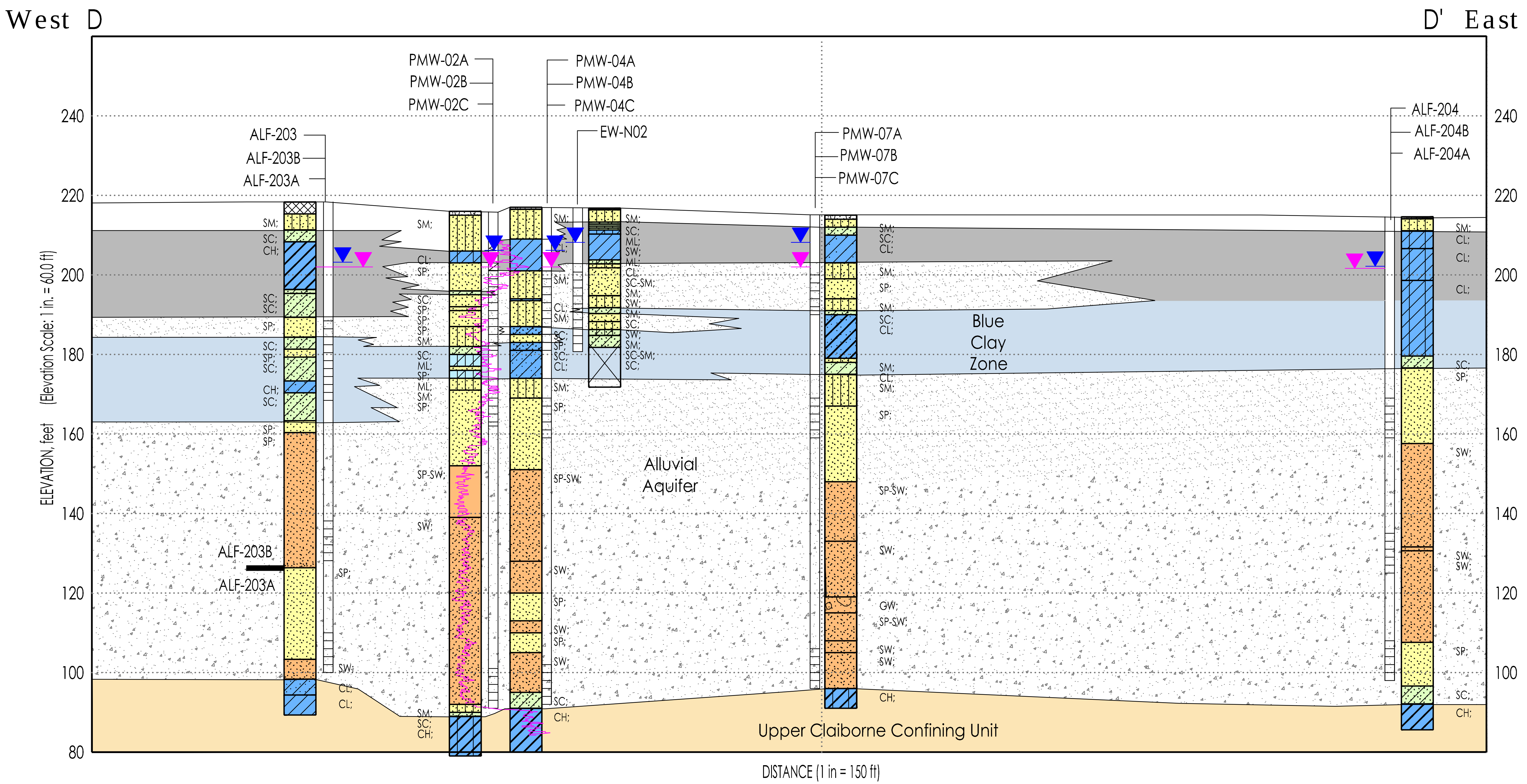
Project Location
Allen Fossil Plant - Memphis, TN

Client/Project
TVA - ALF
175577013

Figure No.
2-3

Title
Cross-Section of Sewers Underlying East Ash Disposal Area

U:\175577013\tva\01 - Allen Facility (ALF)\07 - Geologic Cross Sections\NS Cross Section (8-22-17)\TVA ALF - NS Cross Section (01-29-19) - VSewer.dwg
2019/02/13 11:57 AM By: Toth, Brody



Legend

- ▦ Asphalt
- ▨ Clay (CL)
- ▥ Clayey Silt (MH)
- ▥ Sandy Silt (ML)/Silty Sand (SM)
- ▩ Fill
- ▨ Clay with Sand (CL)
- ▥ Clayey Silt with Sand (ML)
- ▨ Clayey Sand (SC)
- ▨ Clay (CH)
- ▨ Silty Clay (CL)
- ▥ Silt (ML)
- ▥ Sand with Clay (SP-SC)
- ▥ Sand with Silt (SP-SM)
- ▤ Sand (SP)
- ▤ Sand with Gravel (SP or SW)
- ▥ Silt with Sand (ML)
- ☒ No Recovery
- ⌇ Gamma Log
- — — — Approximate Stratigraphic Contact
- ▯ Elevation of well screened intervals (screens of well sets are depicted in a single column, but are actually closely spaced and separate well installations)
- ▼ Shallow Alluvial Aquifer Groundwater Elevation (December 26, 2018) at McKellar Lake Elevation of 203.55 ft msl
- ▼ Intermediate Alluvial Aquifer Groundwater Elevation (December 26, 2018) at McKellar Lake Elevation of 203.55 ft msl

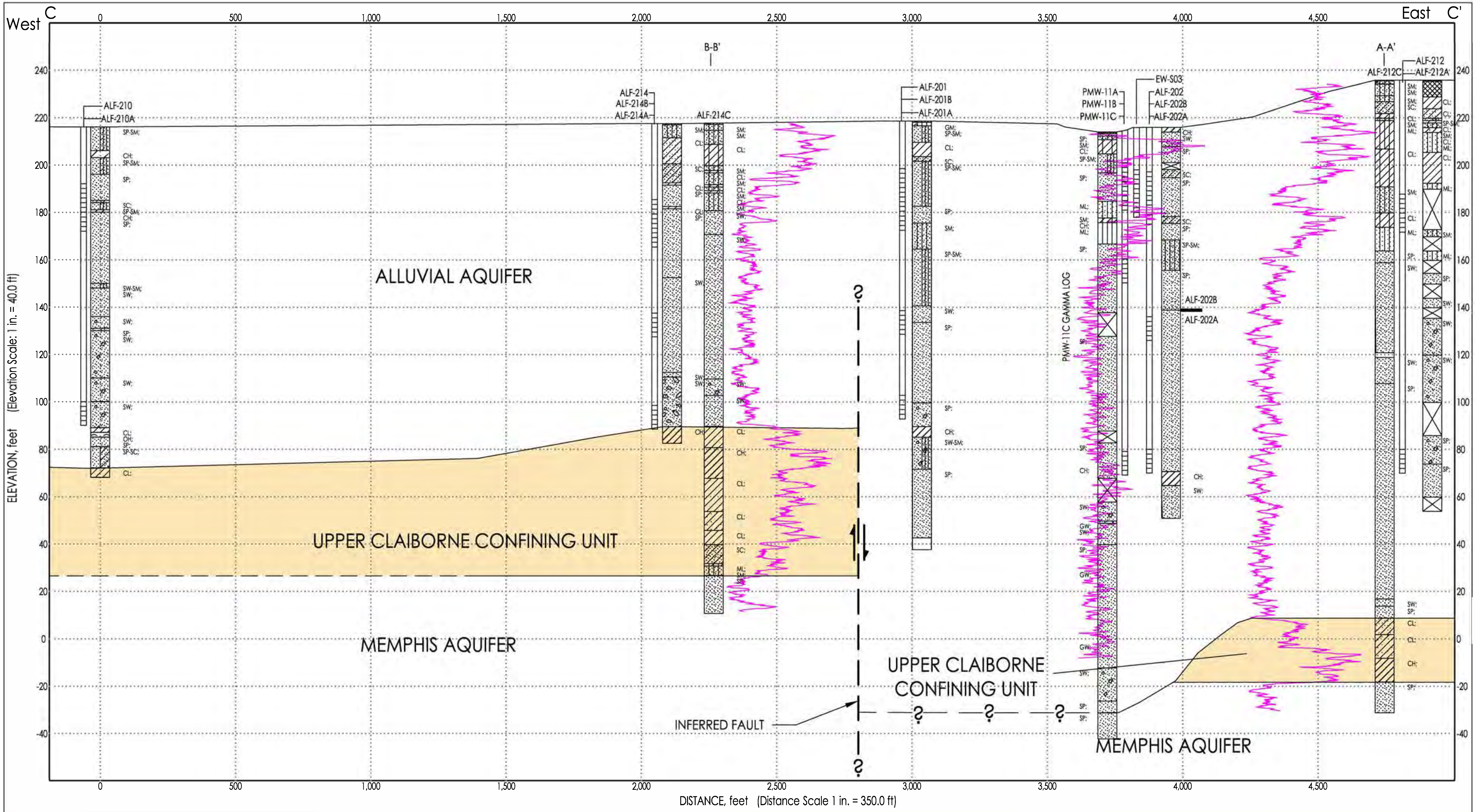
Stantec

Figure No.
2-4

Title
Geologic Cross-Section D-D'
North Boundary of EADA

Client/Project
TENNESSEE VALLEY AUTHORITY
ALLEN FOSSIL PLANT

U:\213402945\TVA\TVA - Allen\3A. RIR REVISED\NEW Maps\CADD\GEO XSECs\RIR GEO XSECs NORTH_SOUTH 2018.dwg
2019/02/21 9:02 AM By: Nolan, Vincent



Legend

- ▨ Asphalt
- ▨ Clay (CL)
- ▨ Clayey Silt (MH)
- ▨ Sandy Silt (ML)/Silty Sand (SM)
- ▨ Organic Silt / Clay (OH)
- ▨ Fill
- ▨ Clay with Sand (CL)
- ▨ Clayey Silt with Sand (ML)
- ▨ Clayey Sand (SC)
- ▨ Clay (CH)
- ▨ Silty Clay (CL)
- ▨ Silt (ML)
- ▨ Sand with Clay (SP-SC)
- ▨ Sand with Silt (SP-SM)
- ▨ Sand (SP)
- ▨ Sand with Gravel (SP or SW)
- ▨ Silt with Sand (ML)
- ☒ No Recovery
- ∿ Gamma Log
- — — — Approximate Stratigraphic Contact
- ▯ Elevation of well screened intervals (screens of well sets are depicted in a single column, but are actually closely spaced and separate well installations)

Notes

1. THE UPPER CLAIBORNE CONFINING UNIT CAN BE COMPOSED OF SEVERAL DIFFERENT FORMATIONS, INCLUDING THE COOK MOUNTAIN FORMATION.

Stantec

Project Location
MEMPHIS, TENNESSEE

Client/Project 175577013
TENNESSEE VALLEY AUTHORITY
ALLEN FOSSIL PLANT

Figure No.
2-5

Prepared by VEN 2017-09-19

Title **GEOLOGIC CROSS SECTION C-C'**
SOUTH BOUNDARY OF EADA

U:\213402945\TVA\TVA - Allen\2. CROSS-SECTIONS\2018 Revisions\175577013-01.dwg
2019/02/21 8:18 AM By: Nolan, Vincent

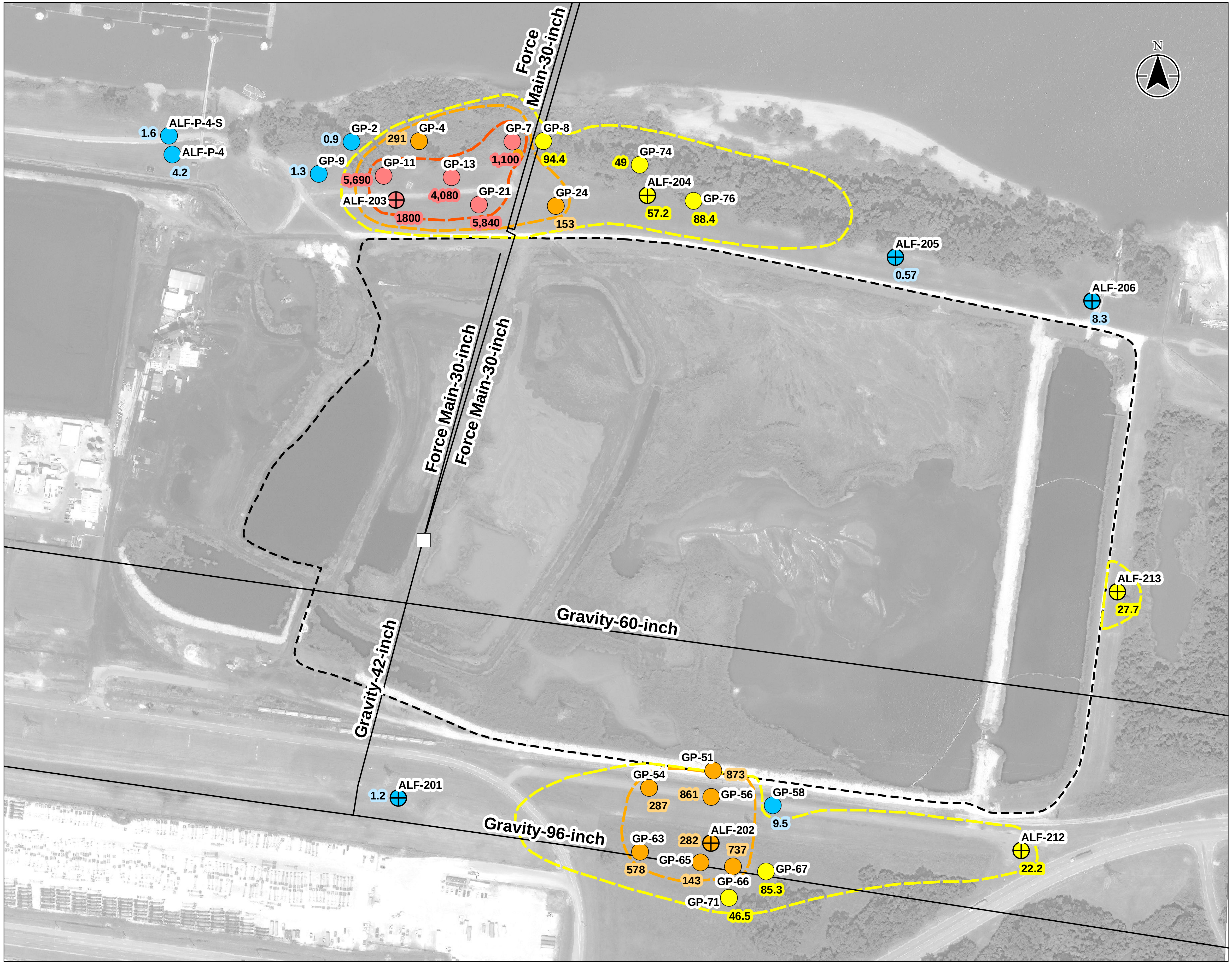


Figure No.
3-1

Title
Arsenic Groundwater Sample Concentrations (June-November 2017)

Client/Project
Tennessee Valley Authority
Allen Fossil Plant

Project Location
Memphis, Tennessee

175577013

Prepared by LT on 2019-02-14
Technical Review by JJ on 2019-02-14

0 300 600
Feet

1:3,600 (At original document size of 11x17)

Legend

Geoprobe Locations
- ● Less than 10 ug/L (Arsenic MCL)
- ● 10 to 100 ug/L
- ● 100 to 1,000 ug/L
- ● Greater than 1,000 ug/L

Monitoring Wells
- ⊕ Less than 10 ug/L (Arsenic MCL)
- ⊕ 10 to 100 ug/L
- ⊕ 100 to 1,000 ug/L
- ⊕ Greater than 1,000 ug/L

- Sewer
- East Ash Pond Boundary

Concentration Areas
- Approximate area above 1000 ug/L
- Approximate area above 100 ug/L
- Approximate area above 10 ug/L
- ☐ Manhole Location of Force Main Transition to Gravity Sewer

*DPT Location (June - August 2017 data)
Permanent monitoring wells (November 2017 data)

*The highest concentration from each direct-push (DPT) sampling location is shown regardless of depth

*Samples from DPT locations were filtered

*Samples from permanent monitoring wells were not filtered

Notes
1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TerraServer (2016)
3. Concentrations reported in micrograms per liter (ug/L)

Stantec TVA

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Figure No.
3-2

Title

Fluoride Groundwater Sample Concentrations (June-November 2017)

Client/Project
Tennessee Valley Authority
Allen Fossil Plant

Project Location
Memphis, Tennessee

175577013
Prepared by LMB on 2019-02-14
Technical Review by BT on 2019-02-14

0 300 600 Feet
1:3,600 (At original document size of 11x17)

Legend

Geoprobe Locations

- ● <4 mg/L (Fluoride MCL)
- ● >4 mg/L

Monitoring Wells

- ⊕ <4 mg/L (Fluoride MCL)
- ⊕ >4 mg/L
- — Sewer
- ▭ East Ash Pond Boundary
- ▭ Approximate area above 4 mg/L
- ☐ Manhole Location of Force Main Transition to Gravity Sewer

*DPT Location (June - August 2017 data)
Permanent monitoring wells (November 2017 data)

*The highest concentration from each direct-push (DPT) sampling location is shown regardless of depth

*Samples from DPT locations were filtered

*Samples from permanent monitoring wells were not filtered

Notes
1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TerraServer (2016)
3. Concentrations reported in milligrams per liter (mg/L)

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Figure No.
3-3

Title
Lead Groundwater Sample Concentrations (June-November 2017)

Client/Project
Tennessee Valley Authority
Allen Fossil Plant

Project Location
Memphis, Tennessee

175577013
Prepared by LMB on 2019-02-14
Technical Review by BT on 2019-02-14

0 300 600
Feet
1:3,600 (At original document size of 11x17)

Legend

Geoprobe Locations
- ● <15 ug/L (Lead MCL)
- ● >15 ug/L

Monitoring Wells
- ⊕ <15 ug/L (Lead MCL)
- ⊕ >15 ug/L
- — Sewer
- ▭ East Ash Pond Boundary
- ▭ Approximate area above 15 ug/L
- ☐ Manhole Location of Force Main Transition to Gravity Sewer

*DPT Location (June - August 2017 data)
Permanent monitoring wells (November 2017 data)

*The highest concentration from each direct-push (DPT) sampling location is shown regardless of depth

*Samples from DPT locations were filtered

*Samples from permanent monitoring wells were not filtered

Notes
1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TerraServer (2016)
3. Concentrations reported in micrograms per liter (ug/L)

Stantec

TVA

U:\TVA-EIP\175567295\gis\mxds\ACC\Figure6_14_Series\ALF_Fig6-14C_Filtered_Lead.mxd Revised: 2019-02-14 By: LBlackman

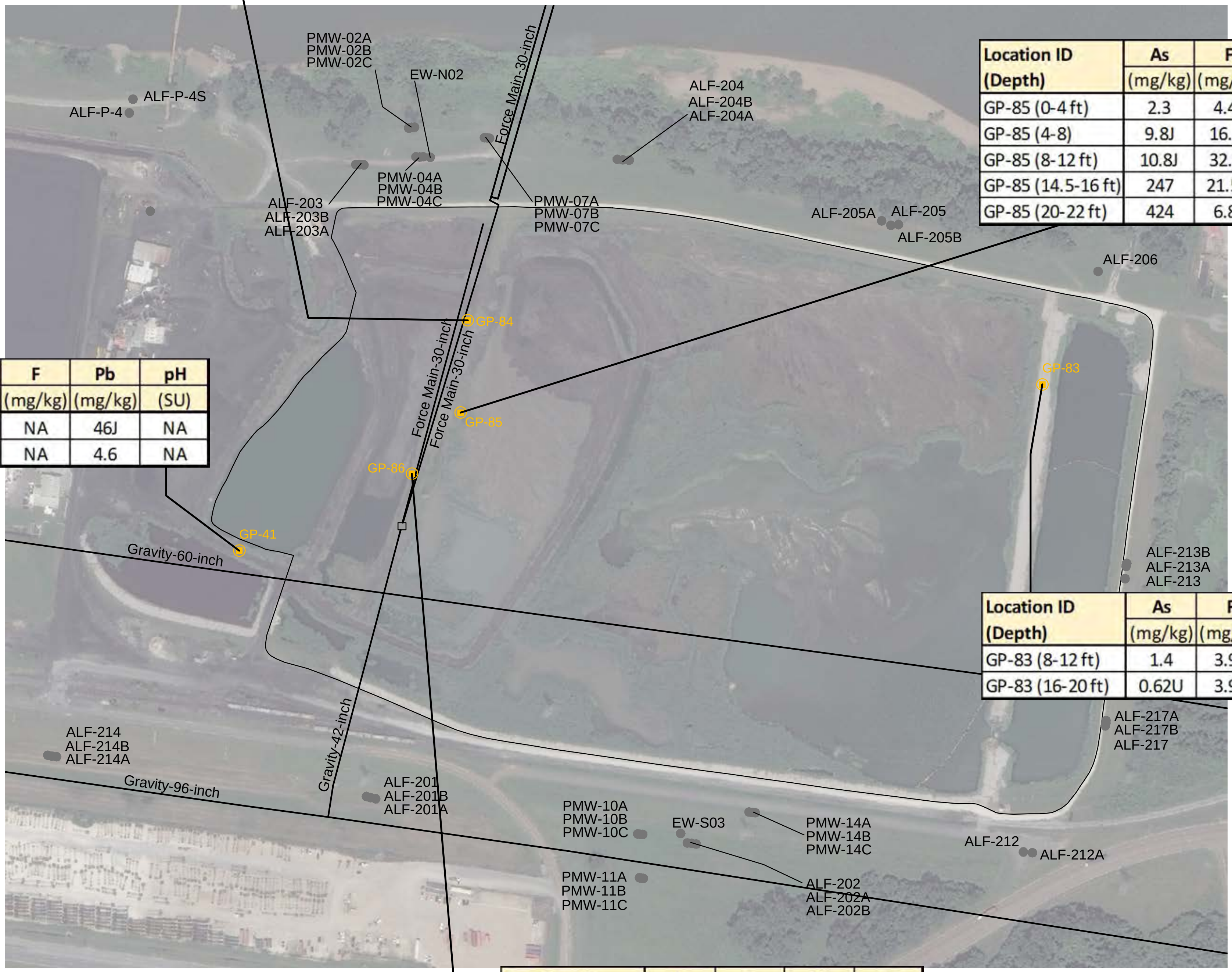
Figure No.
3-4

Title

Arsenic, Fluoride, Lead, and pH Concentrations in Ash

Client/Project

TENNESSEE VALLEY AUTHORITY
ALLEN FOSSIL PLANT



Location ID (Depth)	As (mg/kg)	F (mg/kg)	Pb (mg/kg)	pH (SU)
GP-84 (1.1-8 ft)	50.1	10.90	57.9	11.1
GP-84 (8-10 ft)	0.98UJ	9.5J	1.1J	11.0
GP-84 (16-20 ft)	230	24.7U	344	9.3
GP-84 (20.5-22 ft)	22.5	3.9U	4.1	8.4

Location ID (Depth)	As (mg/kg)	F (mg/kg)	Pb (mg/kg)	pH (SU)
GP-85 (0-4 ft)	2.3	4.40	4.2	9.1
GP-85 (4-8)	9.8J	16.7J	32J	10.8
GP-85 (8-12 ft)	10.8J	32.4J	36.4	9.8
GP-85 (14.5-16 ft)	247	21.5U	207	8.7
GP-85 (20-22 ft)	424	6.80	147	8.3

Location ID (Depth)	As (mg/kg)	F (mg/kg)	Pb (mg/kg)	pH (SU)
GP-41 (7.5 ft)	67.8J	NA	46J	NA
GP-41 (22.5 ft)	10.4	NA	4.6	NA

Location ID (Depth)	As (mg/kg)	F (mg/kg)	Pb (mg/kg)	pH (SU)
GP-83 (8-12 ft)	1.4	3.9U	0.28	7.4
GP-83 (16-20 ft)	0.62U	3.9U	0.19	8.8

Location ID (Depth)	As (mg/kg)	F (mg/kg)	Pb (mg/kg)	pH (SU)
GP-86 (0-4 ft)	19.9	6.50	43.2	10.2
GP-86 (4-8 ft)	19.6	8.10	43.6	10.8
GP-86 (8-12 ft)	14.9	5.80	29.8	11.4
GP-86 (12-16 ft)	3.5	9.00	7.6	11.3
GP-86 (20-21 ft)	122J	6.5J	94.2J	10.9
GP-86 (21-22 ft)	190	7.00	134	10.5

N

0 400’ 800’

Legend

●	Groundwater Monitoring Well (Alluvial Aquifer) (ALF-, EW-, and PMW- series wells)
◉	DPT Ash Sample Location
—	Sanitary Sewer Pipes
☐	Sewer Manhole Location of Force Main Transition to Gravity

Depths reported in feet (ft) below ground surface (bgs).
mg/kg - milligrams per kilogram
J - The result is estimated
U - The analyte was not detected above the indicated reporting limit
Laboratory pH measurements are estimated due to holding time
SU - Standard Units (pH)
NA - Not Analyzed

Notes

1. Coordinate System: GCS WGS 1984
2. Imagery provided by TerraServer (2016)
3. Existing monitoring wells are referenced from TVA Drawing 10W858-03 Allen Fossil Plant Reservation

Stantec

U:\213402945\TVA\TVA - Allen\3A. RIR REVISED\NEW Maps\CADD\As Fl Pb PH In Ash.dwg
2019/01/30 11:07 AM By: Nolan, Vincent

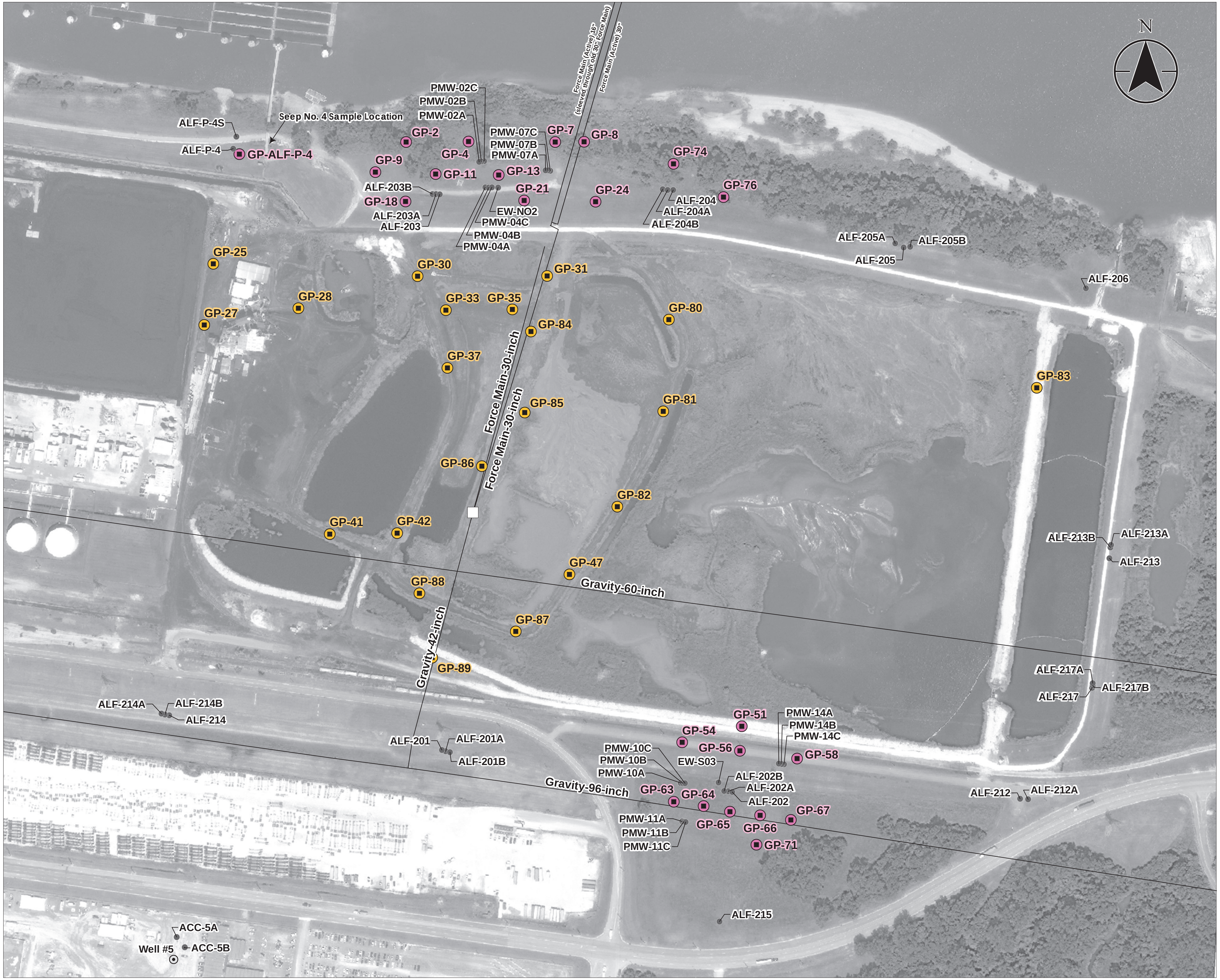


Figure No.

3-5

Title

RI Boring Locations for Groundwater, Pore Water and Ash Sampling

Client/Project

Tennessee Valley Authority
Allen Fossil Plant

Project Location

Memphis, Tennessee

175577013
Prepared by LT on 2019-01-31
Technical Review by JJ on 2019-01-31

0 150 300 450 600 Feet

1:1,800 (At original document size of 22x34)

Legend

- ● Monitoring Well, Extraction Well (EW) or Performance Monitoring Well (PMW)
- ⊙ Production Well (Memphis Sand)
- ▣ DPT Pore Water
- ▣ DPT Groundwater
- — Sanitary Sewer Pipes
- ☐ Manhole Location of Force Main Transition to Gravity Sewer

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TerraServer (2016)

U:\TVA-EIP\175567295\gis\mxds\ACC\ALF_3-1_DPTs_GW_PW_AS.mxd Revised: 2019-01-31 By: mbough

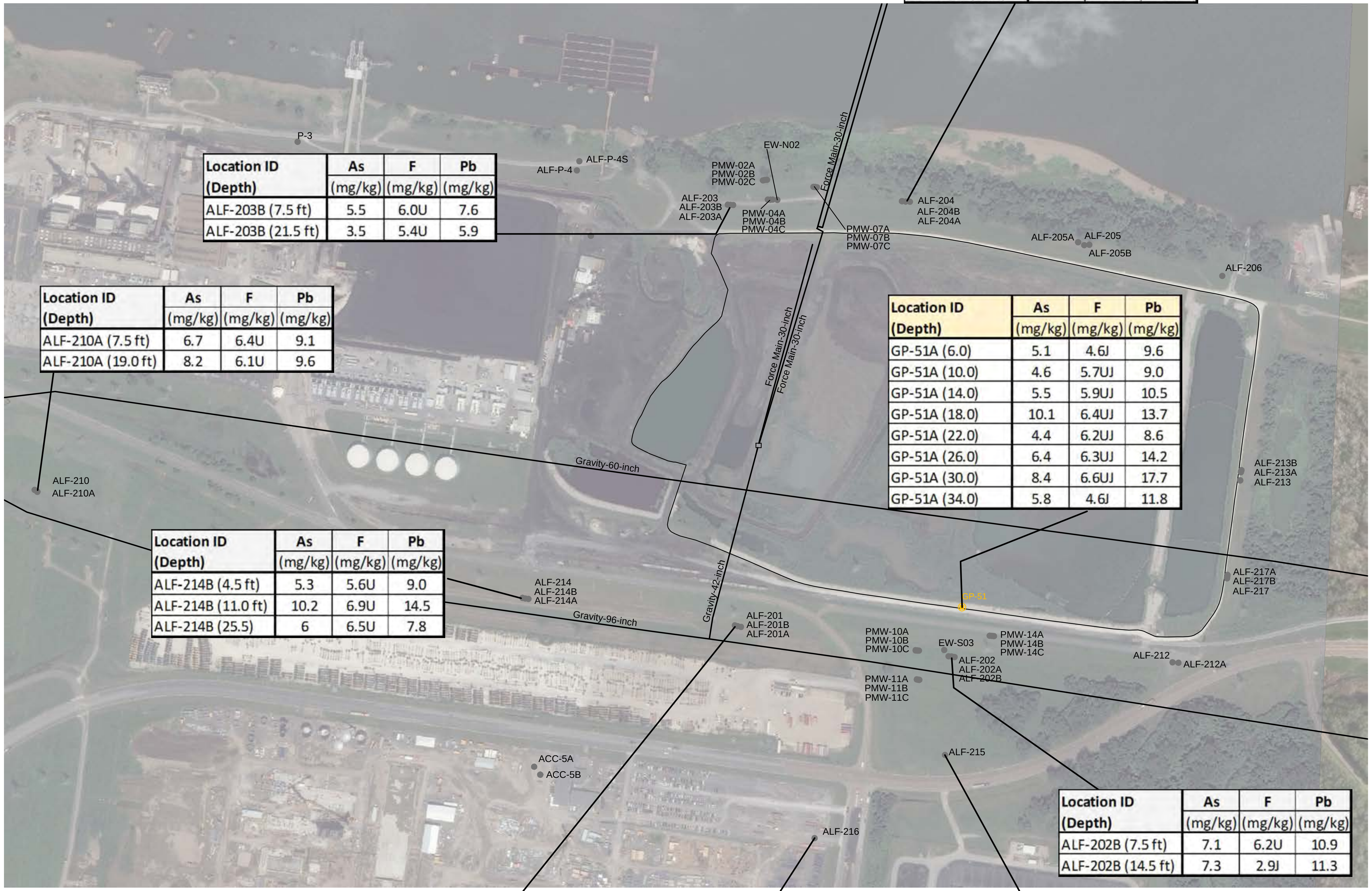
Figure No.
3-6

Title

Arsenic, Fluoride, and Lead Concentrations in Soil

Client/Project

TENNESSEE VALLEY AUTHORITY
ALLEN FOSSIL PLANT



Location ID (Depth)	As (mg/kg)	F (mg/kg)	Pb (mg/kg)
ALF-204B (6.0 ft)	4.2	5.9U	5.5
ALF-204B (10.0 ft)	8.6	6.3U	13.8
ALF-204B (26.0)	6.8	7.2U	9.4

Location ID (Depth)	As (mg/kg)	F (mg/kg)	Pb (mg/kg)
ALF-203B (7.5 ft)	5.5	6.0U	7.6
ALF-203B (21.5 ft)	3.5	5.4U	5.9

Location ID (Depth)	As (mg/kg)	F (mg/kg)	Pb (mg/kg)
ALF-210A (7.5 ft)	6.7	6.4U	9.1
ALF-210A (19.0 ft)	8.2	6.1U	9.6

Location ID (Depth)	As (mg/kg)	F (mg/kg)	Pb (mg/kg)
GP-51A (6.0)	5.1	4.6J	9.6
GP-51A (10.0)	4.6	5.7UJ	9.0
GP-51A (14.0)	5.5	5.9UJ	10.5
GP-51A (18.0)	10.1	6.4UJ	13.7
GP-51A (22.0)	4.4	6.2UJ	8.6
GP-51A (26.0)	6.4	6.3UJ	14.2
GP-51A (30.0)	8.4	6.6UJ	17.7
GP-51A (34.0)	5.8	4.6J	11.8

Location ID (Depth)	As (mg/kg)	F (mg/kg)	Pb (mg/kg)
ALF-214B (4.5 ft)	5.3	5.6U	9.0
ALF-214B (11.0 ft)	10.2	6.9U	14.5
ALF-214B (25.5)	6	6.5U	7.8

Location ID (Depth)	As (mg/kg)	F (mg/kg)	Pb (mg/kg)
ALF-202B (7.5 ft)	7.1	6.2U	10.9
ALF-202B (14.5 ft)	7.3	2.9J	11.3

Location ID (Depth)	As (mg/kg)	F (mg/kg)	Pb (mg/kg)
ALF-201B (5.0 ft)	4.3	5.6U	7.0
ALF-201B (14.5 ft)	11.5	6.7U	19.0
ALF-201B (23.5 ft)	4.2	5.3U	4.2

Location ID (Depth)	As (mg/kg)	F (mg/kg)	Pb (mg/kg)
ALF-216 (14.0 ft)	7.3	3.3J	8.1
ALF-216 (25.0 ft)	2.6	6.1UJ	8.0

Location ID (Depth)	As (mg/kg)	F (mg/kg)	Pb (mg/kg)
ALF-215 (5.0 ft)	11.1	5.6J	19.1
ALF-215 (11.5 ft)	2.8	6.0UJ	3.6

Legend

●	Groundwater Monitoring Well (Alluvial Aquifer) (ALF-, EW-, and PMW- series wells)
◉	DPT Soil Sample Location
—	Sanitary Sewer Pipes
☐	Sewer Manhole Location of Force Main Transition to Gravity

Depths reported in feet (ft) below ground surface (bgs).
mg/kg - milligrams per kilogram
J - The result is estimated
U - The analyte was not detected above the indicated reporting limit

Notes

1. Coordinate System: GCS WGS 1984
2. Imagery provided by TerraServer (2016)
3. Existing monitoring wells are referenced from TVA Drawing 10W858-03 Allen Fossil Plant Reservation

Stantec

U:\213402945\TVA\TVA - Allen\3A. RIR REVISED\NEW Maps\CADD\As Fl Pb In Soil.dwg
2019/01/30 11:02 AM By: Nolan, Vincent

Figure No.
3-7

Title
pH Measurements in Groundwater Samples (June-November 2017)

Client/Project
Tennessee Valley Authority
Allen Fossil Plant

Project Location
Memphis, Tennessee

175577013
Prepared by LMB on 2019-02-14
Technical Review by BT on 2019-02-14

0 300 600
Feet
1:3,600 (At original document size of 11x17)

Legend

Geoprobe Locations
- ● pH less than 8.0 (pH Screening Level)
- ● pH greater than 8.0

Monitoring Wells
- ⊕ pH less than 8.0 (pH Screening Level)
- ⊕ pH greater than 8.0
- — Sewer
- ▭ East Ash Pond Boundary
- ▭ Approximate area with pH above 8.0
- ☐ Manhole Location of Force Main Transition to Gravity Sewer

*DPT Location (June - August 2017 data)
Permanent monitoring wells (November 2017 data)

*The highest laboratory-measured pH concentration from each direct-push sampling location is shown regardless of depth

*Field parameter pH samples from DPT locations and laboratory-submitted pH samples from permanent monitoring wells were not filtered

*pH values are in standard units (SU) and measurements from permanent monitoring wells are estimated due to the hold time

Notes
1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TerraServer (2016)

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APPENDICES

APPENDIX A: BACKGROUND SOIL INFORMATION

Figure No.
1

TVA Restricted Information – Deliberative and Pre-Decisional Privileged

Title

Soil Boring Locations

Client/Project

Tennessee Valley Authority
Allen Fossil Plant

Project Location

Memphis, Tennessee

175568282
Prepared by MB on 2020-02-25
Technical Review by BT on 2020-02-25

0 400 800 1,200 1,600
Feet

1:4,800 (At original document size of 22x34)

Legend

- ● Soil Boring Locations
- ☐ Disposal Area
- ☐ 2019 Imagery Boundary

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA dated 3/15/2018 and 6/4/2019

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SUBSURFACE LOG

Stantec Borehole Identification	ALF-201B	Total Boring Depth	**90.0 ft**
Client	Tennessee Valley Authority	Boring Location	N35°04'09.95", W90°08'22.66" (NAD83)
Project Number	175577013	Surface Elevation	218.4 ft
		Elevation Datum	NGVD29
Project Name	TVA-ALF Remedial Investigation	Date Started	8/22/17
		Completed	8/24/17
Project Location	Memphis, Tennessee	Depth to Water	27.1 ft
		Date/Time	9/6/17
Supervisor	Briggs Evans	Depth to Water	N/A
		Date/Time	N/A
Logged by	Mike Pilot	Driller	Larry Yancey
Drilling Contractor	Cascade Drilling	Drill Rig Type and ID	Terrasonic 150C / #10-00100

Overburden Drilling and Sampling Tools (Type and Size) Sonic Tooling - 9" Bit, 9" Casing, 6" Barrel, 3.5" Rods

Sampler Hammer Type N/A Weight NA Drop NA Efficiency NA

Borehole Azimuth N/A (Vertical) Borehole Inclination (from Vertical) 0 deg.

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
218.4'	0.0'	Top of Hole							
217.9'	0.5'	Topsoil							
		Silty Sand (SM), light brown, moist			0.0' - 6.0'	6.0'	100	--	4" Monitoring Well Installed. See Well Construction Log for details.
212.4'	6.0'							6.0'	
		Poorly Graded Sand (SP) with clay, light brown, moist							
210.4'	8.0'								
		Lean Clay (CL), dark brown, firm, moist			6.0' - 16.0'	10.0'	100	--	
202.4'	16.0'							16.0'	
		Clayey Sand (SC), light brown, fine grained, moist							
200.4'	18.0'								
		Poorly Graded Sand (SP), brown, fine grained, moist to wet			16.0' - 26.0'	9.0'	90	--	
								26.0'	

SUBSURFACE LOG

Stantec Borehole Identification ALF-201B
Total Boring Depth **90.0 ft**
Client Tennessee Valley Authority
Boring Location N35°04'09.95", W90°08'22.66" (NAD83)
Project Number 175577013
Surface Elevation 218.4 ft
Elevation Datum NGVD29

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
		Poorly Graded Sand (SP), brown, fine grained, moist to wet *(Continued)*			26.0' - 36.0'	10.0'	100	--	
182.4'	36.0'							36.0'	
		Poorly Graded Sand (SP), gray, fine grained, wet, trace gravel			36.0' - 46.0'	10.0'	100	--	
								46.0'	
170.9'	47.5'								
		Sand with SIlt (SP-SM), gray, fine grained, wet to wet,			46.0' - 56.0'	10.0'	100	--	
164.4'	54.0'								
		Poorly Graded Sand (SP), gray, fine grained, wet, some silt						56.0'	
157.4'	61.0'				56.0' - 66.0'	10.0'	100	--	
		Poorly Graded Sand (SP),brown, fine grained, wet, trace gravel						66.0'	

Stantec Borehole Identification ALF-201B
Total Boring Depth **90.0 ft**
Client Tennessee Valley Authority
Boring Location N35°04'09.95", W90°08'22.66" (NAD83)
Project Number 175577013
Surface Elevation 218.4 ft
Elevation Datum NGVD29

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
142.4'	76.0'	Poorly Graded Sand (SP),brown, fine grained, wet, trace gravel *(Continued)*			66.0' - 76.0'	3.0'	30	-- 76.0'	
		No recovery			76.0' - 86.0'	0.0'	0	-- 86.0'	No recovery from 76' to 96'
128.4'	90.0'				86.0' - 90.0'	0.0'	0	-- 90.0'	

No Refusal /
Bottom of Hole

Stantec

SUBSURFACE LOG

Stantec Borehole Identification ALF-202B
Total Boring Depth **90.0 ft**
Client Tennessee Valley Authority
Boring Location N35°04'09.09", W90°08'11.98" (NAD83)
Project Number 175577013
Surface Elevation 217.5 ft
Elevation Datum NGVD29
Project Name TVA-ALF Remedial Investigation
Date Started 8/22/17
Completed 8/23/17
Project Location Memphis, Tennessee
Depth to Water 28.2 ft
Date/Time 9/6/17
Supervisor Briggs Evans
Depth to Water N/A
Date/Time N/A
Logged by Mike Pilot
Driller Larry Yancey
Drilling Contractor Cascade Drilling
Drill Rig Type and ID Terrasonic 150C / #10-00100
Overburden Drilling and Sampling Tools (Type and Size) Sonic Tooling - 9" Bit, 9" Casing, 6" Barrel, 3.5" Rods
Sampler Hammer Type N/A
Weight NA
Drop NA
Efficiency NA
Borehole Azimuth N/A (Vertical)
Borehole Inclination (from Vertical) 0 deg.

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
217.5'	0.0'	Top of Hole							
217.0'	0.5'	Topsoil			0.0' - 8.0'	8.0'	100	-- 8.0'	4" Monitoring Well Installed. See Well Construction Log for details.
215.5'	2.0'	Fat Clay (CH), gray, firm, dry to moist							
209.5'	8.0'	Well Graded Sand (SW), light brown, medium to coarse grained, dry to moist							
203.0'	14.5'	Poorly Graded Sand (SP), brown, fine grained, dry to moist			8.0' - 18.0'	7.0'	70	-- 18.0'	
199.5'	18.0'	Well Graded Sand (SW), brown, dry to moist, fine to coarse grained (no recovery 15' to 18')							
196.0'	21.5'	Clayey Sand (SC), light brown, medium to coarse grained, moist to wet			18.0' - 28.0'	7.0'	70	-- 28.0'	
		Poorly Graded Sand (SP), gray, fine grained, wet							

TVA SONIC BORING LOG - NO ROCK ALLEN_175577013 - REV.GPJ FMSM-GRAPHIC LOG.GDT 11/27/17

SUBSURFACE LOG

Stantec Borehole Identification ALF-202B
Total Boring Depth **90.0 ft**
Client Tennessee Valley Authority
Boring Location N35°04'09.09", W90°08'11.98" (NAD83)
Project Number 175577013
Surface Elevation 217.5 ft
Elevation Datum NGVD29

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
179.5'	38.0'	Poorly Graded Sand (SP), gray, fine grained, wet *(Continued)*			28.0' - 38.0'	10.0'	100	-- 38.0'	
176.5'	41.0'	Clayey Sand (SC), brown to gray, fine grained, dense			38.0' - 48.0'	7.0'	70	-- 48.0'	
169.5'	48.0'	Poorly Graded Sand (SP), gray, fine grained, wet							
156.5'	61.0'	Poorly Graded Sand with Silt (SP-SM), brown to gray, fine grained, wet			48.0' - 58.0' 58.0' - 68.0'	8.0' 6.0'	80 60	-- 58.0' -- 68.0'	
		Poorly Graded Sand (SP), gray, fine grained sand, wet							

SUBSURFACE LOG

Stantec Borehole Identification	ALF-202B	Total Boring Depth	**90.0 ft**
Client	Tennessee Valley Authority	Boring Location	N35°04'09.09", W90°08'11.98" (NAD83)
Project Number	175577013	Surface Elevation	217.5 ft
		Elevation Datum	NGVD29

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
139.5'	78.0'	Poorly Graded Sand (SP), gray, fine grained sand, wet *(Continued)*			68.0' - 78.0'	9.0'	90	-- 78.0'	
127.5'	90.0'	No Recovery							
		No Refusal / Bottom of Hole							

TVA SONIC BORING LOG - NO ROCK ALLEN_175577013 - REV.GPJ FMSM-GRAPHIC LOG.GDT 11/27/17

Stantec

SUBSURFACE LOG

Stantec Borehole Identification ALF-203B
Total Boring Depth **92.0 ft**
Client Tennessee Valley Authority
Boring Location N35°04'27.69", W90°08'24.25" (NAD83)
Project Number 175577013
Surface Elevation 218.8 ft
Elevation Datum NGVD29
Project Name TVA-ALF Remedial Investigation
Date Started 8/15/17
Completed 8/16/17
Project Location Memphis, Tennessee
Depth to Water 29.1 ft
Date/Time 9/6/17
Supervisor Briggs Evans
Depth to Water N/A
Date/Time N/A
Logged by Walker Padgett
Driller Larry Yancey
Drilling Contractor Cascade Drilling
Drill Rig Type and ID Terrasonic 150C / #10-00100
Overburden Drilling and Sampling Tools (Type and Size) Sonic Tooling - 9" Bit, 9" Casing, 6" Barrel, 3.5" Rods
Sampler Hammer Type N/A
Weight NA
Drop NA
Efficiency NA
Borehole Azimuth N/A (Vertical)
Borehole Inclination (from Vertical) 0 deg.

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
218.8'	0.0'	Top of Hole							
218.3'	0.5'	Topsoil							
215.8'	3.0'				0.0' - 6.0'	6.0'	100	--	
211.8'	7.0'	Silty Sand (SM), brown, fine grained, very dry to moist, organic material throughout						6.0'	
208.8'	10.0'	Clayey Sand (SC), gray to brown, fine grained, moist							
		Fat Clay (CH), gray to brown, high plasticity, firm, moist			6.0' - 16.0'	9.0'	90	-- 16.0'	
196.8'	22.0'				16.0' - 26.0'	9.0'	90	--	
195.8'	23.0'	Clayey Sand (SC), brown, fine grained, moist							
		Sand with Clay (SP-SC), gray to brown, medium grained, moist						26.0'	
189.8'	29.0'	0.5' Fat Clay Lens (CH) gray-orange mottled, soft moist @ 27.5'							

TVA SONIC BORING LOG - NO ROCK ALLEN_175577013 - REV.GPJ FMSM-GRAPHIC LOG.GDT 11/27/17

Stantec Borehole Identification ALF-203B

Total Boring Depth **92.0 ft**

Client Tennessee Valley Authority

Boring Location N35°04'27.69", W90°08'24.25" (NAD83)

Project Number 175577013

Surface Elevation 218.8 ft

Elevation Datum NGVD29

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
184.8'	34.0'	Poorly Graded Sand (SP), brown, medium grained, moist *(Continued)*			26.0' - 36.0'	9.0'	90	-- 36.0'	
181.8'	37.0'	Clayey Sand (SC), gray to brown, fine grained, moist, 0.5' Fat Clay Lens (CH) @ 35'							
179.8'	39.0'	Poorly Graded Sand (SP), brown, medium grained, moist to wet							
173.8'	45.0'	Clayey Sand (SC), gray to brown, fine grained, wet, stratified organic material (6-10mm). 8" Fat Clay Lens (CH) @ 43'			36.0' - 46.0'	10.0'	100	-- 46.0'	
170.8'	48.0'	Fat Clay with Sand (CH), gray, high plasticity, very soft, moist, fine grained sand							
165.8'	53.0'	Sand with Clay (SP-SC), gray, fine grained, wet			46.0' - 56.0'	10.0'	100	-- 56.0'	
163.8'	55.0'	Clayey Sand (SC), gray, wet, fine grained sand							
160.8'	58.0'	Poorly Graded Sand (SP) with clay, gray, fine grained, wet							
		Poorly Graded Sand (SP), gray, fine to medium grained, wet			56.0' - 66.0'	10.0'	100	-- 66.0'	

SUBSURFACE LOG

Stantec Borehole Identification ALF-203B
Total Boring Depth **92.0 ft**
Client Tennessee Valley Authority
Boring Location N35°04'27.69", W90°08'24.25" (NAD83)
Project Number 175577013
Surface Elevation 218.8 ft
Elevation Datum NGVD29

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
		Poorly Graded Sand (SP), gray, fine to medium grained, wet *(Continued)*			66.0' - 76.0'	0.0'	0	-- 76.0'	
					76.0' - 86.0'	0.0'	0	-- 86.0'	
131.8'	87.0'								
		Well Graded Sand (SW) with gravel, gray, fine to coarse grained sand and gravel, very wet			86.0' - 92.0'	6.0'	100	-- 92.0'	
126.8'	92.0'								
		No Refusal / Bottom of Hole							

SUBSURFACE LOG

Stantec Borehole Identification ALF-204B

Total Boring Depth **91.0 ft**

Client Tennessee Valley Authority

Boring Location N35°04'28.14", W90°08'15.35" (NAD83)

Project Number 175577013

Surface Elevation 214.5 ft

Elevation Datum NGVD29

Project Name TVA-ALF Remedial Investigation

Date Started 8/16/17

Completed 8/17/17

Project Location Memphis, Tennessee

Depth to Water 25.1 ft

Date/Time 9/6/17

Supervisor Briggs Evans

Depth to Water N/A

Date/Time N/A

Logged by Walker Padgett

Driller Larry Yancey

Drilling Contractor Cascade Drilling

Drill Rig Type and ID Terrasonic 150C / #10-00100

Overburden Drilling and Sampling Tools (Type and Size) Sonic Tooling - 9" Bit, 9" Casing, 6" Barrel, 3.5" Rods

Sampler Hammer Type N/A

Weight NA

Drop NA

Efficiency NA

Borehole Azimuth N/A (Vertical)

Borehole Inclination (from Vertical) 0 deg.

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
214.5'	0.0'	Top of Hole							
214.0'	0.5'	Topsoil			0.0' - 6.0'	5.0'	83	-- 6.0'	4" Monitoring Well Installed. See Well Construction Log for details.
212.5'	2.0'	Silty Sand (SM), brown, fine grained, moist, FILL							
211.5'	3.0'								
208.5'	6.0'	Poorly Graded Sand (SP) with Silt, brown, fine grained, dry to moist							
207.5'	7.0'	Silty Sand (SM), brown, fine grained, moist			6.0' - 16.0'	9.0'	90	-- 16.0'	
		Clayey Sand (SC), brown, very fine to fine grained, moist							
197.5'	17.0'	Fat Clay (CH), brown with gray mottling, high plasticity, firm, moist							
192.5'	22.0'	Fat Clay (CH), gray, high plasticity, firm, moist, brown and white mottling			16.0' - 26.0'	10.0'	100	-- 26.0'	
190.5'	24.0'	Clayey Sand (SC), gray, fine grained, wet							
		Fat Clay (CH), gray, high plasticity, soft, moist							

Stantec Borehole Identification ALF-204B
Total Boring Depth **91.0 ft**
Client Tennessee Valley Authority
Boring Location N35°04'28.14", W90°08'15.35" (NAD83)
Project Number 175577013
Surface Elevation 214.5 ft
Elevation Datum NGVD29

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
180.5'	34.0'	Fat Clay (CH), gray, high plasticity, soft, moist *(Continued)*			26.0' - 36.0'	10.0'	100	-- 36.0'	
171.5'	43.0'	Clayey Sand (SC), gray, fine grained, wet, brown mottling			36.0' - 46.0'	5.0'	50	-- 46.0'	
158.5'	56.0'	Poorly Graded Sand (SP), gray, fine grained, wet			46.0' - 56.0'	10.0'	100	-- 56.0'	
151.5'	63.0'	Well Graded Sand with Gravel (SW), brown, fine to coarse grained, very wet			56.0' - 66.0'	7.0'	70	-- 66.0'	
		Well Graded Sand (SW) with gravel, brown, fine to coarse grained, wet							

TVA SONIC BORING LOG - NO ROCK ALLEN_175577013 - REV.GPJ FMSM-GRAPHIC LOG.GDT 11/27/17

SUBSURFACE LOG

Stantec Borehole Identification ALF-204B
Total Boring Depth **91.0 ft**
Client Tennessee Valley Authority
Boring Location N35°04'28.14", W90°08'15.35" (NAD83)
Project Number 175577013
Surface Elevation 214.5 ft
Elevation Datum NGVD29

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
		Well Graded Sand (SW) with gravel, brown, fine to coarse grained, wet *(Continued)*			66.0' - 76.0'	10.0'	100	-- 76.0'	
					76.0' - 91.0'	14.0'	93	-- 91.0'	
123.5'	91.0'								
		No Refusal / Bottom of Hole							

TVA SONIC BORING LOG - NO ROCK ALLEN_175577013 - REV.GPJ FMSM-GRAPHIC LOG.GDT 11/27/17

SUBSURFACE LOG

Stantec Borehole Identification ALF-210A
Total Boring Depth **148.0 ft**
Client Tennessee Valley Authority
Boring Location N35°04'14.38", W90°08'58.94" (NAD83)
Project Number 175577013
Surface Elevation 216.2 ft
Elevation Datum NGVD29
Project Name TVA-ALF Remedial Investigation
Date Started 7/31/17
Completed 8/2/17
Project Location Memphis, Tennessee
Depth to Water 27.4 ft
Date/Time 9/6/17
Supervisor Briggs Evans
Depth to Water N/A
Date/Time N/A
Logged by Walker Padgett
Driller Larry Yancey
Drilling Contractor Cascade Drilling
Drill Rig Type and ID Terrasonic 150C / #10-00100
Overburden Drilling and Sampling Tools (Type and Size) Sonic Tooling - 9" Bit, 9" Casing, 6" Barrel, 3.5" Rods
Sampler Hammer Type N/A
Weight NA
Drop NA
Efficiency NA
Borehole Azimuth N/A (Vertical)
Borehole Inclination (from Vertical) 0 deg.

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
216.2'	0.0'	Top of Hole							
		Poorly Graded Silty Sand (SP-SM), brown, very fine to fine grained, moist			0.0' - 6.0'	6.0'	100	-- 6.0'	4" Monitoring Well Installed. See Well Construction Log for details.
206.2'	10.0'								
		Fat Clay (CH), brown, stiff, moist			6.0' - 16.0'	10.0'	100	-- 16.0'	
203.2'	13.0'								
		Poorly Graded Silty Sand (SP-SM), gray, very fine to fine grained, moist							
196.2'	20.0'								
		Poorly Graded Sand (SP), gray, medium grained, moist			16.0' - 26.0'	10.0'	100	-- 26.0'	

TVA SONIC BORING LOG - NO ROCK ALLEN_175577013 - REV.GPJ FMSM-GRAPHIC LOG.GDT 11/27/17

Stantec Borehole Identification ALF-210A
Total Boring Depth **148.0 ft**
Client Tennessee Valley Authority
Boring Location N35°04'14.38", W90°08'58.94" (NAD83)
Project Number 175577013
Surface Elevation 216.2 ft
Elevation Datum NGVD29

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
185.2'	31.0'				26.0' - 36.0'	10.0'	100	--	
184.2'	32.0'	Clayey Sand (SC), gray, fine grained, moist							
181.2'	35.0'	Poorly Graded Silty Sand (SP-SM), gray, medium grained, wet							
180.2'	36.0'	Fat Clay (CH), gray, stiff, moist						36.0'	
		Poorly Graded Sand (SP), gray, medium grained, wet, trace silt			36.0' - 46.0'	10.0'	100	-- 46.0'	
					46.0' - 56.0'	10.0'	100	-- 56.0'	
150.2'	66.0'				56.0' - 66.0'	10.0'	100	-- 66.0'	
148.2'	68.0'	Well Graded Sand with Silt (SW-SM), gray, fine to medium grained, wet							

SUBSURFACE LOG

Stantec Borehole Identification ALF-210A

Total Boring Depth **148.0 ft**

Client Tennessee Valley Authority

Boring Location N35°04'14.38", W90°08'58.94" (NAD83)

Project Number 175577013

Surface Elevation 216.2 ft

Elevation Datum NGVD29

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
		Well Graded Sand (SW), gray, medium to coarse grained, wet, some gravel *(Continued)*			66.0' - 76.0'	10.0'	100	--	
								76.0'	
136.2'	80.0'								
		Well Graded Sand with Gravel (SW), gray, fine to coarse grained, wet			76.0' - 86.0'	10.0'	100	--	
131.2'	85.0'								
130.2'	86.0'	Poorly Graded Sand (SP), gray, medium grained, wet						86.0'	
		Well Graded Sand with Gravel (SW), gray, fine to coarse grained, wet			86.0' - 96.0'	0.0'	0	--	No recovery from sample 10 due to flapper bit malfunction
								96.0'	
					96.0' - 106.0'	3.0'	30	--	
110.2'	106.0'							106.0'	
		Well Graded Sand with Gravel (SW), gray, fine to coarse grained, wet							

SUBSURFACE LOG

Stantec Borehole Identification ALF-210A
Total Boring Depth **148.0 ft**
Client Tennessee Valley Authority
Boring Location N35°04'14.38", W90°08'58.94" (NAD83)
Project Number 175577013
Surface Elevation 216.2 ft
Elevation Datum NGVD29

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
100.2'	116.0'	Well Graded Sand with Gravel (SW), gray, fine to coarse grained, wet *(Continued)*			106.0' - 116.0'	10.0'	100	-- 116.0'	
89.2'	127.0'	Well Graded Sand with Gravel (SW), gray, fine to coarse grained, wet, some thin beds of organic material / lignite			116.0' - 126.0'	6.0'	60	-- 126.0'	Limited recovery due to sand compression in recovery bags
87.2'	129.0'	Lean Clay (CL) with sand, tan, stiff, wet			126.0' - 136.0'	10.0'	100	-- 136.0'	
85.2'	131.0'	Organic Clay (OH), dark gray, very stiff, wet, lignite							
81.2'	135.0'	Poorly Graded Sand (SP), gray, fine grained, wet, lignite laminations, trace silt							
72.2'	144.0'	Poorly Graded Sand with Clay (SP-SC), gray, wet, dense			136.0' - 146.0'	10.0'	100	-- 146.0'	
68.2'	148.0'	Lean Clay (CL), gray, very stiff, moist (classification based on Particle Size and Atterberg Limits analysis, sample interval 147.1' - 147.6')		ST-16	146.0' - 148.0'	2.0'		--	

No Refusal / Bottom of Hole

SUBSURFACE LOG

Page: 1 of 3

Stantec Borehole Identification ALF-214B
Total Boring Depth **97.0 ft**
Client Tennessee Valley Authority
Boring Location N35°04'10.76", W90°08'33.76" (NAD83)
Project Number 175577013
Surface Elevation 217.5 ft
Elevation Datum NGVD29
Project Name TVA-ALF Remedial Investigation
Date Started 8/21/17
Completed 8/22/17
Project Location Memphis, Tennessee
Depth to Water 28.2 ft
Date/Time 9/6/17
Supervisor Briggs Evans
Depth to Water N/A
Date/Time N/A
Logged by Lee Eaves
Driller Matt Pope
Drilling Contractor Cascade Drilling
Drill Rig Type and ID Prosonic LS600 / #10-00273
Overburden Drilling and Sampling Tools (Type and Size) Sonic Tooling - 8" Bit, 8" Casing, 7" Barrel, 3.5" Rods
Sampler Hammer Type N/A
Weight NA
Drop NA
Efficiency NA
Borehole Azimuth N/A (Vertical)
Borehole Inclination (from Vertical) 0 deg.

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
217.5'	0.0'	Top of Hole							
217.0'	0.5'	Top Soil							
		Clayey Sand (SC), tan to gray, moist			0.0' - 7.0'	5.0'	71	-- 7.0'	4" Monitoring Well Installed. See Well Construction Log for details.
211.5'	6.0'								
		Silty Fat Clay (CH), brown to gray, high plasticity, stiff, moist			7.0' - 17.0'	10.0'	100	-- 17.0'	
199.5'	18.0'								
		Clayey Sand (SC), brown to gray, moist to wet			17.0' - 27.0'	7.0'	70	-- 27.0'	

TVA SONIC BORING LOG - NO ROCK ALLEN_175577013 - REV.GPJ FMSM-GRAPHIC LOG.GDT 11/27/17

SUBSURFACE LOG

Stantec Borehole Identification ALF-214B
Total Boring Depth **97.0 ft**
Client Tennessee Valley Authority
Boring Location N35°04'10.76", W90°08'33.76" (NAD83)
Project Number 175577013
Surface Elevation 217.5 ft
Elevation Datum NGVD29

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
186.5'	31.0'	Clayey Sand (SC), gray, wet			27.0' - 37.0'	5.0'	50	-- 37.0'	
					37.0' - 47.0'	7.0'	70	-- 47.0'	
170.5'	47.0'	Poorly graded Sand (SP), brownish gray, fine to medium grained, wet, trace rounded gravel			47.0' - 57.0'	8.0'	80	-- 57.0'	
					57.0' - 67.0'	10.0'	100	-- 67.0'	

SUBSURFACE LOG

Stantec Borehole Identification ALF-214B
Total Boring Depth **97.0 ft**
Client Tennessee Valley Authority
Boring Location N35°04'10.76", W90°08'33.76" (NAD83)
Project Number 175577013
Surface Elevation 217.5 ft
Elevation Datum NGVD29

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
		Poorly graded Sand (SP), brownish gray, fine to medium grained, wet, trace rounded gravel *(Continued)*			67.0' - 77.0'	8.0'	80	-- 77.0'	
					77.0' - 87.0'	1.5'	15	-- 87.0'	
120.5'	97.0'				87.0' - 97.0'	8.0'	80	-- 97.0'	
		No Refusal / Bottom of Hole							

TVA SONIC BORING LOG - NO ROCK ALLEN_175577013 - REV.GPJ FMSM-GRAPHIC LOG.GDT 11/27/17

SUBSURFACE LOG

Stantec Borehole Identification ALF-215
Total Boring Depth **47.0 ft**
Client Tennessee Valley Authority
Boring Location N35°04'04.93", W90°08'11.95" (NAD83)
Project Number 175577013
Surface Elevation 212.3 ft
Elevation Datum NGVD29
Project Name TVA-ALF Remedial Investigation
Date Started 9/5/17
Completed 9/6/17
Project Location Memphis, Tennessee
Depth to Water 10.2 ft
Date/Time 9/6/17
Supervisor Briggs Evans
Depth to Water N/A
Date/Time N/A
Logged by Briggs Evans
Driller Larry Yancey
Drilling Contractor Cascade Drilling
Drill Rig Type and ID Terrasonic 150C / #10-00100
Overburden Drilling and Sampling Tools (Type and Size) Sonic Tooling - 9" Bit, 9" Casing, 6" Barrel, 3.5" Rods
Sampler Hammer Type N/A
Weight NA
Drop NA
Efficiency NA
Borehole Azimuth N/A (Vertical)
Borehole Inclination (from Vertical) 0 deg.

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
212.3'	0.0'	Top of Hole							
211.8'	0.5'	Top Soil			0.0' - 7.0'	7.0'	100	-- 7.0'	4" Monitoring Well Installed. See Well Construction Log for details.
208.8'	3.5'	Silty Lean Clay (CL), brown, stiff, medium plasticity, moist, trace fine sand							
202.6'	9.7'	Lean Clay (CL), brown, stiff, medium plasticity, moist to wet, trace fine sand			7.0' - 17.0'	10.0'	100	-- 17.0'	
186.3'	26.0'	Poorly Graded Sand (SP), brown, fine grained, wet			17.0' - 27.0'	10.0'	100	-- 27.0'	
182.8'	29.5'	Poorly Graded Silty Sand (SP-SM), gray, wet							

TVA SONIC BORING LOG - NO ROCK ALLEN_175577013 - REV.GPJ FMSM-GRAPHIC LOG.GDT 11/27/17

SUBSURFACE LOG

Stantec Borehole Identification ALF-215

Total Boring Depth **47.0 ft**

Client Tennessee Valley Authority

Boring Location N35°04'04.93", W90°08'11.95" (NAD83)

Project Number 175577013

Surface Elevation 212.3 ft

Elevation Datum NGVD29

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
182.3'	30.0'	Lean Clay (CL), gray, soft, medium plasticity, very moist			27.0' - 37.0'	10.0'	100	-- 37.0'	
181.3'	31.0'	Sandy Silt (ML), gray, soft, wet, fine grained sand							
180.8'	31.5'	Lean Clay (CL), gray, soft, medium plasticity, very moist							
179.8'	32.5'	Sandy Silt (ML), gray, soft, wet, fine grained sand							
179.3'	33.0'	Lean Clay (CL), gray, soft, medium plasticity, very moist							
174.5'	37.8'	Sandy Silt (ML), gray, soft, wet, fine grained sand			37.0' - 47.0'	9.0'	90	-- 47.0'	
172.3'	40.0'	Lean Clay (CL), gray, soft to medium stiff, moist to wet							
168.8'	43.5'	Sandy Silt (ML), gray, soft, wet, fine grained sand							
165.3'	47.0'	Poorly Graded Sandy Silt (SP-ML), gray, fine grained, wet							
		No Refusal / Bottom of Hole							

SUBSURFACE LOG

Stantec Borehole Identification ALF-216

Total Boring Depth **57.0 ft**

Client Tennessee Valley Authority

Boring Location N35°04'01.20", W90°08'18.44" (NAD83)

Project Number 175577013

Surface Elevation 212.9 ft

Elevation Datum NGVD29

Project Name TVA-ALF Remedial Investigation

Date Started 8/29/17

Completed 8/29/17

Project Location Memphis, Tennessee

Depth to Water 24.3 ft

Date/Time 9/6/17

Supervisor Briggs Evans

Depth to Water N/A

Date/Time N/A

Logged by Lee Eaves

Driller Matt Pope

Drilling Contractor Cascade Drilling

Drill Rig Type and ID Prosonic LS600 / #10-00273

Overburden Drilling and Sampling Tools (Type and Size) Sonic Tooling - 8" Bit, 8" Casing, 7" Barrel, 3.5" Rods

Sampler Hammer Type N/A

Weight NA

Drop NA

Efficiency NA

Borehole Azimuth N/A (Vertical)

Borehole Inclination (from Vertical) 0 deg.

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
212.9'	0.0'	Top of Hole							
211.9'	1.0'	ABC Stone							4" Monitoring Well Installed. See Well Construction Log for details.
		Clayey Silt (ML), brown, low plasticity, firm to hard, moist			0.0' - 8.0'	8.0'	100	--	
204.9'	8.0'							8.0'	
202.9'	10.0'	Silty Lean Clay (CL), grayish brown, low to medium plasticity, firm, moist							
		Clayey Silty Sand (SM), grayish brown, fine grained, moist			8.0' - 17.0'	7.0'	78	--	
								17.0'	
194.9'	18.0'								
		Silty Sand (SM), grayish brown, fine grained, wet			17.0' - 27.0'	7.5'	75	--	
185.9'	27.0'							27.0'	
184.4'	28.5'	Silty Sand (SM), gray, fine grained, wet							
183.4'	29.5'	Fat Clay (CH), gray, high							

SUBSURFACE LOG

Stantec Borehole Identification ALF-216

Total Boring Depth **57.0 ft**

Client Tennessee Valley Authority

Boring Location N35°04'01.20", W90°08'18.44" (NAD83)

Project Number 175577013

Surface Elevation 212.9 ft

Elevation Datum NGVD29

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Sonic Core		Run	Rec. Ft.	Rec. %	Run Depth	Remarks
		plasticity, soft, wet Poorly Graded Sand (SP), brownish gray, fine to medium grained, wet *(Continued)*			27.0' - 37.0'	7.0'	70	-- 37.0'	
170.9'	42.0'				37.0' - 47.0'	7.5'	75	-- 47.0'	
		Poorly Graded Sand (SP) with Silt, gray, fine grained, wet							
					47.0' - 57.0'	8.5'	85	-- 57.0'	
155.9'	57.0'								
		No Refusal / Bottom of Hole							

SUBSURFACE LOG

Client Borehole ID N/A
Stantec Boring No. **ALF-BG01**
Client Tennessee Valley Authority
Boring Location 274,750.69 N; 755,090.49 E NAD27 Plant Local
Project Number 175568282
Surface Elevation 219.6 ft
Elevation Datum NGVD29
Project Name ALF TDEC Order
Date Started 8/6/19
Completed 8/6/19
Project Location Memphis, TN
Depth to Water 23.8 ft
Date/Time 8/6/19 11:18
Inspector C. Sexton
Logger C. Sexton
Depth to Water N/A
Date/Time N/A
Drilling Contractor Hawkston (Subcontractor)
Drill Rig Type and ID Geoprobe 3230DT
Overburden Drilling and Sampling Tools (Type and Size) DPT 3.75 Dual Tube
Rock Drilling and Sampling Tools (Type and Size) N/A
Overdrill Tooling (Type and Size) N/A
Overdrill Depth N/A
Sampler Hammer Type N/A
Weight N/A
Drop N/A
Efficiency N/A
Borehole Azimuth N/A
Borehole Inclination (from Vertical) N/A
Reviewed By B. Evans
Approved By L. Price

Lithology				Overburden:	Sample^{1,2}	Depth Ft^3		Rec. Ft	Blows/PSI
Depth Ft^3	Elevation	Graphic	Description	Rock Core:	RQD %	Run Ft		Rec. Ft	Rec. %
0.0	219.6		Top of Hole						
0.5	219.1	▦	Topsoil, detritus	HA	HA01	0.0 - 0.5		0.5	
9.6	210.0	⁘	POORLY GRADED SAND TRACE SILT, SP, 10YR 5/1 (gray), fine, medium dense, moist, stratified	1.0/3.0-20190806	DP01	0.0 - 5.0	0.0 - 5.0	3.0	N/A
				6.0/8.0-20190806	DP02	5.0 - 10.0	5.0 - 10.0	3.2	N/A
13.8	205.8	▨	SANDY FAT CLAY, CH, 10YR 4/2 (dark grayish brown), medium plasticity, soft, wet, iron oxide staining, laminated	11.0/13.0-20190806	DP03	10.0 - 15.0	10.0 - 15.0	3.2	N/A
		⁘	WELL GRADED SAND WITH GRAVEL, SW, 10YR 5/3 (brown) to 7.5YR 5/3 (brown), fine to coarse, loose to medium dense, wet, chert, lignite, etc	16.0/18.0-20190806	DP04	15.0 - 20.0	15.0 - 20.0	3.2	N/A
∇				21.0/23.0-20190806	DP05	20.0 - 25.0	20.0 - 25.0	3.2	N/A

SUBSURFACE LOG

Client Borehole ID N/A
Client Tennessee Valley Authority
Project Number 175568282

Stantec Boring No. **ALF-BG01**
Boring Location 274,750.69 N; 755,090.49 E NAD27 Plant Local
Surface Elevation 219.6 ft Elevation Datum NGVD29

Depth Ft[3]	Elevation	Description
41.0	178.6	WELL GRADED SAND WITH GRAVEL, SW, 10YR 5/3 (brown) to 7.5YR 5/3 (brown), fine to coarse, loose to medium dense, wet, chert, lignite, etc *(Continued)*
45.0	174.6	WELL GRADED SAND WITH GRAVEL, SW, N 3/ (very dark gray), very fine to coarse, dense to very loose, wet, lignite cobbles

Overburden: Sample[1,2] / Rock Core: RQD %	Depth Ft[3] / Run Ft	Rec. Ft / Rec. Ft	Blows/PSI / Rec. %
26.5/28.5-20190806 DP06	25.0 - 30.0 25.0 - 30.0	4.0	N/A
30.0/32.0-20190806 DP07	30.0 - 35.0 30.0 - 35.0	2.0	N/A
35.5/37.5-20190806 DP08	35.0 - 40.0 35.0 - 40.0	2.5	N/A
40.0/41.6-20190806 DP09	40.0 - 45.0 40.0 - 45.0	1.6	N/A

No Refusal /
Bottom of Hole at 45.0 Ft.

1: E = Environmental Sample Custody (two Split Spoons may be required to obtain sufficient sample)
G = Geotechnical Sample Custody
2: a,b,c denote Split Spoon divided between Environmental and Geotechnical Samples
3: Depths are reported in feet below ground surface
4: Grab sample (0.0/0.5-20190806) sampled using hand auger

TVA EIP BORING LOG 175567295 ALF TDEC ORDER.GPJ TDEC SUBSURF DT 20190530.GDT 2/20/20

SUBSURFACE LOG

Client Borehole ID N/A
Stantec Boring No. **ALF-BG02**
Client Tennessee Valley Authority
Boring Location 274,721.33 N; 756,003.73 E NAD27 Plant Local
Project Number 175568282
Surface Elevation 220.6 ft
Elevation Datum NGVD29
Project Name ALF TDEC Order
Date Started 8/14/19
Completed 8/15/19
Project Location Memphis, TN
Depth to Water 25.1 ft
Date/Time 8/15/19 07:17
Inspector C. Sexton
Logger C. Sexton
Depth to Water N/A
Date/Time N/A
Drilling Contractor Hawkston (Subcontractor)
Drill Rig Type and ID Geoprobe 3230DT
Overburden Drilling and Sampling Tools (Type and Size) DPT 3.75 Dual Tube
Rock Drilling and Sampling Tools (Type and Size) N/A
Overdrill Tooling (Type and Size) N/A
Overdrill Depth N/A
Sampler Hammer Type N/A
Weight N/A
Drop N/A
Efficiency N/A
Borehole Azimuth N/A
Borehole Inclination (from Vertical) N/A
Reviewed By B. Evans
Approved By J. Griggs

Lithology				Overburden:	Sample^{1,2}	Depth Ft^{3}		Rec. Ft	Blows/PSI
Depth Ft^{3}	Elevation	Graphic	Description	Rock Core:	RQD %	Run Ft		Rec. Ft	Rec. %
0.0	220.6		Top of Hole						
0.2	220.4		Topsoil, detritus	HA^{4}	HA01	0.0 - 0.5		0.5	
10.6	210.0		POORLY GRADED SAND SOME CLAY, SP, 10YR 4/2 (dark grayish brown), fine, medium dense, moist, stratified	1.5/3.5-20190815	DP01	0.0 - 5.0	0.0 - 5.0	3.8	N/A
				6.5/8.5-20190814	DP02	5.0 - 10.0	5.0 - 10.0	3.7	N/A
			POORLY GRADED SAND TRACE GRAVEL, SP, 10YR 6/2 (light brownish gray) to 10YR 4/2 (dark grayish brown), medium to coarse, medium dense, moist, stratified, chert, olivine, laminae of lignite	11.4/13.4-20190815	DP03	10.0 - 15.0	10.0 - 15.0	3.4	N/A
				16.5/18.5-20190814	DP04	15.0 - 20.0	15.0 - 20.0	4.1	N/A
				21.5/23.5-20190814	DP05	20.0 - 25.0	20.0 - 25.0	4.3	N/A

TVA EIP BORING LOG 175567295 ALF TDEC ORDER.GPJ TDEC SUBSURF DT 20190530.GDT 2/9/20

SUBSURFACE LOG

Client Borehole ID N/A
Client Tennessee Valley Authority
Project Number 175568282
Stantec Boring No. **ALF-BG02**
Boring Location 274,721.33 N; 756,003.73 E NAD27 Plant Local
Surface Elevation 220.6 ft
Elevation Datum NGVD29

Lithology				Overburden:		Sample^{1,2}	Depth Ft^{3}	Rec. Ft	Blows/PSI
Depth Ft^{3}	Elevation	Graphic	Description	Rock Core:		RQD %	Run Ft	Rec. Ft	Rec. %
25.9	194.7								
			WELL GRADED SAND TRACE GRAVEL, SW, N 3/ (very dark gray), very fine to coarse, dense to very loose, wet, chert cobbles	26.3/28.3-20190815	25.0 - 30.0	DP06	25.0 - 30.0	3.3	N/A
				30.8/32.8-20190814	30.0 - 35.0	DP07	30.0 - 35.0	2.8	N/A
				36.5/38.5-20190814	35.0 - 40.0	DP08	35.0 - 40.0	4.8	N/A
				40.3/42.3-20190815	40.0 - 45.0	DP09	40.0 - 45.0	2.3	N/A
45.0	175.6		No Refusal / Bottom of Hole at 45.0 Ft.						

1: E = Environmental Sample Custody (two Split Spoons may be required to obtain sufficient sample)
G = Geotechnical Sample Custody
2: a,b,c denote Split Spoon divided between Environmental and Geotechnical Samples
3: Depths are reported in feet below ground surface
4: Grab sample (0.0/0.5-20190814) sampled using hand auger

TVA EIP BORING LOG 175567295 ALF TDEC ORDER.GPJ TDEC SUBSURF DT 20190530.GDT 2/9/20

SUBSURFACE LOG

Client Borehole ID N/A

Stantec Boring No. **ALF-BG03**

Client Tennessee Valley Authority

Boring Location 273,097.88 N; 759,469.38 E NAD27 Plant Local

Project Number 175568282

Surface Elevation 217.6 ft

Elevation Datum NGVD29

Project Name ALF TDEC Order

Date Started 8/7/19

Completed 8/8/19

Project Location Memphis, TN

Depth to Water 19.65 ft

Date/Time 8/7/19 14:04

Inspector C. Sexton

Logger C. Sexton

Depth to Water N/A

Date/Time N/A

Drilling Contractor Hawkston (Subcontractor)

Drill Rig Type and ID Geoprobe 3230DT

Overburden Drilling and Sampling Tools (Type and Size) DPT 3.75 Dual Tube

Rock Drilling and Sampling Tools (Type and Size) N/A

Overdrill Tooling (Type and Size) N/A

Overdrill Depth N/A

Sampler Hammer Type N/A

Weight N/A

Drop N/A

Efficiency N/A

Borehole Azimuth N/A

Borehole Inclination (from Vertical) N/A

Reviewed By B. Evans

Approved By J. Griggs

Lithology				Overburden:	Sample^{1,2}	Depth Ft^{3}		Rec. Ft	Blows/PSI
Depth Ft^{3}	Elevation	Graphic	Description	Rock Core:	RQD %	Run Ft		Rec. Ft	Rec. %
0.0	217.6		Top of Hole						
0.7	216.9		Topsoil, detritus, roots	HA^{4}	HA01	0.0 - 0.5		0.5	
2.5	215.1		WELL GRADED SAND TRACE GRAVEL, SW, 10YR 6/3 (pale brown), fine to coarse, loose, moist to dry, stratified	1.0/3.0-20190808	DP01	0.0 - 5.0	0.0 - 5.0	3.0	N/A
5.8	211.8		CLAYEY SILTY SAND WITH GRAVEL, SC, 10YR 4/2 (dark grayish brown), very fine, medium dense, moist, iron oxide staining, stratified						
10.9	206.7		FAT CLAY, CH, 10YR 4/2 (dark grayish brown) with 2.5Y 4/1 (dark gray), medium to high plasticity, firm to hard, moist, lignitic stringers Mottled from 8.9' to 10.9'	6.0/8.0-20190807	DP02	5.0 - 10.0	5.0 - 10.0	3.0	N/A
15.2	202.4		CLAYEY POORLY GRADED SAND, SP, 2.5Y 4/2 (dark grayish brown) with 2.5Y 5/1 (gray), very fine to fine, medium dense, moist to wet, stratified	11.4/13.4-20190808	DP03	10.0 - 15.0	10.0 - 15.0	3.4	N/A
			WELL GRADED SAND, SW, 10YR 4/3 (brown), very fine to coarse, loose to medium dense, wet, homogeneous, chert, lignite, muscovite	16.5/18.5-20190807	DP04	15.0 - 20.0	15.0 - 20.0	5.0	N/A

SUBSURFACE LOG

Client Borehole ID N/A
Stantec Boring No. **ALF-BG03**
Client Tennessee Valley Authority
Boring Location 273,097.88 N; 759,469.38 E NAD27 Plant Local
Project Number 175568282
Surface Elevation 217.6 ft
Elevation Datum NGVD29

Lithology				
Depth Ft^3	Elevation	Graphic	Description
24.2	193.4	⁘	WELL GRADED SAND, SW, 10YR 4/3 (brown), very fine to coarse, loose to medium dense, wet, homogeneous, chert, lignite, muscovite *(Continued)*
25.2	192.4	▨	Clay lens, 10YR 5/1 (gray) with 5YR 3/4 (dark reddish brown) staining
26.7	190.9	⁘	WELL GRADED SAND, SW, 10YR 4/3 (brown), very fine to coarse, loose to medium dense, wet, homogeneous, chert, lignite, muscovite
27.5	190.1	▨	Clay lens, 10YR 5/1 (gray) with 5YR 3/4 (dark reddish brown) staining
31.9	185.7	⁘	WELL GRADED SAND, SW, 10YR 4/3 (brown), very fine to coarse, loose to medium dense, wet, homogeneous, chert, lignite, muscovite
32.3	185.3	▨	Clay lens, 10YR 5/1 (gray) with 5YR 3/4 (dark reddish brown) staining
33.3	184.3	⁘	WELL GRADED SAND, SW, 10YR 4/3 (brown), very fine to coarse, loose to medium dense, wet, homogeneous, chert, lignite, muscovite
33.6	184.0	▨	Clay lens, 10YR 5/1 (gray) with 5YR 3/4 (dark reddish brown) staining
38.8	178.8	⁘	WELL GRADED SAND, SW, 10YR 4/3 (brown), very fine to coarse, loose to medium dense, wet, homogeneous, chert, lignite, muscovite
40.0	177.6	☒	No Recovery

Overburden:	Sample^{1,2}	Depth Ft^3		Rec. Ft	Blows/PSI
Rock Core:	RQD %	Run Ft		Rec. Ft	Rec. %
21.5/23.5-20190808	DP05	20.0 - 25.0	20.0 - 25.0	4.4	N/A
26.5/28.5-20190807	DP06	25.0 - 30.0	25.0 - 30.0	4.8	N/A
31.5/33.5-20190808	DP07	30.0 - 35.0	30.0 - 35.0	5.0	N/A
36.5/38.5-20190808	DP08	35.0 - 40.0	35.0 - 40.0	2.4	N/A

No Refusal /
Bottom of Hole at 40.0 Ft.

1: E = Environmental Sample Custody (two Split Spoons may be required to obtain sufficient sample)
G = Geotechnical Sample Custody
2: a,b,c denote Split Spoon divided between Environmental and Geotechnical Samples
3: Depths are reported in feet below ground surface
4: Grab sample (0.0/0.5-20190808) sampled using hand auger

SUBSURFACE LOG

Client Borehole ID N/A
Stantec Boring No. **ALF-BG04**
Client Tennessee Valley Authority
Boring Location 272,299.82 N; 758,879.09 E NAD27 Plant Local
Project Number 175568282
Surface Elevation 215.2 ft
Elevation Datum NGVD29
Project Name ALF TDEC Order
Date Started 8/13/19
Completed 8/14/19
Project Location Memphis, TN
Depth to Water 19.8 ft
Date/Time 8/14/19 13:41
Inspector C. Sexton
Logger C. Sexton
Depth to Water N/A
Date/Time N/A
Drilling Contractor Hawkston (Subcontractor)
Drill Rig Type and ID Geoprobe 3230DT
Overburden Drilling and Sampling Tools (Type and Size) DPT 3.75 Dual Tube
Rock Drilling and Sampling Tools (Type and Size) N/A
Overdrill Tooling (Type and Size) N/A
Overdrill Depth N/A
Sampler Hammer Type N/A
Weight N/A
Drop N/A
Efficiency N/A
Borehole Azimuth N/A
Borehole Inclination (from Vertical) N/A
Reviewed By B. Evans
Approved By J. Griggs

Lithology				Overburden:	Sample[1,2]	Depth Ft[3]		Rec. Ft	Blows/PSI
Depth Ft[3]	Elevation	Graphic	Description	Rock Core:	RQD %	Run Ft		Rec. Ft	Rec. %
0.0	215.2		Top of Hole						
1.4	213.8	▨	SANDY FAT CLAY, CH, 10YR 3/2 (very dark grayish brown) with 5YR 4/6 (yellowish red), firm, moist, iron oxide staining, stratified, roots, compacted soil	HA[4]0.5/2.5-20190813	HA01	0.0 - 0.5		0.5	
15.5	199.7	▨	FAT CLAY TRACE SAND, CH, 10YR 5/1 (gray), medium to high plasticity, soft to very hard, iron oxide staining, calcite nodules, organic materials, manganese nodules, vertical fractures		DP01	0.0 - 5.0	0.0 - 5.0	2.7	N/A
				6.5/8.5-20190813	DP02	5.0 - 10.0	5.0 - 10.0	3.5	N/A
				11.5/13.5-20190813	DP03	10.0 - 15.0	10.0 - 15.0	4.1	N/A
16.5	198.7	⁘	Clayey sand, fine						
18.1	197.1	▨	FAT CLAY TRACE SAND, CH, 10YR 5/1 (gray), medium to high plasticity, soft to very hard, iron oxide staining, calcite nodules, organic materials, manganese nodules, vertical fractures	16.5/18.5-20190813	DP04	15.0 - 20.0	15.0 - 20.0	4.8	N/A
▽		⁘	POORLY GRADED SAND SOME CLAY, SP, 2.5Y 4/3 (olive brown), very fine to medium, loose to medium dense, moist to wet, iron oxide staining, stratified, coal fragments, manganese nodules, coarsening upward sequences						

SUBSURFACE LOG

Client Borehole ID N/A
Stantec Boring No. **ALF-BG04**
Client Tennessee Valley Authority
Boring Location 272,299.82 N; 758,879.09 E NAD27 Plant Local
Project Number 175568282
Surface Elevation 215.2 ft
Elevation Datum NGVD29

Lithology				Overburden: / Rock Core:		Sample^{1,2} / RQD %	Depth Ft^3 / Run Ft		Rec. Ft / Rec. Ft	Blows/PSI / Rec. %
Depth Ft^3	Elevation	Graphic	Description							
				21.5/23.5-20190813		DP05	20.0 - 25.0	20.0 - 25.0	5.0	N/A
24.4	190.8									
			POORLY GRADED SAND, SP, 2.5Y 4/3 (olive brown), fine, medium dense, wet, stratified, laminae of coal fragments and woody fabric, muscovite	26.5/28.5-20190813		DP06	25.0 - 30.0	25.0 - 30.0	5.0	N/A
				31.5/33.5-20190813		DP07	30.0 - 35.0	30.0 - 35.0	5.0	N/A
34.8	180.4									
			POORLY GRADED SAND, SP, 5Y 4/1 (dark gray), medium, medium dense to loose, wet, coal fragments	36.5/38.5-20190813		DP08	35.0 - 40.0	35.0 - 40.0	4.5	N/A
40.0	175.2									

No Refusal /
Bottom of Hole at 40.0 Ft.

1: E = Environmental Sample Custody (two Split Spoons may be required to obtain sufficient sample)
G = Geotechnical Sample Custody
2: a,b,c denote Split Spoon divided between Environmental and Geotechnical Samples
3: Depths are reported in feet below ground surface
4: Grab sample (0.0/0.5-20190814) sampled using hand auger

TVA EIP BORING LOG 175567295 ALF TDEC ORDER.GPJ TDEC SUBSURF DT 20190530.GDT 2/9/20

SUBSURFACE LOG

Client Borehole ID N/A
Stantec Boring No. **ALF-BG05**
Client Tennessee Valley Authority
Boring Location 271,761.07 N; 758,790.16 E NAD27 Plant Local
Project Number 175568282
Surface Elevation 214.3 ft
Elevation Datum NGVD29
Project Name ALF TDEC Order
Date Started 8/12/19
Completed 8/13/19
Project Location Memphis, TN
Depth to Water 19.2 ft
Date/Time 8/12/19 14:16
Inspector C. Sexton
Logger C. Sexton
Depth to Water N/A
Date/Time N/A
Drilling Contractor Hawkston (Subcontractor)
Drill Rig Type and ID Geoprobe 3230DT
Overburden Drilling and Sampling Tools (Type and Size) DPT 3.75 Dual Tube
Rock Drilling and Sampling Tools (Type and Size) N/A
Overdrill Tooling (Type and Size) N/A
Overdrill Depth N/A
Sampler Hammer Type N/A
Weight N/A
Drop N/A
Efficiency N/A
Borehole Azimuth N/A
Borehole Inclination (from Vertical) N/A
Reviewed By B. Evans
Approved By J. Griggs

Lithology				Overburden:	Sample^{1,2}	Depth Ft^{3}		Rec. Ft	Blows/PSI
Depth Ft^{3}	Elevation	Graphic	Description	Rock Core:	RQD %	Run Ft		Rec. Ft	Rec. %
0.0	214.3		Top of Hole						
2.4	211.9	▨	SANDY FAT CLAY, CH, 10YR 3/2 (very dark grayish brown) with 5YR 4/6 (yellowish red), firm, moist, iron oxide staining, stratified, roots, compacted soil	HA^{4}	HA01	0.0 - 0.5		0.5	
				1.2/3.2-20190812	DP01	0.0 - 5.0	0.0 - 5.0	3.2	N/A
6.8	207.5	⁞	SILTY POORLY GRADED SAND WITH CLAY, SM, 10YR 5/3 (brown) to 10YR 7/2 (light gray), fine, loose to medium dense, dry to wet, iron oxide staining, stratified						
				6.2/8.2-20190812	DP02	5.0 - 10.0	5.0 - 10.0	3.2	N/A
20.5	193.8	▨	FAT CLAY TRACE SAND, CH, 10YR 5/1 (gray), medium to high plasticity, soft to very hard, iron oxide staining, organic materials, manganese nodules, vertical fractures Calcite nodules from 13.1' to 13.2'						
				11.5/13.5-20190812	DP03	10.0 - 15.0	10.0 - 15.0	3.8	N/A
				16.5/18.5-20190812	DP04	15.0 - 20.0	15.0 - 20.0	5.0	N/A
19 ▽									
		⁘							

SUBSURFACE LOG

Client Borehole ID N/A
Client Tennessee Valley Authority
Project Number 175568282
Stantec Boring No. **ALF-BG05**
Boring Location 271,761.07 N; 758,790.16 E NAD27 Plant Local
Surface Elevation 214.3 ft
Elevation Datum NGVD29

Lithology				Overburden:	Sample[1,2]	Depth Ft[3]	Rec. Ft	Blows/PSI
Depth Ft[3]	Elevation	Graphic	Description	Rock Core:	RQD %	Run Ft	Rec. Ft	Rec. %
24.9	189.4		POORLY GRADED SAND SOME CLAY, SP, 10YR 4/3 (brown), very fine to medium, medium dense, wet, iron oxide staining, stratified, calcite nodules, lignite fragments, manganese nodules, trace pyrite, coarsening upward sequences *(Continued)*	21.5/23.5-20190812	DP05	20.0 - 25.0	5.0	N/A
			POORLY GRADED SAND, SP, 10YR 4/3 (brown) to 5Y 3/1 (very dark gray), fine, medium dense, wet	26.5/28.5-20190812	DP06	25.0 - 30.0	5.0	N/A
33.6	180.7			31.5/33.5-20190813	DP07	30.0 - 35.0	4.5	N/A
40.0	174.3		POORLY GRADED SAND, SP, 5Y 4/1 (dark gray), medium, medium dense to loose, wet, coal fragments	36.5/38.5-20190813	DP08	35.0 - 40.0	5.0	N/A

No Refusal /
Bottom of Hole at 40.0 Ft.

1: E = Environmental Sample Custody (two Split Spoons may be required to obtain sufficient sample)
G = Geotechnical Sample Custody
2: a,b,c denote Split Spoon divided between Environmental and Geotechnical Samples
3: Depths are reported in feet below ground surface
4: Grab sample (0.0/0.5-20190813) sampled using hand auger

SUBSURFACE LOG

Client Borehole ID N/A
Stantec Boring No. **ALF-BG08**
Client Tennessee Valley Authority
Boring Location 271,123.54 N; 761,826.30 E NAD27 Plant Local
Project Number 175568282
Surface Elevation 212.7 ft
Elevation Datum NGVD29
Project Name ALF TDEC Order
Date Started 8/19/19
Completed 8/20/19
Project Location Memphis, TN
Depth to Water N/A
Date/Time N/A
Inspector C. Sexton
Logger C. Sexton
Depth to Water N/A
Date/Time N/A
Drilling Contractor Hawkston (Subcontractor)
Drill Rig Type and ID Geoprobe 3230DT
Overburden Drilling and Sampling Tools (Type and Size) DPT 3.75 Dual Tube
Rock Drilling and Sampling Tools (Type and Size) N/A
Overdrill Tooling (Type and Size) N/A
Overdrill Depth N/A
Sampler Hammer Type N/A
Weight N/A
Drop N/A
Efficiency N/A
Borehole Azimuth N/A
Borehole Inclination (from Vertical) N/A
Reviewed By B. Evans
Approved By J. Griggs

Lithology				
Depth Ft^3	Elevation	Graphic	Description	
0.0	212.7		Top of Hole	
0.2	212.5	≡	Topsoil, vegetative material	HA^4
2.4	210.3	▨	SANDY LEAN CLAY, CL, 10YR 3/2 (very dark grayish brown) with 5YR 4/6 (yellowish red), low to medium plasticity, firm, moist, iron oxide staining, laminated, roots	1.5/3.5-20190819
7.8	204.9	▨	FAT CLAY, CH, 10YR 5/1 (gray), medium to high plasticity, soft to very hard, iron oxide staining, organic materials, manganese nodules, lignite fragments	6.5/8.5-20190819
13.8	198.9	▨	SANDY FAT CLAY, CH, 10YR 4/3 (brown) with 7.5YR 6/1 (gray), medium to high plasticity, soft to firm, moist to wet, iron oxide staining, manganese and iron nodules	11.5/13.5-20190819
		⁘	POORLY GRADED SAND, SP, 10YR 4/3 (brown) to 10YR 4/2 (dark grayish brown), very fine to medium, medium dense, wet, iron oxide staining, stratified, deep red iron staining 5YR 3/4, manganese nodules, coarsening upward sequences	16.5/18.5-2019081

Overburden: Sample^{1,2}	Depth Ft^3		Rec. Ft	Blows/PSI
Rock Core: RQD %	Run Ft		Rec. Ft	Rec. %
HA01	0.0 - 0.5		0.5	
DP01	0.0 - 5.0	0.0 - 5.0	3.5	N/A
DP02	5.0 - 10.0	5.0 - 10.0	4.2	N/A
DP03	10.0 - 15.0	10.0 - 15.0	4.6	N/A
DP04	15.0 - 20.0	15.0 - 20.0	4.1	N/A

TVA EIP BORING LOG 175567295 ALF TDEC ORDER.GPJ TDEC SUBSURF DT 20190530.GDT 2/9/20

SUBSURFACE LOG

Client Borehole ID N/A
Stantec Boring No. **ALF-BG08**
Client Tennessee Valley Authority
Boring Location 271,123.54 N; 761,826.30 E NAD27 Plant Local
Project Number 175568282
Surface Elevation 212.7 ft
Elevation Datum NGVD29

Lithology									
Depth Ft^3	Elevation	Graphic	Description	Overburden: Rock Core:	Sample^{1,2} RQD %	Depth Ft^3 Run Ft		Rec. Ft Rec. Ft	Blows/PSI Rec. %
24.6	188.1		POORLY GRADED SAND, SP, 10YR 4/3 (brown) to 10YR 4/2 (dark grayish brown), very fine to medium, medium dense, wet, iron oxide staining, stratified, deep red iron staining 5YR 3/4, manganese nodules, coarsening upward sequences *(Continued)*	21.5/23.5-20190819	DP05	20.0 - 25.0	20.0 - 25.0	5.0	N/A
35.0	177.7		POORLY GRADED SAND, SP, 5Y 4/1 (dark gray), medium to coarse, medium dense to loose, wet, coal fragments 'Blue' clay from 32.9' to 33.7'	26.5/28.5-20190819	DP06	25.0 - 30.0	25.0 - 30.0	5.0	N/A
				31.5/33.5-20190819	DP07	30.0 - 35.0	30.0 - 35.0	4.4	N/A

Depth scale: 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35

No Refusal /
Bottom of Hole at 35.0 Ft.

1: E = Environmental Sample Custody (two Split Spoons may be required to obtain sufficient sample)
G = Geotechnical Sample Custody
2: a,b,c denote Split Spoon divided between Environmental and Geotechnical Samples
3: Depths are reported in feet below ground surface
4: Grab sample (0.0/0.5-20190820) sampled using hand auger

SUBSURFACE LOG

Client Borehole ID: N/A
Stantec Boring No.: **ALF-BG09**
Client: Tennessee Valley Authority
Boring Location: 272,708.27 N; 764,840.86 E NAD27 Plant Local
Project Number: 175568282
Surface Elevation: 215.1 ft
Elevation Datum: NGVD29
Project Name: ALF TDEC Order
Date Started: 8/15/19
Completed: 8/16/19
Project Location: Memphis, TN
Depth to Water: N/A
Date/Time: N/A
Inspector: C. Sexton
Logger: C. Sexton
Depth to Water: N/A
Date/Time: N/A
Drilling Contractor: Hawkston (Subcontractor)
Drill Rig Type and ID: Geoprobe 3230DT
Overburden Drilling and Sampling Tools (Type and Size): DPT 3.75 Dual Tube
Rock Drilling and Sampling Tools (Type and Size): N/A
Overdrill Tooling (Type and Size): N/A
Overdrill Depth: N/A
Sampler Hammer Type: N/A
Weight: N/A
Drop: N/A
Efficiency: N/A
Borehole Azimuth: N/A
Borehole Inclination (from Vertical): N/A
Reviewed By: B. Evans
Approved By: J. Griggs

Lithology			Description		Overburden: Sample^{1,2}	Depth Ft^{3}		Rec. Ft	Blows/PSI
Depth Ft^{3}	Elevation	Graphic			Rock Core: RQD %	Run Ft		Rec. Ft	Rec. %
0.0	215.1		Top of Hole						
0.6	214.5	▦	Topsoil, gravel, roots, bottom ash gravels	HA^{4}	HA01	0.0 - 0.5		0.5	
		▨	SANDY FAT CLAY, CH, 10YR 3/2 (very dark grayish brown) to 10YR 4/1 (dark gray), low to medium plasticity, soft to firm, moist to wet, iron oxide staining, roots, gravels	1.5/3.5-20190816	DP01	0.0 - 5.0	0.0 - 5.0	3.7	N/A
		▨		6.5/8.5-20190816	DP02	5.0 - 10.0	5.0 - 10.0	4.8	N/A
11.4	203.7	▨							
		▨	LEAN CLAY TRACE SAND, CL, 10YR 5/1 (gray), medium plasticity, soft to firm, wet to moist, trace gravel, roots	11.5/13.5-20190816	DP03	10.0 - 15.0	10.0 - 15.0	5.0	N/A
16.2	198.9	▨							
		▨	FAT CLAY, CH, 10YR 4/1 (dark gray), high plasticity, firm to very hard, moist, roots	16.5/18.5-20190816	DP04	15.0 - 20.0	15.0 - 20.0	5.0	N/A

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TVA EIP BORING LOG 175567295 ALF TDEC ORDER.GPJ TDEC SUBSURF DT 20190530.GDT 2/9/20

SUBSURFACE LOG

Client Borehole ID N/A
Client Tennessee Valley Authority
Project Number 175568282
Stantec Boring No. **ALF-BG09**
Boring Location 272,708.27 N; 764,840.86 E NAD27 Plant Local
Surface Elevation 215.1 ft
Elevation Datum NGVD29

Lithology				Overburden:	Sample[1,2]	Depth Ft[3]	Rec. Ft	Blows/PSI
Depth Ft[3]	Elevation	Graphic	Description	Rock Core:	RQD %	Run Ft	Rec. Ft	Rec. %
18 19 20 21		▨	FAT CLAY, CH, 10YR 4/1 (dark gray), high plasticity, firm to very hard, moist, roots *(Continued)*					
22 23 24 25		▨		21.5/23.5-20190816	DP05	20.0 - 25.0 20.0 - 25.0	5.0	N/A
26 27 28 29		▨		26.5/28.5-20190816	DP06	25.0 - 30.0 25.0 - 30.0	5.0	N/A
30 30.0	185.1	▨						

No Refusal /
Bottom of Hole at 30.0 Ft.

1: E = Environmental Sample Custody (two Split Spoons may be required to obtain sufficient sample)
G = Geotechnical Sample Custody
2: a,b,c denote Split Spoon divided between Environmental and Geotechnical Samples
3: Depths are reported in feet below ground surface
4: Grab sample (0.0/0.5-20190816) sampled using hand auger

TVA EIP BORING LOG 175567295 ALF TDEC ORDER.GPJ TDEC SUBSURF DT 20190530.GDT 2/9/20

SUBSURFACE LOG

Client Borehole ID N/A
Stantec Boring No. **ALF-BG10**
Client Tennessee Valley Authority
Boring Location 271,853.70 N; 761,926.76 E NAD27 Plant Local
Project Number 175568282
Surface Elevation 212.2 ft
Elevation Datum NGVD29
Project Name ALF TDEC Order
Date Started 8/22/19
Completed 8/22/19
Project Location Memphis, TN
Depth to Water N/A
Date/Time N/A
Inspector C. Sexton
Logger C. Sexton
Depth to Water N/A
Date/Time N/A
Drilling Contractor Hawkston (Subcontractor)
Drill Rig Type and ID Geoprobe 3230DT
Overburden Drilling and Sampling Tools (Type and Size) DPT 3.75 Dual Tube
Rock Drilling and Sampling Tools (Type and Size) N/A
Overdrill Tooling (Type and Size) N/A
Overdrill Depth N/A
Sampler Hammer Type N/A
Weight N/A
Drop N/A
Efficiency N/A
Borehole Azimuth N/A
Borehole Inclination (from Vertical) N/A
Reviewed By B. Evans
Approved By J. Griggs

Lithology				Overburden:	Sample^{1,2}	Depth Ft^{3}		Rec. Ft	Blows/PSI
Depth Ft^{3}	Elevation	Graphic	Description	Rock Core:	RQD %	Run Ft		Rec. Ft	Rec. %
0.0	212.2		Top of Hole						
1.0	211.2	○	rock fill, vegetative material, and soil	HA^{4}	HA01	0.0 - 0.5		0.5	
7.0	205.2	▧	SANDY LEAN CLAY, CL, 10YR 3/2 (very dark grayish brown) with 5YR 4/6 (yellowish red), low to medium plasticity, firm, moist, iron oxide staining, roots	0.9/2.9-20190822	DP01	0.0 - 5.0	0.0 - 5.0	2.9	N/A
7.8	204.4	▨	FAT CLAY, CH, 10YR 5/1 (gray), medium to high plasticity, firm to very hard, moist, organic materials, mg nodules, lignite fragments	6.5/8.5-20190822	DP02	5.0 - 10.0	5.0 - 10.0	3.9	N/A
13.8	198.4	▨	SANDY FAT CLAY, CH, 10YR 4/3 (brown) with 7.5YR 6/1 (gray), medium to high plasticity, soft to firm, moist to wet, iron oxide staining, manganese and iron nodules	11.5/13.5-20190822	DP03	10.0 - 15.0	10.0 - 15.0	3.5	N/A
		⁘	POORLY GRADED SAND, SP, 10YR 4/3 (brown) to 10YR 4/2 (dark grayish brown), very fine to medium, medium dense, wet, iron oxide staining, stratified, deep red iron staining 5YR 3/4, manganese nodules, coarsening upward sequences	16.5/18.5-20190822	DP04	15.0 - 20.0	15.0 - 20.0	5.0	N/A

SUBSURFACE LOG

Client Borehole ID N/A
Client Tennessee Valley Authority
Project Number 175568282
Stantec Boring No. **ALF-BG10**
Boring Location 271,853.70 N; 761,926.76 E NAD27 Plant Local
Surface Elevation 212.2 ft
Elevation Datum NGVD29

Lithology				Overburden:	Sample^{1,2}	Depth Ft^{3}		Rec. Ft	Blows/PSI
Depth Ft^{3}	Elevation	Graphic	Description	Rock Core:	RQD %	Run Ft		Rec. Ft	Rec. %
24.6	187.6		POORLY GRADED SAND, SP, 10YR 4/3 (brown) to 10YR 4/2 (dark grayish brown), very fine to medium, medium dense, wet, iron oxide staining, stratified, deep red iron staining 5YR 3/4, manganese nodules, coarsening upward sequences *(Continued)*	21.5/23.5-20190822	DP05	20.0 - 25.0	20.0 - 25.0	4.4	N/A
40.0	172.2		POORLY GRADED SAND SOME CLAY, SP, 5Y 4/1 (dark gray), medium to coarse, medium dense to loose, wet, coal and roots fragments, coarsening upward sequences	26.5/28.5-20190822	DP06	25.0 - 30.0	25.0 - 30.0	5.0	N/A
				31.5/33.5-20190822	DP07	30.0 - 35.0	30.0 - 35.0	4.4	N/A
				36.5/38.5-20190822	DP08	35.0 - 40.0	35.0 - 40.0	5.0	N/A

No Refusal /
Bottom of Hole at 40.0 Ft.

1: E = Environmental Sample Custody (two Split Spoons may be required to obtain sufficient sample)
G = Geotechnical Sample Custody
2: a,b,c denote Split Spoon divided between Environmental and Geotechnical Samples
3: Depths are reported in feet below ground surface
4: Grab sample (0.0/0.5-20190822) sampled using hand auger

SUBSURFACE LOG

Client Borehole ID N/A
Stantec Boring No. **ALF-BG12**
Client Tennessee Valley Authority
Boring Location 270,722.18 N; 757,941.48 E NAD27 Plant Local
Project Number 175568282
Surface Elevation 212.8 ft
Elevation Datum NGVD29
Project Name ALF TDEC Order
Date Started 8/21/19
Completed 8/21/19
Project Location Memphis, TN
Depth to Water N/A
Date/Time N/A
Inspector C. Sexton
Logger C. Sexton
Depth to Water N/A
Date/Time N/A
Drilling Contractor Hawkston (Subcontractor)
Drill Rig Type and ID Geoprobe 3230DT
Overburden Drilling and Sampling Tools (Type and Size) DPT 3.75 Dual Tube
Rock Drilling and Sampling Tools (Type and Size) N/A
Overdrill Tooling (Type and Size) N/A
Overdrill Depth N/A
Sampler Hammer Type N/A
Weight N/A
Drop N/A
Efficiency N/A
Borehole Azimuth N/A
Borehole Inclination (from Vertical) N/A
Reviewed By B. Evans
Approved By J. Griggs

Lithology				Overburden:	Sample[1,2]	Depth Ft[3]		Rec. Ft	Blows/PSI
Depth Ft[3]	Elevation	Graphic	Description	Rock Core:	RQD %	Run Ft		Rec. Ft	Rec. %
0.0	212.8		Top of Hole						
1.0	211.8		Topsoil, crop detritus	HA[4]	HA01	0.0 - 0.5		0.5	
2.9	209.9		SANDY FAT CLAY, CH, 10YR 3/2 (very dark grayish brown), medium to high plasticity, soft, moist to dry	1.5/3.5-20190822	DP01	0.0 - 5.0	0.0 - 5.0	3.9	N/A
8.1	204.7		FAT CLAY, CH, 10YR 3/2 (very dark grayish brown) with 5YR 4/6 (yellowish red), medium to high plasticity, firm, moist, iron oxide staining, roots, mottling	6.5/8.5-20190822	DP02	5.0 - 10.0	5.0 - 10.0	4.2	N/A
14.0	198.8		SILTY POORLY GRADED SAND WITH CLAY, SP, 10YR 5/3 (brown) to 10YR 7/2 (light gray), fine, loose to medium dense, wet	11.5/13.5-20190822	DP03	10.0 - 15.0	10.0 - 15.0	5.0	N/A
			POORLY GRADED SAND, SP, 10YR 7/2 (light gray), very fine to medium, medium dense, wet, iron oxide staining, coarsening upward sequences	16.5/18.5-20190822	DP04	15.0 - 20.0	15.0 - 20.0	5.0	N/A

SUBSURFACE LOG

Client Borehole ID N/A
Client Tennessee Valley Authority
Project Number 175568282
Stantec Boring No. **ALF-BG12**
Boring Location 270,722.18 N; 757,941.48 E NAD27 Plant Local
Surface Elevation 212.8 ft Elevation Datum NGVD29

Lithology				Overburden:	Sample^{1,2}	Depth Ft^{3}		Rec. Ft	Blows/PSI
Depth Ft^{3}	Elevation	Graphic	Description	Rock Core:	RQD %	Run Ft		Rec. Ft	Rec. %
24.7	188.1		POORLY GRADED SAND, SP, 10YR 7/2 (light gray), very fine to medium, medium dense, wet, iron oxide staining, coarsening upward sequences *(Continued)* Clay and sandy clay from 18.8' to 19.8'	21.5/23.5-20190822	DP05	20.0 - 25.0	20.0 - 25.0	5.0	N/A
30.0	182.8		POORLY GRADED SAND, SP, 10YR 5/1 (gray), very fine to medium, medium dense, wet, coal fragments, coarsening upward sequences	26.5/28.5-20190822	DP06	25.0 - 30.0	25.0 - 30.0	4.1	N/A

No Refusal /
Bottom of Hole at 30.0 Ft.

1: E = Environmental Sample Custody (two Split Spoons may be required to obtain sufficient sample)
G = Geotechnical Sample Custody
2: a,b,c denote Split Spoon divided between Environmental and Geotechnical Samples
3: Depths are reported in feet below ground surface
4: Grab sample (0.0/0.5-20190822) sampled using hand auger

SUBSURFACE LOG

Client Borehole ID N/A
Stantec Boring No. **ALF-BG13**
Client Tennessee Valley Authority
Boring Location 269,414.78 N; 757,766.71 E NAD27 Plant Local
Project Number 175568282
Surface Elevation 212.1 ft
Elevation Datum NGVD29
Project Name ALF TDEC Order
Date Started 8/21/19
Completed 8/21/19
Project Location Memphis, TN
Depth to Water N/A
Date/Time N/A
Inspector C. Sexton
Logger C. Sexton
Depth to Water N/A
Date/Time N/A
Drilling Contractor Hawkston (Subcontractor)
Drill Rig Type and ID Geoprobe 3230DT
Overburden Drilling and Sampling Tools (Type and Size) DPT 3.75 Dual Tube
Rock Drilling and Sampling Tools (Type and Size) N/A
Overdrill Tooling (Type and Size) N/A
Overdrill Depth N/A
Sampler Hammer Type N/A
Weight N/A
Drop N/A
Efficiency N/A
Borehole Azimuth N/A
Borehole Inclination (from Vertical) N/A
Reviewed By B. Evans
Approved By J. Griggs

Lithology				Overburden:	Sample^{1,2}	Depth Ft^{3}		Rec. Ft	Blows/PSI
Depth Ft^{3}	Elevation	Graphic	Description	Rock Core:	RQD %	Run Ft		Rec. Ft	Rec. %
0.0	212.1		Top of Hole						
1.0	211.1	▦	Topsoil, crop detritus	HA^{4}	HA01	0.0 - 0.5		0.5	
7.3	204.8	▨	FAT CLAY, CH, 10YR 3/2 (very dark grayish brown) with 5YR 4/6 (yellowish red), medium to high plasticity, firm, moist, iron oxide staining, roots, mottling	1.5/3.5-20190821	DP01	0.0 - 5.0	0.0 - 5.0	4.0	N/A
15.9	196.2	⁘	SILTY POORLY GRADED SAND WITH CLAY, SP, 10YR 5/3 (brown) to 10YR 7/2 (light gray), fine, loose to medium dense, wet	6.5/8.5-20190821 11.5/13.5-20190821	DP02 DP03	5.0 - 10.0 10.0 - 15.0	5.0 - 10.0 10.0 - 15.0	4.1 4.3	N/A N/A
		⁘		16.5/18.5-20190821	DP04	15.0 - 20.0	15.0 - 20.0	4.0	N/A

SUBSURFACE LOG

Client Borehole ID N/A
Client Tennessee Valley Authority
Project Number 175568282
Stantec Boring No. **ALF-BG13**
Boring Location 269,414.78 N; 757,766.71 E NAD27 Plant Local
Surface Elevation 212.1 ft Elevation Datum NGVD29

Lithology				Overburden:	Sample^{1,2}	Depth Ft^{3}		Rec. Ft	Blows/PSI
Depth Ft^{3}	Elevation	Graphic	Description	Rock Core:	RQD %	Run Ft		Rec. Ft	Rec. %
30.0	182.1		POORLY GRADED SAND, SP, 10YR 6/3 (pale brown), very fine to medium, medium dense, wet, iron oxide staining, calcite nodules, lignite fragments, manganese nodules, trace pyrite, coarsening upward sequences *(Continued)*						
				21.5/23.5-20190821	DP05	20.0 - 25.0	20.0 - 25.0	5.0	N/A
				26.5/28.5-20190821	DP06	25.0 - 30.0	25.0 - 30.0	4.3	N/A

No Refusal /
Bottom of Hole at 30.0 Ft.

1: E = Environmental Sample Custody (two Split Spoons may be required to obtain sufficient sample)
G = Geotechnical Sample Custody
2: a,b,c denote Split Spoon divided between Environmental and Geotechnical Samples
3: Depths are reported in feet below ground surface
4: Grab sample (0.0/0.5-20190821) sampled using hand auger

APPENDIX B: STATISTICAL EVALUATION OF BACKGROUND GROUNDWATER QUALITY

TECHNICAL MEMORANDUM

2019 Statistical Evaluation of Background Groundwater Quality for Allen Fossil Plant

Prepared for:

Tennessee Valley Authority
Allen Fossil Plant
Memphis, Tennessee

Prepared by:

Stantec Consulting Services Inc.

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SIGN-OFF SHEET

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

APPENDICES

1.0 INTRODUCTION

This Technical Memorandum was prepared by Stantec Consulting (Stantec) to summarize the results of a statistical evaluation performed by MacStat Consulting Ltd., documented in a report entitled “2019 Statistical Analysis Report for Allen Fossil Plant Remedial Investigation.” The purpose of the statistical evaluation was to support groundwater evaluations associated with the Remedial Investigation and Groundwater Interim Response Action around the East Ash Disposal Area, located at the Tennessee Valley Authority (TVA) Allen Fossil Plant (ALF) in Memphis, Tennessee.

Representative site-specific background groundwater concentrations were established for CCR Rule Appendix III and Appendix IV constituents, Tennessee Department of Environment and Conservation (TDEC) Appendix I Metals, and additional water quality criteria. Groundwater quality in downgradient wells was subsequently evaluated based on comparisons to these established background groundwater values. This memorandum provides a review of the derived background groundwater values and the results of the statistical comparison of these values to groundwater quality observed in downgradient wells. A summary of the statistical methods applied to complete these analyses is also provided. Additional details regarding these statistical methods are provided in the MacStat report which has been included as **Appendix A** of this memorandum.

This evaluation supersedes background values used for comparison purposes in earlier reports. The values presented herein represent one point in time and may be updated in the future as appropriate.

2.0 EVALUATION OF BACKGROUND GROUNDWATER QUALITY

Statistical methods were applied to establish representative site-specific background groundwater concentrations for CCR Rule Appendix III and Appendix IV constituents, TDEC Appendix I Metals and additional water quality criteria. This section summarizes the data used, the statistical approach applied, and the results of this background groundwater quality analysis.

2.1 BACKGROUND GROUNDWATER MONITORING NETWORK

The background groundwater quality analysis relied on data available from five wells that are hydraulically upgradient of the ALF coal combustion residual (CCR) units and do not exhibit constituents typically associated with CCR-impacted groundwater (e.g., boron, sulfate) (**Table 1, Figure 1**). All wells are located within the Alluvial aquifer at various depths.

Table 1. Background Groundwater Monitoring Network Wells for Allen Fossil Plant

Well ID	Screen Elevation (ft msl)	Screen Depth (ft bgs)
ALF 216	177.6-157.6	35.3-55.3
ACC-1A	54.7-44.7	156.2-166.2
ACC-3A	98.7-88.7	117-127
ACC-5A	86.8-76.8	129.8-139.8
ACC-5B	170.1-160.1	45.9-55.9

2.2 SAMPLING EVENTS INCLUDED IN BACKGROUND GROUNDWATER QUALITY STATISTICAL ANALYSES

Background groundwater quality statistical analyses were conducted using validated analytical data collected from the following seven sampling events performed at ALF: September 2017, October 2017, November 2017, November 2018, April 2019, June 2019, and September 2019. Stantec collected groundwater samples; Pace Laboratories performed the laboratory analysis; and Environmental Standards Inc. provided Data Quality Assurance.

2.3 BACKGROUND CONSTITUENTS

Site-specific background concentrations were established for the constituents listed in **Table 2.**

Table 2. Background Groundwater Constituents Assessed for Allen Fossil Plant

CCR Rule Appendix III Constituents	CCR Rule Appendix IV Constituents	TDEC Appendix I Metals	Additional Constituents
Boron	Antimony	Copper	Magnesium
Calcium	Arsenic	Nickel	Potassium
Chloride	Barium	Silver	Sodium
Fluoride	Beryllium	Vanadium	Alkalinity as Bicarbonate
Sulfate	Cadmium	Zinc	Alkalinity as Carbonate
pH (SU)	Chromium (total)		
Total Dissolved Solids	Cobalt		
	Fluoride		
	Lead		
	Lithium		
	Mercury (inorganic)		
	Molybdenum		
	Selenium		
	Thallium		
	Radium 226 & 228		

2.4 STATISTICAL METHODS

For each evaluated constituent, data collected from the five background groundwater monitoring wells identified in **Section 2.1** were relied on to calculate representative site-specific background concentrations following accepted statistical procedures and methods as described in the USEPA document "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities. Unified Guidance" (Unified Guidance – USEPA, 2009). A brief summary of the methods used is provided below.

1. Outlier testing. Data from all five wells were pooled and screened for outliers. Two outliers were confirmed in total, one for Total Dissolved Solids (TDS) and one for zinc (see **Appendix A**). These outliers were excluded from further analysis.

2. Testing for normality. The pooled baseline data (with identified outliers excluded) were analyzed to determine whether they could be fit to a known statistical model. This was achieved by applying a series of mathematical transformations to the data and then testing the transformed data for normality using Filliben's normality test. For datasets that were normal or could be normalized using a mathematical transformation, the best-fitting model for that dataset is identified in **Table 1**. The remaining datasets, for which no suitable normalizing distribution was identified, are identified in **Table 1** as non-parametric.

3. Calculation of tolerance limits or tolerance intervals. Per the Unified Guidance, upper tolerance limits (UTLs) were then generated using either parametric methods (for data that fit a known distribution) or non-parametric methods (if no suitable distribution was identified). When all data for a COC were non-detect, the UTL was set to the highest reported detection limit. For pH, a lower tolerance limit (LTL) was also calculated to create a tolerance interval.

2.5 BACKGROUND THRESHOLD VALUES

A mix of parametric and non-parametric methods were employed to calculate site-specific UTLs (and an LTL for pH). The choice of method was dependent solely on data characteristics. The background data set will be updated when additional samples are collected from the background groundwater monitoring network and re-evaluation is deemed necessary.

The resulting UTLs (and LTL for pH) are summarized in **Table 3**

Table 3. Background Groundwater Quality Tolerance Limits and Tolerance Intervals for Allen Fossil Plant

Constituent	Unit	Sample Size (n)	Percent Non-Detects	Distribution	Tolerance Limit Method	Confidence	95% LTL	95% UTL
CCR Rule Appendix III Constituents								
Boron	mg/L	33	21%	Normal	Parametric	0.95	NA	0.24
Calcium	mg/L	33	0%	Cube	Parametric	0.95	NA	160
Chloride	mg/L	33	0%	Log	Parametric	0.95	NA	23
Fluoride	mg/L	33	0%	Log	Parametric	0.95	NA	0.23
pH	SU	33	0%	Log	Parametric	0.95	6	7.7
Sulfate	mg/L	33	3%	Square Root	Parametric	0.95	NA	130
Total Dissolved Solids (TDS)	mg/L	32	0%	Square	Parametric	0.95	NA	620
CCR Rule Appendix IV Constituents								
Antimony	mg/L	33	97%	Non-parametric	Non-parametric	0.82	NA	0.0025
Arsenic	mg/L	33	0%	Log	Parametric	0.95	NA	0.0098
Barium	mg/L	33	0%	Normal	Parametric	0.95	NA	1.1
Beryllium	mg/L	33	100%	Non-parametric	Non-parametric	0.82	NA	0.0005
Cadmium	mg/L	33	100%	Non-parametric	Non-parametric	0.82	NA	0.0004
Chromium	mg/L	33	100%	Non-parametric	Non-parametric	0.82	NA	0.0025
Cobalt	mg/L	33	39%	Log	Parametric	0.95	NA	0.0071
Fluoride	mg/L	33	0%	Log	Parametric	0.95	NA	0.23
Lead	mg/L	33	85%	Non-parametric	Non-parametric	0.82	NA	0.0005
Lithium	mg/L	33	6%	Cube Root	Parametric	0.95	NA	0.034
Mercury	mg/L	33	100%	Non-parametric	Non-parametric	0.82	NA	0.0002
Molybdenum	mg/L	33	15%	Log	Parametric	0.95	NA	0.002
Rad226+228	pCi/L	33	0%	Tenth Root	Parametric	0.95	NA	3.8
Selenium	mg/L	33	100%	Non-parametric	Non-parametric	0.82	NA	0.0025
Thallium	mg/L	33	100%	Non-parametric	Non-parametric	0.82	NA	0.0005
TDEC Metals Appendix I Constituents								
Copper	mg/L	33	88%	Cube Root	Parametric	0.95	NA	0.0017
Nickel	mg/L	33	39%	Log	Parametric	0.95	NA	0.012
Silver	mg/L	33	100%	Non-parametric	Non-parametric	0.82	NA	0.002
Vanadium	mg/L	33	100%	Non-parametric	Non-parametric	0.82	NA	0.0015
Zinc	mg/L	32	63%	Cube Root	Parametric	0.95	NA	0.01
Additional Constituents								
Magnesium	mg/L	33	0%	Normal	Parametric	0.95	NA	47
Potassium	mg/L	33	0%	Square	Parametric	0.95	NA	3.5
Sodium	mg/L	33	0%	Log	Parametric	0.95	NA	21
Alkalinity, Bicarbonate (as CaCO3)	mg/L	33	0%	Cube	Parametric	0.95	NA	560
Alkalinity, Carbonate (as CaCO3)	mg/L	33	100%	Non-parametric	Non-parametric	0.82	NA	5

3.0 EVALUATION OF DOWNGRADIENT GROUNDWATER QUALITY

Statistical methods were applied to compare current groundwater conditions across the ALF groundwater monitoring network to the background groundwater conditions established in **Section 2.0**. This section summarizes the data used, the statistical approach applied, and the results of this statistical evaluation.

3.1 GROUNDWATER MONITORING NETWORK

A summary of the general locations and well depths of the groundwater monitoring network wells included in the statistical comparison to background groundwater conditions is provided in **Table 4**. The focus of this analysis was to compare concentrations of constituents in groundwater samples from downgradient wells to upper and lower (where applicable) tolerance limits that were developed based on background well concentrations. The wells used to determine the background concentrations (ALF 216, ACC-1A, ACC-3A, ACC-5A, and ACC-5B) were also included in this analysis.

Table 4. Summary of Groundwater Monitoring Network Wells for Allen Fossil Plant

Background Wells		South-Side Wells		North-Side Wells		East-Side Wells	
Well ID	**Bottom of Well Elevation (ft NGVD 29)**	**Well ID**	**Bottom of Well Elevation (ft NGVD 29)**	**Well ID**	**Bottom of Well Elevation (ft NGVD 29)**	**Well ID**	**Bottom of Well Elevation (ft NGVD 29)**
ALF-216	157	ALF-201	172	ALF-203	168	ALF-212	171
ACC-1A	44	ALF-201B	128	ALF-203B	128	ALF-212A	70
ACC-3A	88	ALF-201A	92	ALF-203A	100	ALF-213	159
ACC-5A	76	ALF-202	175	ALF-204	159	ALF-213A	119
ACC-5B	160	ALF-202B	126	ALF-204B	125	ALF-213B	78
		ALF-202A	70	ALF-204A	98	ALF-217	169
		ALF-210	171	ALF-205	165	ALF-217A	109
		ALF-210A	90	ALF-205B	135	ALF-217B	48
		ALF-214	166	ALF-205A	109		
		ALF-214B	128	ALF-206	162		
		ALF-214A	88	ALF-P4	138		
		ALF-215	186	ALF-P4S	166		
		ALF-PMW10A	178	ALF-PMW02A	180		
		ALF-PMW10B	149	ALF-PMW02B	161		
		ALF-PMW10C	70	ALF-PMW02C	90		
		ALF-PMW11A	180	ALF-PMW04A	180		
		ALF-PMW11B	150	ALF-PMW04B	159		
		ALF-PMW11C	69	ALF-PMW04C	91		
		ALF-PMW14A	180	ALF-PMW07A	190		
		ALF-PMW14B	151	ALF-PMW07B	159		
		ALF-PMW14C	78	ALF-PMW07C	96		

3.2 SAMPLING EVENTS INCLUDED IN EVALUATION

Data collected from the wells listed in **Table 4** between May 2017 and September 2019 were relied on to provide a statistical evaluation of current groundwater conditions across the ALF groundwater monitoring network to the background groundwater conditions established in **Section 2.0**. Stantec Consulting Services, Inc. (Stantec) collected groundwater samples; Pace Laboratories performed the laboratory analysis; and Environmental Standards Inc. provided Data Quality Assurance.

3.3 STATISTICAL METHODS

For each evaluated constituent, accepted statistical procedures and methods as described in the USEPA document "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities. Unified Guidance" (Unified Guidance – USEPA, 2009) were applied to compare current groundwater conditions across the ALF groundwater monitoring network to the background groundwater conditions established in **Section 2.0**. A brief summary of the methods used is provided below.

1. Outlier testing. Data for each well-constituent pair were reviewed to identify possible outliers and outlier testing was applied as needed. In total, 18 outliers were identified and excluded from subsequent calculations (see **Appendix A**).

2. Constructing linear confidence bands for each well-constituent pair. For each well-constituent pair (with identified outliers excluded), a linear trend line was fit to the data and a confidence interval band corresponding to a 99% lower confidence limit was constructed. Where non-detect data were present, this process involved an adjustment made to incorporate the censored measurements. This adjustment is described in more detail in **Appendix A.**

3. Comparison of confidence interval bands to the derived background groundwater tolerance limits or tolerance intervals. Each confidence band was compared against the appropriate background threshold values (BTVs) derived in **Section 2.5**. For most constituents, a statistically significant increase (SSI) above the background concentration was only determined when the entire confidence band exceeded the BTV at the most recent sampling event. The only exception was for pH, for which an SSI was determined if the confidence band either fully exceeded the upper BTV or was fully below the lower BTV.

3.4 RESULTS

The final linear trend lines and confidence bands for each constituent and well, contrasted with the background threshold values determined in **Section 2.0** are provided in full in **Appendix A**. A summary of the results of this analysis is provided in **Table 5**. In this table, each well-constituent pair is color coded according to the following classifications:

- Green: Confidence band is below or within the BTV limits for the most recent sampling event.
- Yellow: The upper edge of the confidence band exceeds the BTV or the lower edge of the confidence band is at least 65% of the BTV for the most recent sampling event. For pH, a well could also receive a yellow classification if the confidence band was straddling or approaching the lower BTV.
- Red: Statistically significant increase (SSI) above the background concentration observed for the most recent sampling event (i.e., the entire confidence band exceeds the BTV or, for pH only, the entire confidence band falls below the lower BTV).

The following observations were made based on this evaluation (as summarized in **Table 5**):

- SSIs above background were not observed for the following constituents: antimony, barium, beryllium, bicarbonate, cadmium, calcium, chromium, cobalt, copper, lithium, magnesium, mercury, nickel, radium 226+228, selenium, silver, thallium, and zinc.

- SSIs above background were rarely observed (at two or fewer wells) for lead, pH, carbonate, TDS, and vanadium.

- The constituents with the largest number of wells with SSIs indicating a significant variation from background conditions include:
    - Chloride (4 wells)
    - Potassium (5 wells)
    - Sulfate (6 wells)
    - Arsenic (10 wells)
    - Sodium (15 wells)
    - Fluoride (19 wells)
    - Boron (22 wells)
    - Molybdenum (22 wells)

Table 5- Summary of Confidence Band Evaluation
Groundwater Data
TVA ALF, Memphis, TN

Well ID	Bottom of Well Elevation (ft bgs)	Antimony	Arsenic	Barium	Beryllium	Bicarbonate	Boron	Cadmium	Calcium	Carbonate	Chloride	Chromium	Cobalt	Copper	Fluoride	Lead	Lithium	Magnesium	Mercury	Molybdenum	Nickel	pH	Potassium	Rad226+228	Selenium	Silver	Sodium	Sulfate	TDS	Thallium	Vanadium	Zinc	Total Number of SSIs
Background Wells																																	
ALF-216	157	G	G	G	G	Y	Y	G	Y	Y	G	G	G	Y	G	G	G	Y	Y	G	G	G	G	G	G	G	G	G	Y	G	G	Y	0
ACC-1A	44	G	G	G	G	G	G	G	G	Y	G	G	G	Y	Y	G	G	G	Y	G	G	G	G	G	G	G	G	G	G	G	G	Y	0
ACC-3A	88	G	G	Y	G	G	Y	G	G	G	G	G	G	Y	G	G	G	G	G	G	G	Y	G	Y	G	G	G	G	Y	G	G	Y	0
ACC-5A	76	G	G	G	G	G	G	G	G	G	Y	G	G	Y	G	G	G	G	G	G	G	G	G	G	G	G	G	Y	G	G	G	Y	0
ACC-5B	160	G	G	G	G	Y	G	G	Y	G	G	G	G	G	Y	G	G	G	G	Y	Y	Y	G	G	G	G	G	G	Y	G	G	Y	0
South-Side Wells																																	
ALF-201	172	G	G	G	Y	G	Y	G	G	G	G	Y	G	G	Y	Y	G	G	G	Y	G	G	G	G	Y	G	Y	G	G	Y	G	G	0
ALF-201B	128	Y	G	G	Y	G	R	Y	G	G	G	Y	G	Y	R	Y	G	G	G	R	G	Y	Y	G	Y	Y	R	Y	G	Y	Y	Y	4
ALF-201A	92	G	G	G	Y	G	R	G	G	G	G	G	G	G	R	G	G	G	G	R	G	Y	G	G	G	G	R	G	G	G	G	G	4
ALF-202	175	G	R	G	G	G	R	G	G	G	G	G	G	Y	R	Y	G	G	G	R	G	Y	G	G	G	G	R	Y	G	G	Y	Y	5
ALF-202B	126	G	G	G	G	G	R	G	G	G	G	G	G	Y	Y	G	G	G	G	R	G	G	G	G	G	G	G	G	G	G	G	Y	2
ALF-202A	70	G	G	G	G	G	R	G	G	G	G	G	G	G	Y	G	G	G	G	R	G	G	G	G	G	G	G	G	G	G	G	Y	2
ALF-210	171	G	G	G	G	G	G	G	G	G	G	Y	G	G	Y	G	G	G	G	Y	G	G	G	G	G	G	G	G	Y	G	G	G	0
ALF-210A	90	Y	G	G	G	G	R	Y	Y	G	R	Y	G	Y	G	Y	G	G	G	Y	G	Y	R	G	Y	Y	R	R	R	Y	Y	Y	6
ALF-214	166	Y	G	G	Y	G	Y	Y	G	G	G	Y	G	Y	R	Y	G	G	G	Y	G	Y	G	G	Y	Y	G	G	G	Y	G	Y	1
ALF-214B	128	Y	G	G	Y	G	G	Y	G	G	R	Y	G	Y	G	Y	G	G	G	Y	G	G	G	G	Y	Y	R	R	G	Y	Y	Y	3
ALF-214A	88	Y	G	G	Y	G	G	Y	G	G	R	Y	G	Y	G	Y	G	G	G	Y	G	G	Y	G	Y	Y	R	R	R	Y	Y	Y	4
ALF-215	186	G	G	G	G	G	Y	G	G	G	G	G	Y	Y	Y	G	G	G	G	Y	G	G	G	G	G	G	G	G	G	G	G	G	0
North-Side Wells																																	
ALF-203	168	G	R	G	Y	G	R	Y	G	R	G	Y	G	Y	R	R	G	G	G	R	G	R	G	G	Y	Y	R	R	Y	Y	R	Y	10
ALF-203B	128	G	Y	G	Y	G	Y	G	G	G	G	G	G	G	Y	Y	G	G	G	Y	G	Y	G	G	G	G	Y	G	G	G	G	Y	0
ALF-203A	100	G	G	G	G	G	Y	G	G	G	G	G	G	Y	G	G	G	G	G	Y	G	Y	G	G	G	G	G	G	G	G	G	G	0
ALF-204	159	G	Y	G	Y	G	R	G	G	G	G	G	G	G	Y	Y	G	G	G	R	G	G	Y	G	G	G	G	G	G	Y	Y	Y	2
ALF-204B	125	G	G	G	G	G	R	G	G	G	G	G	G	G	Y	G	G	G	G	R	G	Y	G	G	G	G	G	G	G	G	G	Y	2
ALF-204A	98	G	G	G	G	G	G	G	G	G	G	G	G	G	Y	G	G	G	G	Y	G	G	G	G	G	G	G	G	G	G	G	Y	0
ALF-205	165	Y	G	G	Y	G	R	Y	G	G	G	Y	G	Y	R	Y	G	G	G	R	G	Y	Y	G	Y	G	R	G	Y	Y	Y	G	4
ALF-205B	135	Y	G	G	Y	G	G	Y	G	G	G	Y	G	Y	Y	Y	G	G	G	G	G	Y	G	G	Y	Y	G	G	G	Y	Y	Y	0
ALF-205A	109	Y	G	G	Y	G	G	Y	G	G	G	Y	G	Y	Y	Y	G	G	G	G	G	Y	G	G	Y	Y	G	G	G	Y	Y	Y	0
ALF-206	162	G	G	G	Y	G	G	G	G	G	G	G	G	G	R	Y	G	G	G	R	G	G	G	G	G	G	G	G	G	Y	G	G	2
ALF-P4	138	G	G	G	Y	G	G	G	G	G	G	G	G	G	R	Y	G	G	G	Y	G	Y	G	G	G	G	G	G	G	Y	G	G	1
ALF-P4S	166	G	G	G	G	G	G	G	G	G	G	G	G	G	R	G	G	G	Y	R	G	Y	G	G	Y	G	G	G	Y	G	G	Y	2
ALF-PMW02A	180	Y	R	G	Y	G	R	Y	G	R	G	Y	G	Y	R	Y	Y	G	Y	R	Y	Y	G	Y	Y	Y	R	R	Y	Y	Y	Y	7
ALF-PMW02B	161	G	Y	G	G	G	Y	G	G	Y	G	G	G	G	Y	G	G	G	Y	Y	G	G	Y	G	G	G	Y	Y	Y	G	Y	Y	0
ALF-PMW02C	90	G	G	G	G	G	Y	G	G	Y	G	G	G	G	Y	G	G	G	Y	Y	G	Y	G	Y	G	G	G	G	G	G	G	G	0
ALF-PMW04A	180	G	R	G	Y	G	R	Y	G	Y	G	G	G	Y	R	G	G	G	Y	R	Y	Y	R	Y	G	G	R	Y	Y	G	Y	Y	6
ALF-PMW04B	159	G	Y	G	G	G	R	G	G	Y	Y	G	G	Y	Y	G	G	G	Y	R	G	Y	Y	Y	G	G	Y	Y	G	G	Y	Y	2
ALF-PMW04C	91	G	G	G	G	G	G	G	G	Y	G	G	G	G	Y	G	G	G	Y	Y	G	Y	G	Y	G	G	G	G	G	G	G	G	0
ALF-PMW07A	190	G	Y	G	G	G	R	Y	G	Y	G	G	G	Y	R	Y	Y	G	Y	R	G	Y	Y	G	G	G	R	R	Y	G	Y	Y	5
ALF-PMW07B	159	G	Y	G	G	G	Y	G	G	Y	G	G	G	Y	Y	G	G	G	Y	Y	G	Y	Y	G	G	G	Y	G	G	G	Y	Y	0
ALF-PMW07C	96	G	G	G	G	G	Y	G	G	Y	G	G	G	Y	Y	Y	G	G	Y	Y	G	Y	G	G	G	G	G	G	G	G	G	Y	0
East-Side Wells																																	
ALF-212	171	G	Y	G	Y	G	R	G	G	G	G	G	G	G	R	Y	G	G	G	R	G	G	G	G	G	G	R	G	G	Y	Y	Y	4
ALF-212A	70	G	G	G	G	G	G	G	G	G	R	G	G	G	Y	G	G	G	G	G	G	Y	Y	G	G	G	G	G	G	G	G	Y	1
ALF-213	159	G	Y	G	Y	G	Y	G	G	G	G	G	G	G	R	Y	G	G	G	R	G	Y	Y	G	G	G	Y	G	G	Y	G	Y	2
ALF-213A	119	Y	G	G	Y	G	G	Y	G	Y	Y	Y	G	Y	Y	Y	G	G	Y	Y	G	G	Y	G	Y	Y	Y	G	Y	Y	Y	Y	0
ALF-213B	78	Y	G	G	Y	Y	G	Y	Y	Y	Y	Y	G	Y	Y	Y	G	Y	Y	Y	G	Y	Y	Y	Y	Y	Y	G	Y	Y	Y	Y	0
ALF-217	169	Y	R	G	Y	G	R	Y	G	Y	G	Y	G	Y	R	Y	G	G	Y	R	G	Y	R	Y	Y	Y	R	G	G	Y	Y	Y	6
ALF-217A	109	Y	Y	G	Y	G	G	Y	G	Y	Y	Y	G	Y	G	Y	Y	G	Y	Y	G	Y	Y	Y	Y	Y	Y	G	G	Y	Y	Y	0
ALF-217B	48	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	G	Y	Y	Y	G	Y	Y	Y	G	Y	Y	Y	Y	Y	G	G	Y	Y	Y	Y	0
ALF-PMW10A	178	G	R	G	Y	G	R	G	G	Y	G	G	G	Y	R	G	G	G	Y	R	G	Y	Y	G	G	G	Y	G	G	G	R	Y	5
ALF-PMW10B	149	G	R	G	G	Y	Y	G	Y	Y	G	G	G	Y	Y	G	Y	G	Y	Y	G	Y	R	G	G	G	Y	G	Y	G	G	Y	2
ALF-PMW10C	70	G	G	G	G	G	R	G	G	Y	G	G	G	Y	Y	G	G	G	Y	R	G	G	G	Y	G	G	Y	G	G	G	Y	Y	2
ALF-PMW11A	180	G	R	G	Y	G	R	G	G	Y	G	G	G	Y	R	G	G	G	Y	R	G	Y	G	G	G	G	R	Y	G	G	Y	Y	5
ALF-PMW11B	150	G	Y	G	G	Y	Y	G	Y	Y	Y	G	G	Y	Y	G	G	G	Y	Y	G	Y	Y	G	G	G	Y	Y	G	G	Y	Y	0
ALF-PMW11C	69	G	G	G	Y	G	Y	G	G	Y	G	G	G	Y	R	Y	G	G	Y	Y	G	G	G	Y	G	G	Y	G	G	G	Y	Y	1
ALF-PMW14A	180	Y	R	G	Y	G	R	Y	G	Y	G	Y	G	Y	R	Y	Y	G	Y	R	G	G	G	Y	Y	G	R	G	G	Y	Y	G	5
ALF-PMW14B	151	G	R	G	Y	G	R	G	G	Y	G	G	G	Y	Y	Y	G	G	Y	Y	G	G	R	Y	G	G	G	G	G	G	Y	Y	3
ALF-PMW14C	78	G	G	G	G	G	R	G	G	Y	G	G	G	Y	Y	G	G	G	Y	Y	G	Y	G	G	G	G	G	G	G	G	Y	Y	1
Total Number of SSIs		0	10	0	0	0	22	0	0	2	4	0	0	0	19	1	0	0	0	22	0	1	5	0	0	0	15	6	2	0	2	0	

R	Statistically Significant Increase (SSI)above background threshold value (BTV).
Y	(1) The upper edge of the confidence band is above the BTV or (2) the lower edge of the confidence band is at least 65% of the BTV.
G	Confidence band is below or within the BTV limits.

Bottom of Well Elevation (feet NGVD 29)

4.0 REFERENCES

USEPA, 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance. EPA 530-R-09-007

FIGURES

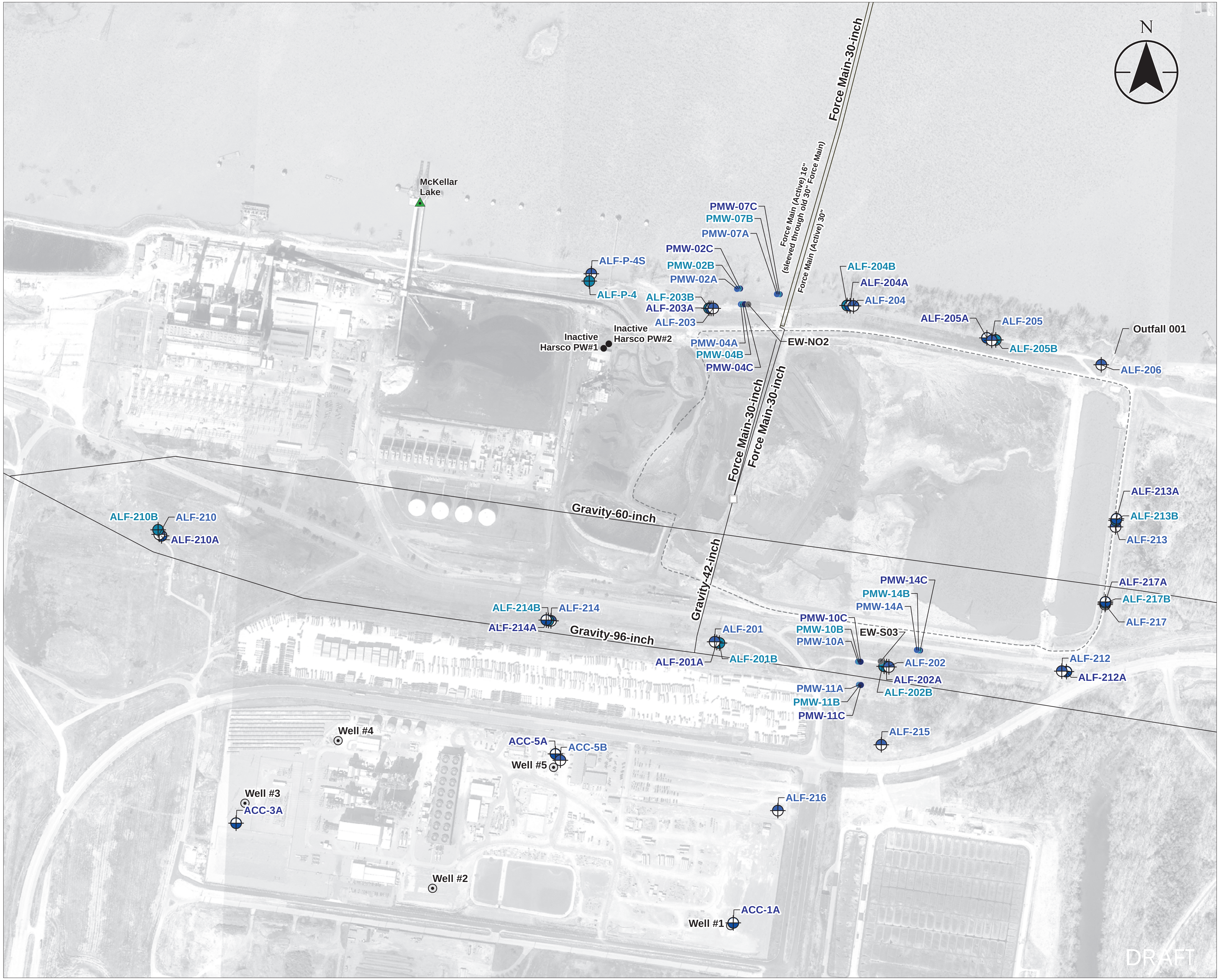

Figure No.
1

Title

Allen Fossil Plant and ACC Plant Well Locations

Client/Project

Tennessee Valley Authority
Allen Fossil Plant

Project Location
Memphis, Tennessee

175577013
Prepared by LT on 2019-10-31
Technical Review by JJ on 2019-10-31

0 250 500 750 1,000 Feet
1:3,000 (At original document size of 22x34)

Legend

- ● Inactive Harsco Production Wells (PW)
- ▲ McKellar Lake Gauging Station
- ● Performance Monitoring Well (PMW) (Shallow)
- ● Performance Monitoring Well (PMW) (Intermediate)
- ● Performance Monitoring Well (PMW) (Deep)
- ● IRA Extraction Well (EW)
- ⊕ Monitoring Well (Shallow)
- ⊕ Monitoring Well (Intermediate)
- ⊕ Monitoring Well (Deep)
- ⊙ Production Well (Memphis Sand)
- ☐ Sewer Manhole Location of Force Main Transition to Gravity
- — Sanitary Sewer Pipes
- ⬚ East Ash Pond Boundary

Wells are screened in the Alluvial Aquifer unless otherwise noted.

Notes
1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2018)

U:\TVA-EIP\175567295\gis\mxds\ACC\ALF_1_MonitoringWells.mxd Revised: 2019-10-31 By: mbough

APPENDIX A

2019 Statistical Analysis Report for Allen Fossil Plant Remedial Investigation

Kirk Cameron, Ph.D
MacStat Consulting, Ltd
01/29/2020

TVA DELIBERATIVE AND

PRE-DECISIONAL

2019

2019 Statistical Analysis Report for Allen Fossil Plant Remedial Investigation

Kirk Cameron, Ph.D.
MacStat Consulting, Ltd.

01/29/2020

CONTENTS

1. Introduction

This report describes the methodology used to compute the background statistics and to compare those statistics to compliance well data at the Tennessee Valley Authority (TVA) Allen Fossil Plant (ALF), for purposes of the Remedial Investigation (RI) process. A set of background statistics were constructed, as requested by the Tennessee Department of Environmental Quality (TDEQ), known as background threshold values (BTV). BTVs are typically used to estimate the magnitude and range of the background concentration distribution, so that areas or sites above background and in need of remediation can be delineated and prioritized.

At the ALF network, the sampling results used to compute the background statistics were obtained from a set of designated background wells (ALF-216, ACC-1A, ACC-3A, ACC-5A, and ACC-5B) using data collected from mid-2017 until September 2019. Groundwater samples were analyzed for 32 distinct constituents as required for the RI by TDEQ. Only non-filtered sample results were utilized for the statistical analysis.

Once the background limits were computed, they were compared to each of 55 well locations (including the background wells) for each constituent, in order to determine which well-constituent pairs, if any, exceeded the limits.

The ‘R’ Statistical Analysis package (www.r-project.org) in conjunction with R-Studio (www.rstudio.com) (both popular public domain software products) and other analytical tools were used in the production of the statistical values and graphs. ProUCL data dumps from TVA’s EQuIS Professional and Enterprise Database were used to populate the R-based statistical analyses.

2. Statistical Analysis

The basic steps in the analysis included the following:

1) Developing background threshold values (BTVs) for each constituent;

2) Computing trends and associated confidence interval (CI) bands for each well location and constituent (i.e., each well-constituent pair); and

3) Comparing each CI band against its respective BTV to assess whether an exceedance occurred.

2.1. Developing Background Threshold Values (BTVs)

In cases where a background limit must be computed, USEPA’s Unified Guidance recommends different strategies for computing a background-based standard (USEPA, Unified Guidance, 2009, Section 7.5). One of these strategies — a 95% confidence, 95% coverage upper tolerance limit (UTL) on background — was selected and used to compute the BTV on site-specific background data for each parameter. In the case of pH, a two-sided tolerance interval was computed instead.

To compute each upper tolerance limit (UTL), the following steps were taken:

1) The data were first summarized and modeled. The background data from the five background well locations were initially examined and graphed.

Time series plots of each well-constituent pair display the individual measurement results, while side-by-side boxplots, colored by gradient, allow visual comparisons between upgradient/ background wells versus downgradient locations.

2) All the background data from 2017 to 2019 were grouped and checked for possible outliers.

Outlier screening was performed visually on time series plots of the data, as well as systematically via a modified version of Tukey's boxplot rule. In a boxplot, the length of the box is the range of the central 50% of the sorted measurements. Tukey's original outlier rule states that any observation more than 1.5 box lengths above or below the edges of the boxplot classifies as a possible outlier. For stable, symmetric data distributions, Tukey's rule often works well.

Groundwater data is often skewed instead of symmetric, and may exhibit shorter (i.e., localized) or longer-term (non-linear) trends. Because of this reality, a modified version of Tukey's rule is generally needed to avoid classifying too many possible outliers. The modification consists of two parts: a) a possible outlier is only flagged if flagged both on the nominal scale of measurement as well as on the log-scale (i.e., when each observation is first mathematically transformed by taking a logarithm); and b) an outlier is only flagged if more than 3 box lengths above the edges of the boxplot. Together, these modifications better account for data skewness and localized trends in the background observations.

If any possible outliers are flagged, they are visually compared against observations at other well locations. If similar patterns or measurement ranges are common, the suspect values are kept in the data. If not, the suspected outliers are formally assessed using Rosner's outlier test. Any confirmed outliers are excluded from the UTL computations.

Two outliers were flagged and confirmed using this approach, one for TDS at well location 216, and one for zinc at location ACC5B. These values were excluded from the BTV calculations.

3) The grouped baseline data — excluding any confirmed outliers — were analyzed to determine whether they could be fit to a known statistical model. If so, a parametric UTL was computed; if not, a nonparametric UTL was constructed.

To fit potential statistical models, a series of normalizing mathematical transformations was applied to each baseline dataset. These transformations are known as power transformations, since they raise each observation to a mathematical power. The goal is to find, if possible, a transformation that normalizes the data on the transformed scale. Models tested ranged from the tenth root to the tenth power, and included the null transformation (power = 1), which assumes the data are normally distributed without transformation, the logarithm, which models the lognormal distribution, and the cube root, which closely mimics the gamma distribution.

The transformation which most nearly normalized the data was then formally tested using Filliben's probability plot correlation coefficient test. Filliben's test checks for normality of the transformed measurements by computing the correlation between the data and matched quantiles (i.e., z-scores) from a standard normal distribution. The process parallels fitting a line on a normal probability plot of the (transformed) data. The closer to a linear fit, the higher the correlation; the further from a linear fit, the smaller the correlation. Filliben's test formally assesses the strength of the correlation to determine whether it is high enough to declare that the data are consistent with a normal distributional model.

Filliben’s test yields a p-value measuring the statistical significance of the result. A p-value no less than 0.01 was judged as sufficient to assume normality of the (transformed) observations, while data with a Filliben’s test p-value less than 0.01 were judged significantly non-normal. Datasets passing Filliben’s test were assumed to have a parametric model corresponding to the transformation employed, e.g., data tested on the log-scale were assumed consistent with the lognormal distribution; data tested on the square root scale were assumed consistent with the square-root normal distribution, and so on.

Datasets which could not be sufficiently normalized, thus failing Filliben’s test, were analyzed by nonparametric means. In many instances, this may occur when the data includes a large fraction of non-detects.

4) The final statistical model for each constituent was used to compute an upper tolerance limit (UTL) with 95% coverage and 95% confidence.

When a parametric model is appropriate, on the normalized scale, a UTL is computed using the standard normal theory equation:

$$UTL = \bar{x} + \kappa s$$

where $\bar{x}$ and s represent the mean and standard deviation of the (transformed) observations, and κ is a multiplier which depends on the number of baseline measurements, as well as the desired coverage and confidence levels. If the data have been transformed, the final UTL is derived by back-transforming the scaled UTL, e.g, for a log transformation, the result is exponentiated; for a square-root transformation, the result is squared, etc.

For nonparametric models, the normal theory equation does not apply. Instead, the UTL is selected as one of the largest of the sample values, typically the maximum. Because there is no multiplier as in the parametric case, the confidence level associated with a nonparametric UTL is computed ‘after the fact,’ based on the sample size and desired coverage level: the smaller the sample size, the lower the confidence; the bigger the sample size, the higher the confidence level.

Since nonparametric UTLs do not assume a known statistical model, unless the sample size is fairly large, the achieved confidence level can be much lower than the target of 95%. When this happens, the computed UTL may not be very accurate. A more accurate UTL would likely be larger than the one computed from the available sample data. Unfortunately, without a statistical model, and especially with a large percentage of non-detects, little improvement is possible in the UTL estimates unless a larger sample size is employed (i.e., additional data is collected from the background wells and added to the existing measurements).

Table 1 displays the estimated BTVs, calculated as UTLs (or a tolerance interval for pH).

Table 1. AFL Remedial Investigation BTVs

COC	n	Lower BTV	Upper BTV
Antimony	33		0.0025

Arsenic	33		0.0098
Barium	33		1.1404
Beryllium	33		0.0005
Bicarbonate	33		563.5139
Boron	33		0.2397
Cadmium	33		0.0004
Calcium	33		159.2463
Carbonate	33		5.0000
Chloride	33		22.9426
Chromium	33		0.0025
Cobalt	33		0.0071
Copper	33		0.0017
Fluoride	33		0.2278
Lead	33		0.0005
Lithium	33		0.0339
Magnesium	33		46.7174
Mercury	33		0.0002
Molybdenum	33		0.0020
Nickel	33		0.0123
pH	33	6.0067	7.6604
Potassium	33		3.5191
Rad226+228	33		3.7890
Selenium	33		0.0025
Silver	33		0.0020
Sodium	33		20.5168
Sulfate	33		129.0412
TDS	32		620.3322
Thallium	33		0.0005
Vanadium	33		0.0015
Zinc	32		0.0100

2.2. Computing Trend Lines and Confidence Interval Bands

USEPA's Unified Guidance recommends comparing some type of confidence interval (CI) against fixed limits like BTVs in order to assess whether or not the limit has been exceeded with statistical significance. If the entire interval exceeds the BTV, a statistically significant increase (SSI) is identified. If none of the interval, or only part, exceeds the BTV, no SSI is recorded.

The rationale behind this procedure is predicated on the following:

1) A confidence interval is typically designed to 'contain' or 'capture' a specific target or feature of the underlying groundwater population, usually the mean or median measurement value. An interval rather than a point estimate is utilized because that is the only way to ensure the target is captured with a high degree of statistical confidence.
2) When a confidence interval is entirely on one side or the other of a fixed numerical limit, the confidence is high that the desired population target is also to that side of the limit.
3) Because the target may exist anywhere in the range represented by the confidence interval, an interval that 'straddles' the fixed limit is not guaranteed to be either above or below the GWPS, and certainly not with high or known statistical confidence.

USEPA's logic ensures that a correct decision about the occurrence of an SSI can be made with high statistical assurance.

Since groundwater data are collected over time, and not all at once, some or most of the variation in the measurements may be due to a trend. To better account for this possibility, USEPA also recommends a variation on the confidence interval method known as a confidence interval band around a trend line. In this case, a (linear) trend line is first fit to the data, then a confidence band is constructed around the trend line. The confidence interval band can be compared against a BTV in much the same fashion as a confidence interval, only now a comparison can be made at different points in time by comparing the 'cross-section' of the band for a given sampling date. If the interval represented by the confidence band cross-section fully exceeds the BTV, an SSI is identified for that sampling event.

CI bands were constructed (as described below) for each well-constituent pair using all available sample data. Cross-sections of each band were then compared to the BTV for the most recent sampling event in each case for the purpose of identifying any SSIs. Note that in cases where the data are obviously trending, the CI band technique provides a much more powerful and accurate means of judging exceedances above BTVs. Ignoring a trend typically makes a standard confidence interval much too wide and uncertain to be of much use, due to the extra variation imparted by the trend. For data that are more stable, both methods will tend to give similar results.

2.2.2. Trend Lines Using Linear Regression

Unless there are extreme outliers and/or curvature in the data, linear regression provides a standard and well-tested method for estimating the linear portion of a trend. The slope of the regression line points to the magnitude and direction of the trend. There is also a standard method for computing a confidence band around a linear regression trend line. For instance, equations [21.24] and [21.25] of Section 21.3 in the Unified Guidance can be compactly written as

$$CB_{1-\alpha} = \hat{x}_0 \pm \sqrt{2s_e^2 F_{1-\alpha,n-2}\left[\frac{1}{n} + \frac{(t_0 - \bar{t})^2}{(n-1)s_t^2}\right]}$$

where CB = confidence band, $\hat{x}_0$ is the regression line estimate at time t_0, s_e^2 is the mean squared error of the regression line, *F* is a quantile from the F-distribution with 2 and n–2 degrees of freedom, and $\bar{t}$ and s_t^2 represent the mean and standard deviation of the sampling dates.

For well-constituent pairs with no non-detects, linear regression and the formula above were used to construct each confidence band with 98% overall confidence, corresponding to a lower confidence limit with 99% confidence. When non-detects are present, the same formulas apply but an adjustment must be made for the censored measurements. The strategy adopted for this analysis involves the following steps:

1) Each non-detect is assumed to follow a triangle distribution centered at half the (sample-specific) reporting limit, and with limits extending from zero to the reporting limit. Then an imputation for each non-detect is randomly drawn from this distribution;

2) The combined set of detected values and imputed non-detects are used to estimate a linear regression trend line and associated confidence band with 98% statistical confidence;

3) Steps (1) and (2) are repeated 500 times, each time with a different set of random imputations, leading to 500 potentially different trend lines and confidence bands;

4) The 500 sets of trends lines and bands are averaged point-wise (i.e., at each time along a sequence of dates spanning the time range of the data) to compute the final trend and confidence band estimates.

By repeating this sequence of steps a large number of times (500), the uncertainty associated with the non-detects can be reasonably captured within the final CI band estimate.

2.2.3. Outliers

Prior to constructing any of the confidence interval (CI) bands, the data at each well-constituent pair were examined for possible outliers. As with the grouped background data, visual examination was done with time series plots and the modified Tukey's boxplot rule was utilized for initial screening. Eighteen additional observations were flagged and confirmed as outliers. These values were excluded from calculation of the CI bands.

2.3. Comparing Confidence Interval Bands Against GWPS

To assess whether any SSIs occurred, the confidence interval (CI) bands described in **Section 2.2** were compared against the constituent-specific BTVs described in **Section 2.1**. Of note, an SSI was identified if and only if the CI band fully exceeded the BTV at the *most recent* sampling event. This is consistent with the notion that a well-constituent pair is considered to exceed background only if its constituent levels currently exceed the BTV. This is best assessed by considering the cross-section of the CI band associated with the most recent sampling event.

3. Summary of Statistical Analysis

To facilitate an 'at-a-glance' summary of the statistical comparison results, **Attachment A** is a 'traffic light' matrix, showing a compact representation of each well location matched against each constituent. Green cells indicate that no SSI was observed. Red cells indicate the opposite: an SSI was flagged at the most recent sampling event. Yellow cells are warnings which indicate that a well-constituent pair should be closely watched. These cases have a CI band whose lower limit is at least 65% of the BTV. Often, the CI band cross-section straddles the BTV in yellow cells.

4. References

1) US Environmental Protection Agency (2009) *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance* - Office of Resource Conservation and Recovery EPA 530/R-09-007

2) US Environmental Protection Agency (2007) *Framework for Metals Risk Assessment* EPA 120/R-07/001 Office of the Science Advisor Risk Assessment Forum, Washington, DC 20460

Attachment A

coc	216	ACC1A	ACC3A	ACC5A	ACC5B	201	201A	201B	202	202A	202B	203	203A	203B	204	204A
Antimony	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Arsenic	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	RED	GREEN	GREEN	RED	GREEN	YELLOW	YELLOW	GREEN
Barium	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Beryllium	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	YELLOW	YELLOW	GREEN	GREEN	GREEN	YELLOW	GREEN	YELLOW	YELLOW	GREEN
Bicarbonate	YELLOW	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Boron	YELLOW	GREEN	YELLOW	GREEN	GREEN	YELLOW	RED	RED	RED	RED	RED	RED	YELLOW	YELLOW	RED	GREEN
Cadmium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN
Calcium	YELLOW	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Carbonate	YELLOW	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	GREEN
Chloride	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Chromium	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	YELLOW	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN
Cobalt	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Copper	YELLOW	YELLOW	YELLOW	YELLOW	GREEN	GREEN	GREEN	YELLOW	YELLOW	GREEN	YELLOW	YELLOW	YELLOW	GREEN	GREEN	GREEN
Fluoride	GREEN	YELLOW	GREEN	GREEN	YELLOW	YELLOW	RED	RED	RED	YELLOW	YELLOW	RED	GREEN	YELLOW	YELLOW	YELLOW
Lead	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	YELLOW	YELLOW	GREEN	GREEN	RED	GREEN	YELLOW	YELLOW	GREEN
Lithium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Magnesium	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Mercury	YELLOW	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Molybdenum	GREEN	GREEN	GREEN	GREEN	YELLOW	YELLOW	RED	RED	RED	RED	RED	RED	YELLOW	YELLOW	RED	YELLOW
Nickel	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
pH	GREEN	GREEN	YELLOW	GREEN	YELLOW	GREEN	YELLOW	YELLOW	YELLOW	GREEN	GREEN	RED	YELLOW	YELLOW	GREEN	GREEN
Potassium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN
Rad226+228	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Selenium	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	YELLOW	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN
Silver	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN
Sodium	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	RED	RED	RED	GREEN	GREEN	RED	GREEN	YELLOW	GREEN	GREEN
Sulfate	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	YELLOW	YELLOW	GREEN	GREEN	RED	GREEN	GREEN	GREEN	GREEN
TDS	YELLOW	GREEN	YELLOW	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN
Thallium	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	YELLOW	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	YELLOW	GREEN
Vanadium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	YELLOW	GREEN	GREEN	RED	GREEN	GREEN	YELLOW	GREEN
Zinc	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	GREEN	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	GREEN	YELLOW	YELLOW	YELLOW

coc	204B	205	205A	205B	206	210	210A	212	212A	213	213A	213B	214	214A	214B	215
Antimony	GREEN	YELLOW	YELLOW	YELLOW	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	GREEN
Arsenic	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Barium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Beryllium	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	GREEN	GREEN	YELLOW	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	GREEN
Bicarbonate	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN
Boron	RED	RED	GREEN	GREEN	GREEN	GREEN	RED	RED	GREEN	YELLOW	GREEN	GREEN	YELLOW	GREEN	GREEN	YELLOW
Cadmium	GREEN	YELLOW	YELLOW	YELLOW	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	GREEN
Calcium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN
Carbonate	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	YELLOW	GREEN	GREEN	GREEN	GREEN
Chloride	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	RED	GREEN	RED	GREEN	YELLOW	YELLOW	GREEN	RED	RED	GREEN
Chromium	GREEN	YELLOW	YELLOW	YELLOW	GREEN	YELLOW	YELLOW	GREEN	GREEN	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	GREEN
Cobalt	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW
Copper	GREEN	YELLOW	YELLOW	YELLOW	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW
Fluoride	YELLOW	RED	YELLOW	YELLOW	RED	YELLOW	GREEN	RED	YELLOW	RED	YELLOW	YELLOW	RED	GREEN	GREEN	YELLOW
Lead	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	GREEN	YELLOW	YELLOW	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	GREEN
Lithium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Magnesium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN
Mercury	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	YELLOW	GREEN	GREEN	GREEN	GREEN
Molybdenum	RED	RED	GREEN	GREEN	RED	YELLOW	YELLOW	RED	GREEN	RED	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW
Nickel	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
pH	YELLOW	YELLOW	YELLOW	YELLOW	GREEN	GREEN	YELLOW	GREEN	YELLOW	YELLOW	GREEN	YELLOW	YELLOW	GREEN	GREEN	GREEN
Potassium	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	RED	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	GREEN	YELLOW	GREEN	GREEN
Rad226+228	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN
Selenium	GREEN	YELLOW	YELLOW	YELLOW	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	GREEN
Silver	GREEN	GREEN	YELLOW	YELLOW	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	GREEN
Sodium	GREEN	RED	GREEN	GREEN	GREEN	GREEN	RED	RED	GREEN	YELLOW	YELLOW	YELLOW	GREEN	RED	RED	GREEN
Sulfate	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	RED	RED	GREEN
TDS	GREEN	YELLOW	GREEN	GREEN	GREEN	YELLOW	RED	GREEN	GREEN	GREEN	YELLOW	YELLOW	GREEN	RED	GREEN	GREEN
Thallium	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	GREEN	YELLOW	YELLOW	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	GREEN
Vanadium	GREEN	YELLOW	YELLOW	YELLOW	GREEN	GREEN	YELLOW	YELLOW	GREEN	GREEN	YELLOW	YELLOW	GREEN	YELLOW	YELLOW	GREEN
Zinc	YELLOW	GREEN	YELLOW	YELLOW	GREEN	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	GREEN

coc	217	ALF-217A	ALF-217B	P4	P4S	PMW02A	PMW02B	PMW02C	PMW04A	PMW04B	PMW04C	PMW07A	PMW07B	PMW07C	PMW10A	PMW10B
Antimony	YELLOW	YELLOW	YELLOW	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Arsenic	RED	YELLOW	YELLOW	GREEN	GREEN	RED	YELLOW	GREEN	RED	YELLOW	GREEN	YELLOW	YELLOW	GREEN	RED	RED
Barium	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Beryllium	YELLOW	YELLOW	YELLOW	YELLOW	GREEN	YELLOW	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN
Bicarbonate	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW
Boron	RED	GREEN	YELLOW	GREEN	GREEN	RED	YELLOW	YELLOW	RED	RED	GREEN	RED	YELLOW	YELLOW	RED	YELLOW
Cadmium	YELLOW	YELLOW	YELLOW	GREEN	GREEN	YELLOW	GREEN	GREEN	YELLOW	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN
Calcium	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW
Carbonate	YELLOW	YELLOW	YELLOW	GREEN	GREEN	RED	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW
Chloride	GREEN	YELLOW	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Chromium	YELLOW	YELLOW	YELLOW	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Cobalt	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Copper	YELLOW	YELLOW	YELLOW	GREEN	GREEN	YELLOW	GREEN	GREEN	YELLOW	YELLOW	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW
Fluoride	RED	GREEN	YELLOW	RED	RED	RED	YELLOW	YELLOW	RED	YELLOW	YELLOW	RED	YELLOW	YELLOW	RED	YELLOW
Lead	YELLOW	YELLOW	YELLOW	YELLOW	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	YELLOW	GREEN	GREEN
Lithium	GREEN	YELLOW	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	YELLOW
Magnesium	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Mercury	YELLOW	YELLOW	YELLOW	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW
Molybdenum	RED	YELLOW	YELLOW	YELLOW	RED	RED	YELLOW	YELLOW	RED	RED	YELLOW	RED	YELLOW	YELLOW	RED	YELLOW
Nickel	GREEN	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
pH	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW
Potassium	RED	YELLOW	YELLOW	GREEN	GREEN	GREEN	YELLOW	GREEN	RED	YELLOW	GREEN	YELLOW	YELLOW	GREEN	YELLOW	RED
Rad226+228	YELLOW	YELLOW	YELLOW	GREEN	GREEN	YELLOW	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN
Selenium	YELLOW	YELLOW	YELLOW	GREEN	YELLOW	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Silver	YELLOW	YELLOW	YELLOW	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Sodium	RED	YELLOW	GREEN	GREEN	GREEN	RED	YELLOW	GREEN	RED	YELLOW	GREEN	RED	YELLOW	GREEN	YELLOW	YELLOW
Sulfate	GREEN	GREEN	GREEN	GREEN	GREEN	RED	YELLOW	GREEN	YELLOW	YELLOW	GREEN	RED	GREEN	GREEN	GREEN	GREEN
TDS	GREEN	GREEN	YELLOW	GREEN	YELLOW	YELLOW	YELLOW	GREEN	YELLOW	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	YELLOW
Thallium	YELLOW	YELLOW	YELLOW	YELLOW	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Vanadium	YELLOW	YELLOW	YELLOW	GREEN	GREEN	YELLOW	YELLOW	GREEN	YELLOW	YELLOW	GREEN	YELLOW	YELLOW	GREEN	RED	GREEN
Zinc	YELLOW	YELLOW	YELLOW	GREEN	YELLOW	YELLOW	YELLOW	GREEN	YELLOW	YELLOW	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW

coc	PMW10C	PMW11A	PMW11B	PMW11C	PMW14A	PMW14B	PMW14C
Antimony	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN
Arsenic	GREEN	RED	YELLOW	GREEN	RED	RED	GREEN
Barium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Beryllium	GREEN	YELLOW	GREEN	YELLOW	YELLOW	YELLOW	GREEN
Bicarbonate	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN
Boron	RED	RED	YELLOW	YELLOW	RED	RED	RED
Cadmium	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN
Calcium	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN
Carbonate	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW
Chloride	GREEN	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN
Chromium	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN
Cobalt	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Copper	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW
Fluoride	YELLOW	RED	YELLOW	RED	RED	YELLOW	YELLOW
Lead	GREEN	GREEN	GREEN	YELLOW	YELLOW	YELLOW	GREEN
Lithium	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN
Magnesium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Mercury	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW
Molybdenum	RED	RED	YELLOW	YELLOW	RED	YELLOW	YELLOW
Nickel	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
pH	GREEN	YELLOW	YELLOW	GREEN	GREEN	GREEN	YELLOW
Potassium	GREEN	GREEN	YELLOW	GREEN	GREEN	RED	GREEN
Rad226+228	YELLOW	GREEN	GREEN	YELLOW	YELLOW	YELLOW	GREEN
Selenium	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN
Silver	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Sodium	YELLOW	RED	YELLOW	YELLOW	RED	GREEN	GREEN
Sulfate	GREEN	YELLOW	YELLOW	GREEN	GREEN	GREEN	GREEN
TDS	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Thallium	GREEN	GREEN	GREEN	GREEN	YELLOW	GREEN	GREEN
Vanadium	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW	YELLOW
Zinc	YELLOW	YELLOW	YELLOW	YELLOW	GREEN	YELLOW	YELLOW

APPENDIX C: GEOCHEMICAL EVALUATION OF BACKGROUND GROUNDWATER QUALITY

GEOCHEMICAL EVALUATION OF ALLUVIAL AQUIFER BACKGROUND GROUNDWATER QUALITY FOR ALLEN FOSSIL PLANT TECHNICAL MEMORANDUM

Prepared for:

Tennessee Valley Authority
Allen Fossil Plant
Memphis, Tennessee

Prepared by:

Stantec Consulting Services Inc.

1340 Treat Boulevard Suite 300
Walnut Creek CA 94597-7966

July 2, 2020

SIGN-OFF SHEET

This document entitled Draft Geochemical Evaluation of Alluvial Aquifer Background Groundwater Quality for the Allen Fossil Plant Technical Memorandum was prepared by Stantec Consulting Services Inc. (“Stantec”) for the account of the Tennessee Valley Authority (the “Client”). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec’s professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

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(signature)

Shannon Zahuranec, MS
Senior Geochemist

Reviewed by Angus
(signature)

Angus McGrath, PhD
Principal Geochemist

Approved by Kim Kesler Arnold
(signature)

Kim Kesler-Arnold TN PG No. 5969
Vice President

GEOCHEMICAL EVALUATION OF ALLUVIAL AQUIFER BACKGROUND GROUNDWATER QUALITY FOR ALLEN FOSSIL PLANT TECHNICAL MEMORANDUM

July 2, 2020

Table of Contents

LIST OF FIGURES

1.0 INTRODUCTION

This Technical Memorandum was prepared by Stantec Consulting Services, Inc. (Stantec) to summarize the results of a geochemical evaluation of groundwater analytical data from the Allen Combined Cycle (ACC) Plant monitoring wells located at the Tennessee Valley Authority (TVA) Allen Fossil Plant (ALF) in Memphis, Tennessee. These Alluvial aquifer wells, composed of ACC-1A, ACC-3A, ACC-5A, ACC-5B, and ALF-216 (collectively referred to herein as the ACC Plant wells) are used as background monitoring wells in the Remedial Investigation (RI) and Groundwater Interim Response Action (IRA) groundwater monitoring program at the East Ash Disposal Area (EADA) (**Figure 1**). The purpose of the evaluation presented in this technical memorandum was to determine whether there is geochemical evidence that the groundwater in the background ACC Plant wells is influenced by EADA coal combustion residuals (CCR).

Representative site-specific background threshold values (BTVs) were established for CCR Rule Appendix III and Appendix IV constituents, Tennessee Department of Environment and Conservation (TDEC) Appendix I Metals, and additional water quality criteria by MacStat (2020) and Stantec (2020). Groundwater quality in downgradient wells was subsequently evaluated based on comparisons to these established BTVs. The Stantec statistical evaluation memorandum provided a review of the derived BTVs and the results of the statistical comparison of these BTVs to groundwater quality observed in downgradient wells (Stantec, 2020).

2.0 HYDROGEOLOGY

Geologic mapping indicates that the EADA is immediately underlain by fill and Quaternary age (Holocene-upper Pleistocene) alluvium deposits. The upper portion of this alluvium unit is composed of fine- to medium-grained silty sand with intervals of clay, clayey silty sand, clayey sand, sandy silt, clayey silt, and silty clay that compose an upper alluvium deposit and an underlying interbedded “blue clay” zone ranging in thickness from one to 27 ft. Because of the fine-grained, less permeable nature of the blue clay zone, groundwater elevations were found to be mounded within this zone (i.e., elevated by several feet relative to the underlying, more permeable sandy intervals of the Alluvial aquifer). The section of alluvium underlying the blue clay zone is more uniform than the upper section and is dominated by sands with less than 5% fines. This section of fine- to coarse-grained sand with trace to common fine- to coarse-grained gravel compose the sandy zone of the shallow Alluvial aquifer. The sand lithology of the underlying intermediate and deep intervals of the Alluvial aquifer becomes more poorly sorted, with coarser-grained sands and increasing occurrences of gravelly sand and sandy gravel at depth.

The EADA is located in an area of Shelby County where the regional groundwater flow direction is toward the north or northwest (Brahana and Broshears, 2001). Locally, the horizontal groundwater flow directions in the shallow, intermediate, and deep intervals of the Alluvial aquifer at the EADA are influenced by the stage height of adjacent McKellar Lake to the north, which ranges between approximately 175 to 220 feet elevation. Site-specific transducer data recorded between September 2017 and December 2018 indicates groundwater elevation fluctuations at individual wells ranged up to 40 ft with an average of approximately 25 ft variation over time across the ALF. During relatively low lake levels, groundwater flow direction was generally northward toward McKellar Lake at the EADA. During relatively high lake levels, the groundwater flow direction was southward from the lake toward the EADA. These trends were observed throughout the 2019 groundwater monitoring period. High lake levels (e.g., 209.89 ft elevation [April 2019], 212.53 ft elevation [June 2019], and 205.25 ft elevation [December 2019]) resulted in groundwater flow to the south to south-southeast toward the EADA. Lower lake levels (e.g., 189.58 ft elevation [September 2019]) resulted in groundwater flow to the north to north-northeast toward McKellar Lake.

Because the five designated background wells at the ACC Plant (the ACC Plant wells) appear to be situated downgradient of the EADA in those periods of relatively high McKellar Lake levels, the groundwater geochemistry represented by the ACC Plant wells was reviewed to evaluate whether it represents background conditions or has been influenced by CCR.

The following sections summarize the results of the geochemical analysis.

3.0 GEOCHEMICAL EVALUATION

Stantec evaluated the general ion chemistry of groundwater from the ACC Plant wells using Piper diagrams and radial plots. In addition, cross plots were developed to evaluate whether the groundwater chemistry of ACC wells appeared to be influenced by CCR constituents from the EADA. This section summarizes the groundwater analytical data set, the general ion parameters that were characterized, the methods used to evaluate the general ion chemistry, and the cross plots used during the evaluation.

The background groundwater quality analysis relied on analytical data available from the five ACC Plant wells (ACC-1A, ACC-3A, ACC-5A, ACC-5B, and ALF-216) covering the period between October 2017 and December 2019. For comparison, a subset of wells located near the southern border of the EADA were selected for evaluation, including wells known to be impacted by CCR. These wells are: ALF-201, ALF-201A, ALF-201B; ALF-202, ALF-202A, ALF-202B; ALF-212, ALF-212A; and ALF-214, ALF-214A, and ALF-214B (see Table 3-1 in Stantec, 2019 for well screen elevation details for the ACC-series and ALF-series monitoring wells).

The general ion chemistry was analyzed using Piper and radial diagrams to illustrate the distribution of major ions (calcium, magnesium, potassium, sodium, bicarbonate, carbonate, chloride, and sulfate). Piper diagrams (**Figure 2** for ACC Plant and ALF wells) and radial plots (**Figure 3** for ACC Plant wells and **Figure 4** for ALF wells) were developed using data from the December 2019 groundwater monitoring event. Seasonal fluctuations resulted in only minor differences to the ionic signatures.

3.1 PIPER DIAGRAMS

On the Piper diagrams, ACC Plant wells are represented by solid symbols and EADA monitoring wells are represented by open symbols. The ACC Plant wells cluster with a similar water type that is dominated by calcium and bicarbonate. EADA well ALF-214 has a similar distribution to the ACC wells, but ALF-202 (known to be impacted with CCR constituents) has a higher proportion of sulfate, an indicator of CCR influence. Major ion distributions of other EADA wells exist between the two endmembers.

3.2 RADIAL DIAGRAMS

The radial diagrams are provided as **Figures 3** and **4. Figure 3** indicates there are minor changes in the relative distribution of ions within the ACC Plant wells that may be representative of natural variability within flow zones at different depths of the Alluvial aquifer. These ACC Plant wells indicated a calcium-bicarbonate water type with a relatively similar distribution. **Figure 4** indicates a different major ion distribution, as represented by the differences in shape, for some of the EADA wells that have been impacted by CCR constituents. For example, ALF-202 exhibits more of a mixed magnesium and calcium-sulfate water type and shape, that is distinctly different from the ACC Plant wells that are predominantly calcium-bicarbonate water type. The other ALF wells exhibit variable major ion chemistry ranging from calcium-bicarbonate to a mixed calcium-sulfate-bicarbonate type depending on the extent of CCR influence.

3.3 CROSS PLOTS

Cross plots were used to evaluate the geochemical signature of the groundwater observed in the ACC Plant wells compared to the groundwater around the EADA. A cross plot between calcium and boron was selected for this analysis because calcium is a common dominant cation observed in all of the wells and boron is a highly mobile CCR constituent that has the greatest potential to migrate from the EADA to the ACC Plant wells under a southward groundwater flow gradient. **Figure 5** is the calcium-boron cross plot that includes both the ACC Plant and EADA wells. The oval on the figure highlights the ACC Plant wells that do not appear to contain boron above background concentrations. The calcium-boron cross plot shows no correlation between calcium and boron for ACC Plant wells (i.e., the wells all plot along the same boron concentration independent of calcium concentration), indicating that the ACC Plant wells were not influenced by boron from the EADA. In contrast, the EADA well calcium concentrations vary with boron concentration, as would be expected given that calcium is a constituent in CCR. The lack of boron correlation with calcium across the ACC Plant wells, suggests that the influence of CCR constituents observed in some EADA wells does not extend to the ACC Plant wells.

4.0 SUMMARY

Based on an assessment of geochemical conditions, the periodic reversals of groundwater flow gradients caused by fluctuations in McKellar Lake do not appear to have resulted in migration of CCR constituents from the EADA into the area around the ACC Plant wells, indicating that the ACC Plant wells are representative of upgradient background conditions. The following is a summary of the geochemical evaluation findings:

- All ACC Plant wells have similar ion chemistry that is predominantly calcium-bicarbonate water type, which differs significantly from some EADA wells that exhibit influence of CCR constituents (see **Figures 2**, **3**, and **4**).
- A cross plot between calcium and boron for the ACC Plant and EADA wells shows no correlation between calcium and boron for ACC Plant wells indicating that the influence of CCR constituents observed in some EADA wells does not extend to the ACC Plant wells (see **Figure 5**).

5.0 REFERENCES

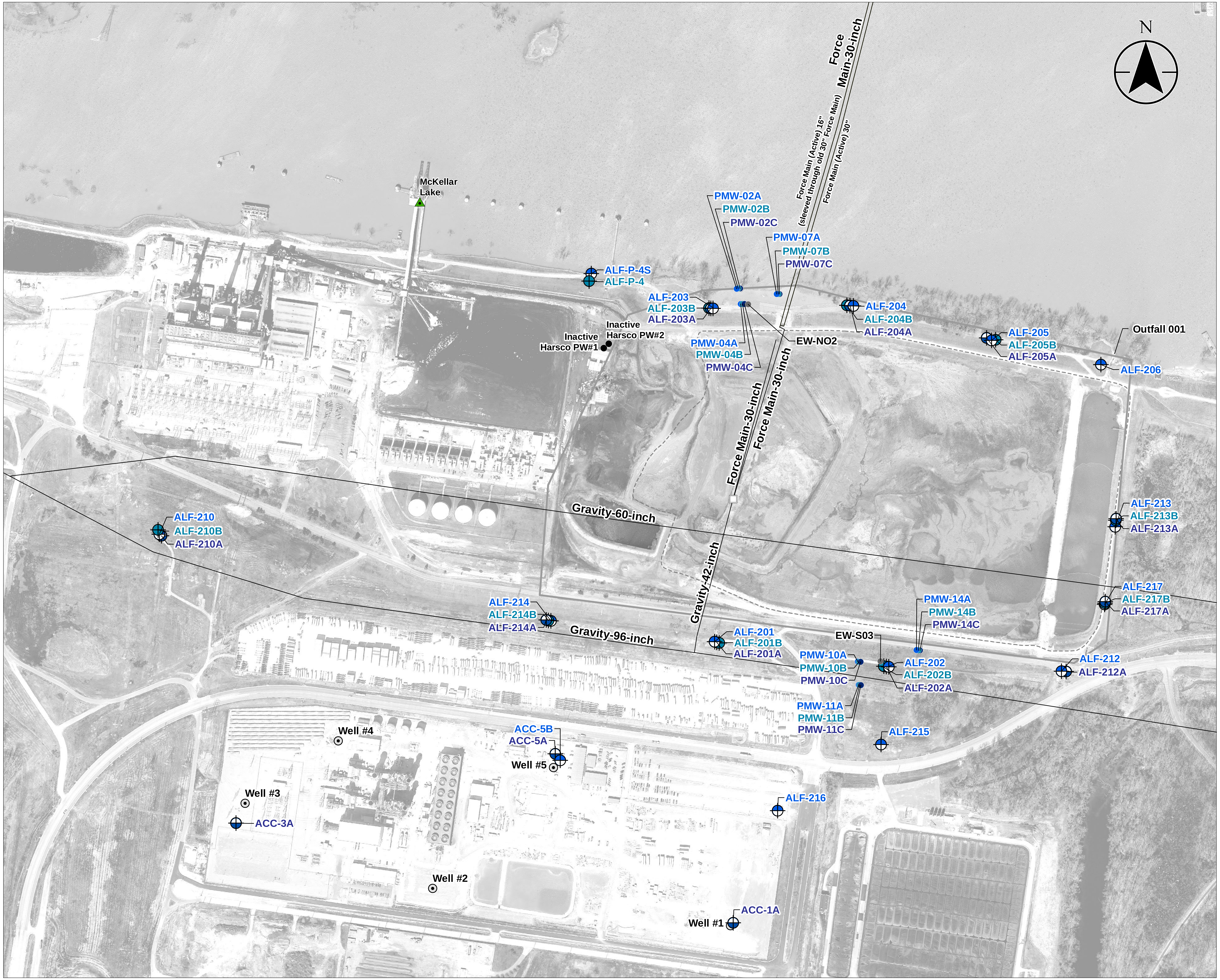
Brahana, J.V. and R.E. Broshears, 2001. Hydrogeology and ground-water flow in the Memphis and Fort Pillow aquifers in the Memphis area, Tennessee, *Water-Resources Investigations Report 89-4131*, 56 p.

Cameron, K., 2020. 2019 Statistical Analysis Report for Allen Fossil Plant Remedial Investigation, MacStat Consulting, Ltd, January 29, 2020 [Appendix to Draft 2019 *Remedial Investigation & Interim Response Action Groundwater Monitoring Annual Report for TVA ALF*].

Stantec Consulting Services Inc., 2019. *Updated TVA Allen Fossil Plant – East Ash Disposal Area – Remedial Investigation Report*, May 31, 2018

Stantec Consulting Services, Inc. 2020. Draft 2019 Statistical Evaluation of Background Groundwater Quality for Allen Fossil Plant Technical Memorandum [Appendix to Draft 2019 *Remedial Investigation & Interim Response Action Groundwater Monitoring Annual Report for TVA ALF*].

FIGURES



Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

U:\TVA-EIP\175567295\gis\mxds\ACC\ALF_1_MonitoringWells.mxd Revised: 2020-04-09 By: mbough

Figure No.
1

Title
Allen Fossil Plant and ACC Plant Well Locations

Client/Project
Tennessee Valley Authority
Allen Fossil Plant

Project Location
Memphis, Tennessee

175577013
Prepared by LT on 2020-04-09
Technical Review by JJ on 2020-04-09

0 250 500 750 1,000
Feet
1:3,000 (At original document size of 22x34)

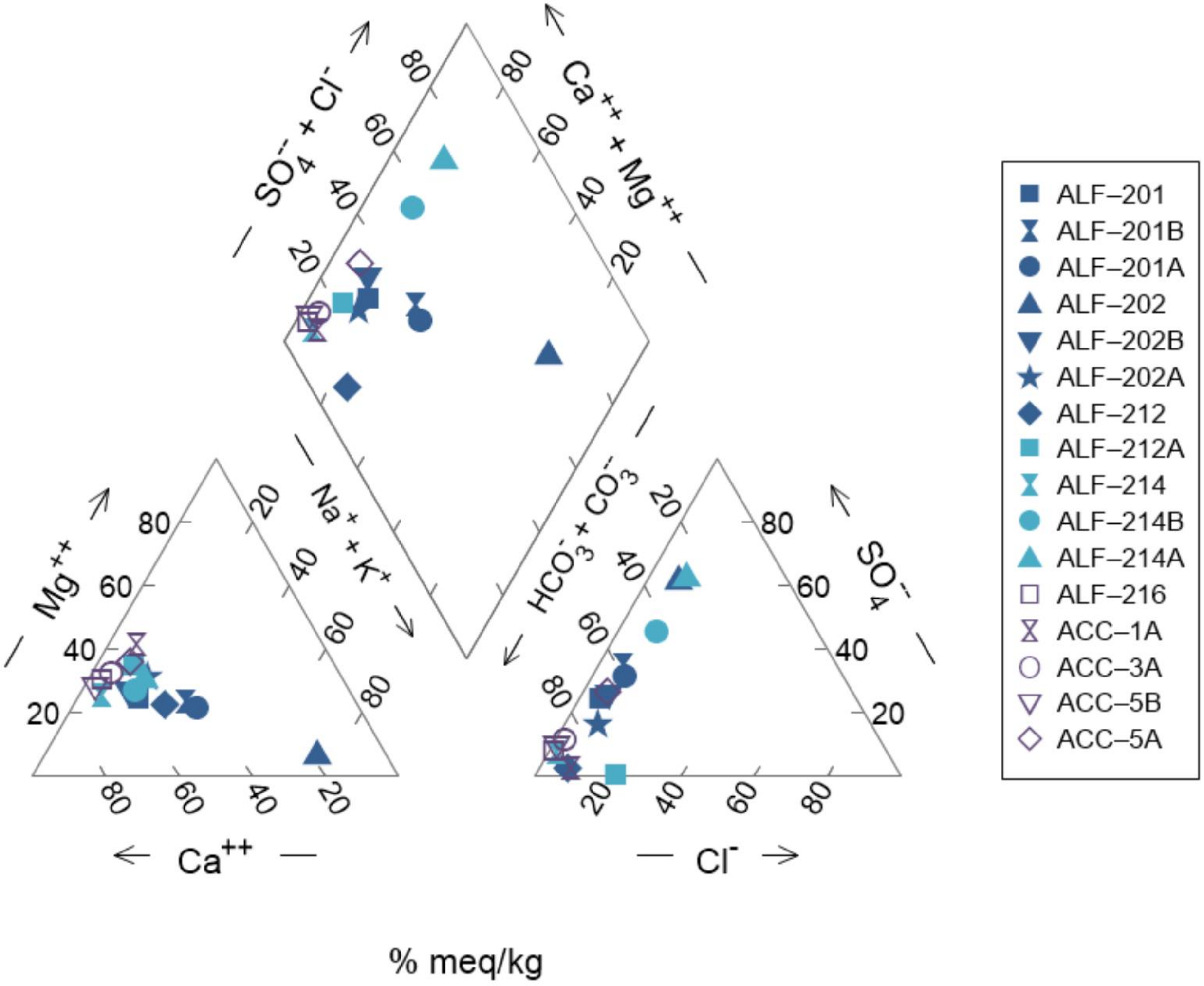
Legend

- ● Inactive Harsco Production Wells (PW)
- ▲ McKellar Lake Gauging Station
- ● Performance Monitoring Well (PMW) (Shallow)
- ● Performance Monitoring Well (PMW) (Intermediate)
- ● Performance Monitoring Well (PMW) (Deep)
- ● IRA Extraction Well (EW)
- ⊕ Monitoring Well (Shallow)
- ⊕ Monitoring Well (Intermediate)
- ⊕ Monitoring Well (Deep)
- ⊙ Production Well (Memphis Sand)
- ☐ Sewer Manhole Location of Force Main Transition to Gravity
- — Sanitary Sewer Pipes
- ☐ East Ash Pond Boundary
- ☐ 2019 Imagery Boundary

Wells are screened in the Alluvial Aquifer unless otherwise noted.

Notes
1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA dated 3/15/2018 and 6/4/2019

Stantec
TVA



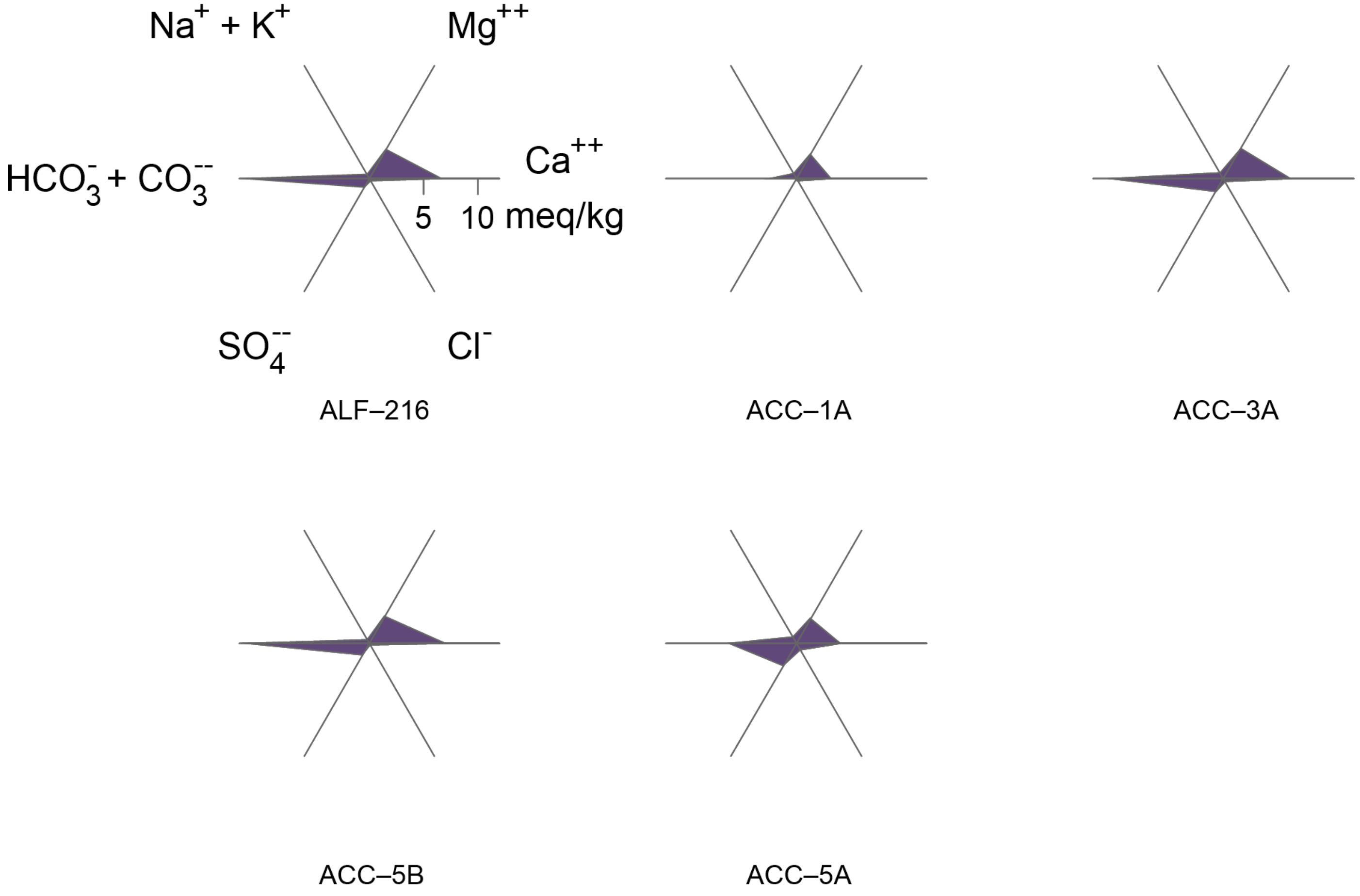
Stantec

Title
Piper Diagram for Select Groundwater Monitoring Wells - Dec 2019

Project Name	ALF Background Evaluation	Project No.	175578046
Client Name	TVA Allen Fossil Plant	Date	6/30/2020

FIGURE
2

https://stantec.sharepoint.com/teams/175577013/Shared Documents/Geochemistry/Background Well Eval/Figs 2 through 4_090120.xlsx



Title
Radial Diagram for Background Monitoring Wells - Dec 2019

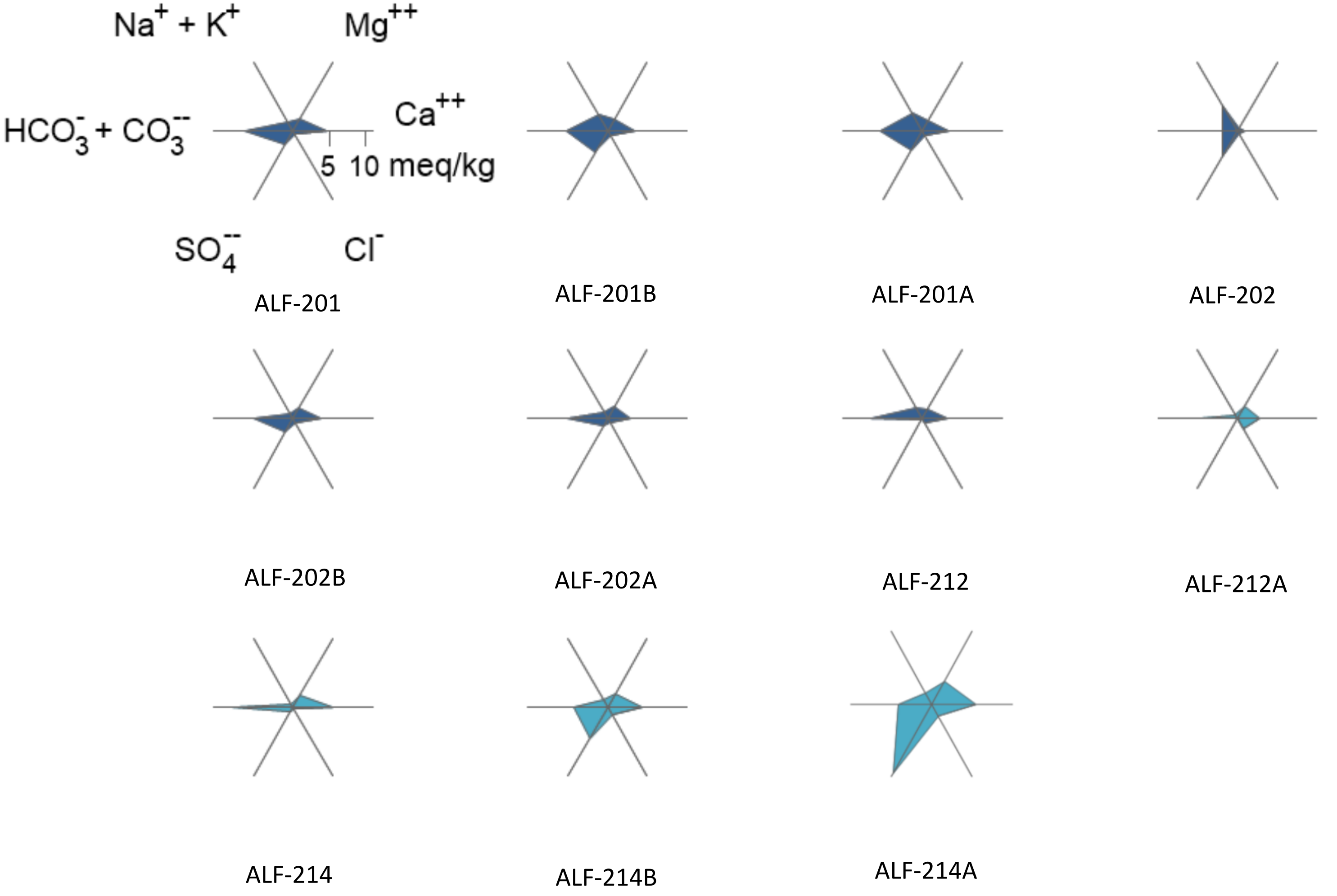
Project Name: ALF Background Evaluation

Project No.: 175578046

Client Name: TVA Allen Fossil Plant

Date: 6/30/2020

FIGURE 3

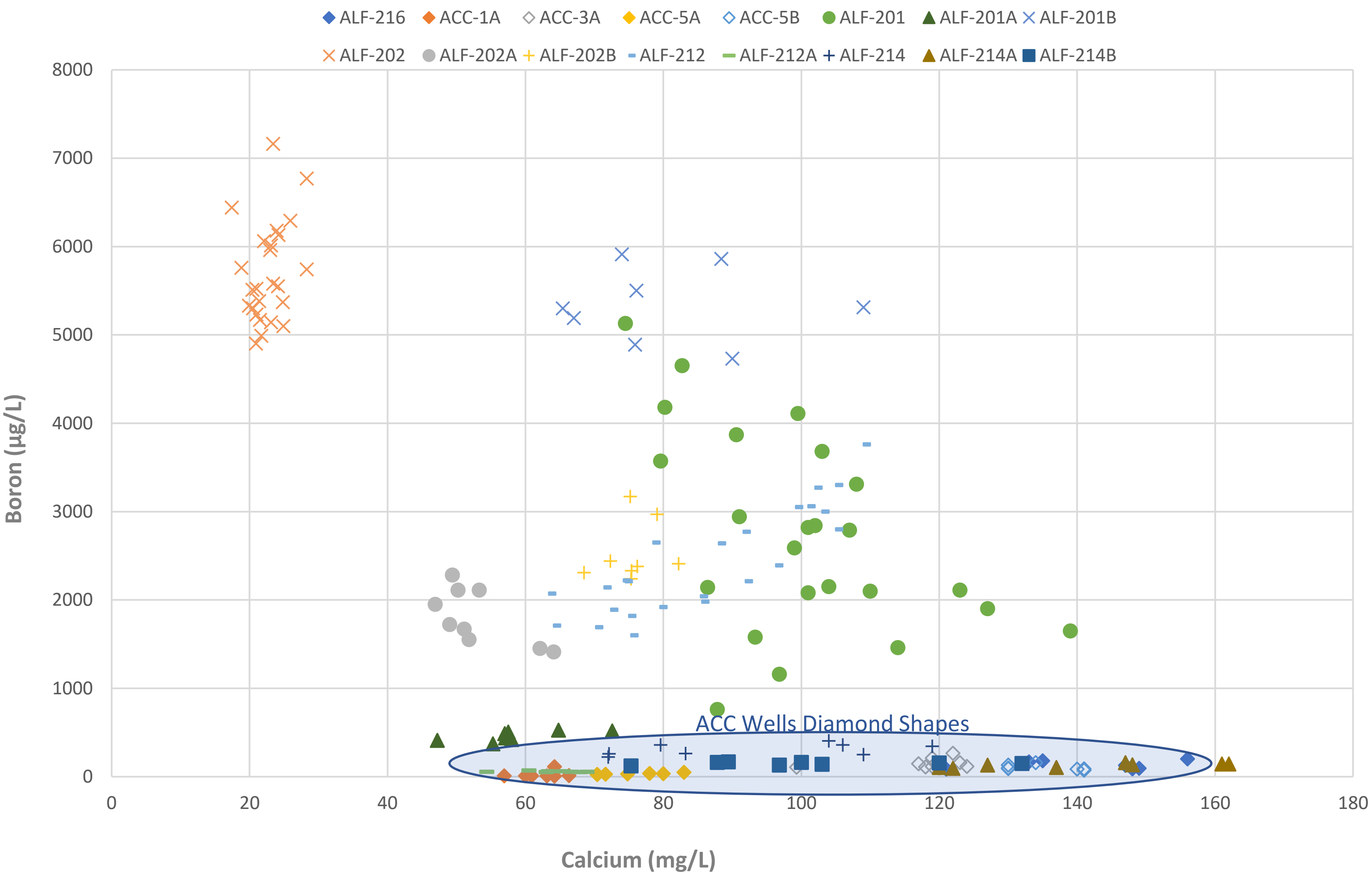


Stantec

Title

Radial Diagram for Select Monitoring Wells - Dec 2019

Project Name ALF Background Evaluation	Project No. 175578046	FIGURE 4
Client Name TVA Allen Fossil Plant	Date 6/30/2020	



Stantec

TVA

Title

Calcium-Boron Cross Plot

Project Name	ALF Background Evaluation	Project No.	175578046	FIGURE 5
Client Name	TVA Allen Fossil Plant	Date	6/30/2020	

APPENDIX D: DEVELOPMENT OF RISK-BASED SCREENING LEVELS

Development of Risk-Based Screening Levels for the East Ash Disposal Area, TVA Allen Fossil Plant

Allen Fossil Plant
Memphis, Shelby County, Tennessee

Revision 0

August 26, 2020

Prepared for:

Tennessee Valley Authority
Chattanooga, TN

Prepared by:

Stantec Consulting Services Inc.
Bellevue, WA

Stantec Project No. 175568282

This document entitled Development of Risk-Based Screening Levels for the East Ash Disposal Area, TVA Allen Fossil Plant was prepared by Stantec Consulting Services Inc. ("Stantec") for the account of the Tennessee Valley Authority (TVA) (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by Bruce Narloch

Bruce Narloch, Ph.D., Principal Toxicologist

Prepared by

Valerie Chen, M.S., Risk Assessor

Reviewed by Bradly R Toth

Bradly Toth, Principal

Reviewed by Kim Kesler Arnold

Kim Kesler-Arnold, TN PG No. 5969
Vice President

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

Executive Summary

The Tennessee Valley Authority (TVA) is in the process of planning for closure of the East Ash Disposal Area (EADA) and is planning to excavate coal combustion residuals (CCR) and underlying soils within the footprint of the impoundment, followed by placement of clean fill material within the excavation. TVA is working with the Tennessee Department of Environment and Conservation (TDEC) throughout the closure process. The media of interest are the soil remaining post-excavation, groundwater, and surface water.

This document provides risk-based screening levels (RBSLs) for evaluating potential impacts of the EADA on soil, groundwater, and surface water at the TVA Allen Fossil Plant (ALF). Soil remaining after the CCR excavation may serve as a source of exposure of future site workers. To evaluate this potential exposure pathway, generic and site-specific RBSLs were developed for hypothetical future industrial workers and hypothetical future construction/utility workers, respectively. Post-excavation soil sample results can be compared first to background levels and then to these soil screening levels. Soil remaining after the CCR excavation may also serve as a source of CCR-related constituents migrating to groundwater through leaching. To evaluate this potential migration pathway, site-specific soil screening levels (SSLs) were developed for the soil-to-groundwater pathway, and post-excavation soil sample results can be compared first to background levels and then to soil-to-groundwater screening levels. Future groundwater quality can also be evaluated using a tiered approach, as described herein. The methods used to derive the SSLs are presented in this document and the derived SSLs are included in the attached tables.

Abbreviations

ACC	Allen Combined Cycle
ALF	Allen Fossil Plant
AWQC	Ambient Water Quality Criterion
BTV	Background Threshold Value
CC	Confidence Coefficient
CCC	Criterion Continuous Concentration
CCR	Coal Combustion Residuals
CMC	Criterion Maximum Concentration
COC	Constituent of Concern
CSM	Conceptual Site Model
CWA	Clean Water Act
DAF	Dilution Attenuation Factor
EADA	East Ash Disposal Area
EAR	Environmental Assessment Report
EI	Environmental Investigation
EIP	Environmental Investigation Plan
EIS	Environmental Impact Statement
E. coli	Escherichia coli
EPA	United States Environmental Protection Agency
ESA	Endangered Species Act
HUC	Hydrologic Unit Code
IRA	Interim Response Actions
KM	Kaplan-Meier
MCLs	Maximum Contaminant Levels
mg/kg	Milligrams Per Kilogram
MLGW	Memphis Light, Gas and Water Division
MS4	Municipal Separate Storm Sewer System

ND	Non-Detect
NPDES	National Pollutant Discharge Elimination System
PCBs	Polychlorinated Biphenyls
PRG	Preliminary Remediation Goal
RBSL	Risk-Based Screening Level
RI	Remedial Investigation
RSL	Regional Screening Level
S-GW	Soil-to-Groundwater
SSL	Soil Screening Level
Stantec	Stantec Consulting Services Inc.
SW-DAF	Surface Water Dilution Attenuation Factor
TDEC	Tennessee Department of Environment and Conservation
TDEC Order	Commissioner’s Order No. OGC15-0177
TMDL	Total Maximum Daily Load
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
UCL	Upper Confidence Limit
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UTL	Upper Tolerance Limit
WADA	West Ash Disposal Area
WWTP	Wastewater Treatment Plant

1.0 INTRODUCTION

This technical memorandum was prepared by Stantec Consulting Services, Inc. (Stantec) for the Tennessee Valley Authority (TVA) to provide risk-based screening levels (RBSLs) for evaluating potential impacts of the East Ash Disposal Area (EADA) on soil, groundwater, and surface water at the TVA Allen Fossil Plant (ALF).

1.1 OBJECTIVE

TVA is planning for the closure of the EADA, which includes excavating coal combustion residuals (CCR) and underlying soils within the footprint of the impoundment, followed by placement of clean fill material within the excavations. TVA is working with the Tennessee Department of Environmental Conservation (TDEC) throughout the closure process. The media of interest are the soil remaining post excavation and groundwater beneath the EADA. The intended future use of the ALF property is for industrial operations, which is consistent with the surrounding area. This report describes an approach for evaluating soil and groundwater sampling results to be collected following excavation of the EADA.

1.2 ENVIRONMENTAL INVESTIGATIONS

On August 6, 2015, TDEC issued Commissioner's Order No. OGC15-0177 (TDEC Order) to the TVA regarding compliance with the provisions of Tennessee's solid waste management and disposal laws in the management and disposal of CCR. The Order has two purposes: the first is to establish a transparent comprehensive process for the investigation, assessment, and remediation of unacceptable risks resulting from the management and disposal of CCR at the TVA coal fired power plants, and the second is to establish the process whereby TDEC will oversee TVA's implementation of the 2015 United States Environmental Protection Agency (EPA) Final CCR Rule to ensure coordination and compliance with Tennessee laws and regulations that govern the management and disposal of CCR (TVA, 2019a).

Compliant with the TDEC Order, TVA developed an Environmental Investigation Plan (EIP) for the ALF, which was approved by TDEC on March 19, 2019. The EIP for the ALF focuses on the West Ash Disposal Area (WADA) and is currently being implemented. The results and conclusions of the environmental investigation (EI) for the ALF will be provided to TDEC in accordance with the requirement of the TDEC Order.

In addition to the EI underway for the WADA, investigative activities have also been performed for the EADA. In 2017, arsenic, lead, and fluoride (constituents of concern, or COCs) were detected in groundwater at concentrations above EPA maximum contaminant levels (MCLs) during TVA's routine groundwater monitoring around the EADA. In May 2017, TVA voluntarily initiated an investigation to evaluate groundwater conditions on the north and south sides of the EADA where constituents of concern (COCs) had been detected. TVA subsequently received a letter in July 2017 from TDEC requesting a remedial investigation (RI). The RI included the installation of several monitoring wells near the EADA, soil sampling, and pore-water sampling. The results of the RI were submitted to TDEC in May 2019 (Stantec, 2019). TVA continues to collect routine groundwater samples from the Alluvial aquifer every three months.

1.3 CLOSURE ACTIVITIES

In 2019, TVA began dewatering the EADA to drawdown the level of free water and pore-water within the impoundment. Concurrently, TVA published a draft Environmental Impact Statement (EIS) pursuant to the National Environmental Policy Act (NEPA) analyzing the impacts of the closure of the East and West Ash Disposal Areas. The final EIS was published in March 2020 and the closure alternatives presented in included 1) No Action and 2) Closure-by-Removal either to an off-site landfill and/or to a beneficial reuse facility. TVA anticipates that the final EIS and a record-of-decision will be issued in 2020.

In addition, interim response actions (IRA) have been initiated to extract and treat impacted groundwater from the Alluvial aquifer. The IRA focuses on the groundwater areas located north and south of the EADA where primary COCs have concentrations above MCLs. The extraction and treatment system will be installed in 2020.

2.0 PROJECT SETTING

This section provides general descriptions and environmental characteristics of the ALF, EADA, and surrounding areas.

2.1 SITE DESCRIPTION

ALF was a TVA coal-fired power plant located in Shelby County in the southwest corner of the City of Memphis, Tennessee (**Figure 1**). ALF was constructed in the 1950s by Memphis Light, Gas and Water Division (MLGW). TVA purchased ALF plant and underlying property in 1984 (TVA, 2016) and operated the facility until early 2018, when coal-combustion operations ceased (TVA, 2019a). The underlying property purchase by TVA did not include most of the property underlying the East and West Disposal Areas. ALF is located on the south shore of McKellar Lake, which is situated on the eastern bank of the Mississippi River and adjacent to a United States Army Corps of Engineers (USACE) flood-control levee (**Figure 1**). The local topography is relatively flat except for the USACE levee and the CCR disposal area dikes, which rise approximately 20 to 25 feet above the surrounding land (TVA, 2019a).

Two CCR units are present at ALF: the WADA and the EADA (**Figure 2**). The WADA was the original fly ash impoundment for the ALF and received sluiced fly ash and boiler slag until 1978. The WADA intermittently received minimal CCR materials between 1992 and October 2015, when all flow was rerouted to the EADA. The WADA has not received any CCR since that time and does not impound water (TVA, 2016) and is not regulated under the Federal CCR Rule. The EADA received CCR until early 2018, when coal combustion operations ceased at ALF, and it is currently an inactive impoundment; the EADA is regulated by the Federal CCR Rule.

2.2 ENVIRONMENTAL CHARACTERISTICS

2.2.1 Geology

ALF is located in the north-central part of the Mississippi Embayment geological depositional environment. The Mississippi embayment is a geologic basin filled with 3,000 feet or more of Cretaceous to Recent age sediments deposited primarily in a Coastal Plain setting. The sedimentary sequence is dominated by unconsolidated sand, silt, and clay with minor lignite (Hosman and Weiss, 1991). ALF lies within the Mississippi Alluvial Plain, which is adjacent to the western boundary of the East Gulf Coastal Plain of the Coastal Plain physiographic province. The Mississippi Alluvial Plain is relatively flat with alluvial deposition features, and the East Gulf Coastal Plain is characterized by loess covered hills and bluffs (Stantec, 2019).

The plant and surrounding areas are underlain by artificial fill and Quaternary age alluvial deposits. The fill generally consists of alluvium dredged from McKellar Lake, materials from cut and fill excavations from the surrounding floodplain, and possibly loess in select locations. The fill can range in thickness from a few feet to tens of feet beneath industrial areas in the river floodplain (Stantec, 2019).

In general, the upper portion of this alluvium unit is composed of fine- to medium-grained silty sand with intervals of clay, clayey silty sand, clayey sand, sandy silt, clayey silt, and silty clay that compose an upper alluvium deposit. The lower portion of the alluvium is composed of fine- to coarse-grained sand with trace to common fine- to coarse-grained gravel. Thickness of the alluvium ranges from 111-128 ft (including fill) underlying most of the EADA, to a maximum thickness of approximately 245 ft (including fill) observed near the ALF-202 well location along the southeastern margin of the EADA (Stantec, 2019).

The alluvium is underlain by finely bedded and laminated, stiff to hard, lean to fat clay composing the upper Claiborne confining unit. The stratigraphic position and prominence of clay and silt in these strata are consistent with the Eocene-age Cook Mountain Formation. When present, the upper Claiborne confining unit near the EADA ranges in thickness from approximately 27-69 ft (Stantec, 2019). Underlying the upper Claiborne confining unit is the Memphis Sand, composed of sand interbedded at certain horizons with lignite, clay, and silt. This thickness of the Memphis Sand ranges from zero to 900 feet according to Parks and Carmichael (1990).

2.2.2 Groundwater

The principal aquifers of the region include (in descending order): Alluvial aquifer [alluvium], the Memphis Aquifer (also known as the Memphis Sand Aquifer), and the Fort Pillow Sand. The Alluvial aquifer is not a major groundwater source in the Memphis area, even though it is a major water-bearing zone and can supply large quantities of water to wells. Depth to groundwater is generally 10 to 30 feet below ground surface and seasonally fluctuates with lake levels (Stantec, 2019). There are no known public water supply wells completed in the Alluvial aquifer within at least one mile of ALF (Shelby County Health Department, 2016). Two water production wells screened in the Alluvial aquifer on the west side of the EADA were associated with the Harsco Metal and Minerals industrial water use; however, these wells have been taken out of service and there are no known plans to resume their operation.

The Memphis and Fort Pillow aquifers are the primary drinking water sources for the surrounding area, including portions of eastern Arkansas and northern Mississippi. Except for the Davis Well Field, the well fields are more than 5.5 miles east of the ALF (the Davis Well Field is approximately two miles south of the ALF). The Memphis aquifer is the most productive aquifer in the region, providing approximately 98% of the total water pumped to the City of Memphis in 1980 from multiple well fields (Brahana and Broshears, 2001), and it remains the primary supply of drinking water in the area. Depending on location, the top of the Memphis aquifer is approximately 190-255 ft below surface grade near the ALF based on drilling programs conducted in the area (Stantec, 2019). A series of five production wells screened in the Memphis Aquifer were installed in 2016-2017 by TVA in conjunction with the Allen Combined Cycle (ACC) Plant. These wells are being maintained in a non-operational mode as TVA currently purchases water from MLGW to obtain cooling water for the ACC plant. There are no plans to use these wells until modeling and monitoring indicate using these production wells will not potentially impact the Memphis Aquifer.

2.2.3 Surface Water

The ALF is located within the McKellar Lake surface water system. McKellar Lake was created around 1950 when the Tennessee Chute (the Mississippi River side channel flowing around the eastern side of Presidents Island) was blocked by an earthen embankment at the upstream end (Lauderdale, 2011). The embankment supports the Jack Carley Causeway, which is located on the north side of McKellar Lake and provides access to the industrial area developed on President's Island. A separate smaller island, Treasure Island, is located within McKellar Lake. McKellar Lake is a 6.6-mile long, 1,550-acre water body that is connected to the Mississippi River (excluding Treasure Island) (TVA, 2014).

The hydrodynamics of McKellar Lake are important for water quality conditions in the lake as it controls mixing and flushing. The hydrodynamic conditions are complex as they are influenced by watershed runoff inflow and river stage changes. River stage changes, and therefore McKellar Lake stages, span a range of greater than 50 feet from low stage to flood stage.

The ALF is located in-between hydrologic units (HUC, as designated by USGS), the Lower Mississippi-Memphis (HUC #08010100) and the Nonconnah Creek Basin (HUC #08010211) watersheds. McKellar Lake is designated for industrial water supply, fish and aquatic life, recreation and navigation designated uses (TDEC, 2013). There are water quality concerns in many of the stream segments in both watersheds. Fish consumption advisories have been issued for McKellar Lake, Mississippi River and Nonconnah Creek upstream from McKellar Lake with chlordane, other organics, and mercury listed as the pollutants (TDEC, 2018a).

The federal Clean Water Act (CWA) requires all states to identify all waters where required pollution controls are not sufficient to attain or maintain applicable water quality standards and to establish priorities for the development of limits based on the severity of the pollution and the sensitivity of the established uses of those waters. States are required to submit reports to the EPA. The term "303(d) list" refers to the list of impaired and threatened streams and water bodies identified by the state. McKellar Lake is listed on the TDEC 303(d) list for polychlorinated biphenyls (PCBs), dioxins, Escherichia coli (*E. coli*), and chlordane from contaminated sediments due to historical industrial activities not associated with ALF. It is also listed for E. coli, low dissolved oxygen, Nitrate + Nitrite, and sedimentation/siltation from sanitary sewer overflows and discharges from municipal separate storm sewer system (MS4s). Mercury is also listed due to atmospheric deposition. The nearby Mississippi River and the Horn Lake cutoff are generally listed for similar pollutants from similar sources (TDEC, 2018b). TDEC also identified the total maximum daily load (TMDL) priority for all pollutants for McKellar Lake as low priority (TDEC, 2018b).

2.2.4 Habitat

The ALF is in Shelby County, Tennessee, which is located in the Lower Mississippi Riverine Forest Province (Bailey, 1995). The province consists of flat to gently sloping broad floodplain and low terraces made up of alluvium and loess. Historically the vegetation of this province was dominated by bottomland deciduous forest with an abundance of green ash, elm, cottonwood, sugarberry, sweetgum, and water tupelo, as well as oak and bald cypress. Pecan was also present, associated with eastern sycamore and rough-leaf dogwood (Bailey, 1995).

Land use/land cover within the region (i.e., in Shelby County within a five-mile radius of ALF) is dominated by undeveloped lands with various vegetative cover types, including: cultivated crops (9,297 acres or 24.0 percent), woody wetlands (6,457 acres or 16.7 percent), open water (6,365 acres or 16.4 percent), and deciduous forest (2,950 acres or 4.9 percent). Developed lands in the vicinity of ALF are associated with the industrial uses of the Frank C. Pidgeon Industrial Park and the International Port of Memphis and the non-industrial, residential uses in the neighborhoods of southeast Memphis (TVA, 2019b).

Developed areas within the ALF property boundary are characterized by industrial development. Land cover within undeveloped portions of the ALF is primarily mowed herbaceous cover. No unique plant communities have been identified at ALF (TVA, 2016).

2.2.5 Wildlife

2.2.5.1 Terrestrial

Important Bird Areas in Tennessee are designated by the Tennessee Wildlife Resources Agency (TWRA), partnered with the National Audubon Society's Audubon Important Bird Area program, and are identified as being important for the conservation of bird populations. The ALF is included within the boundaries of the Ensley Bottoms Complex, part of the Mississippi Alluvial Valley in the Tennessee Important Bird Area. The Ensley Bottoms Complex is described as containing sludge treatment ponds, fields for drying sludge, some agricultural experimental plots, industrial areas, agricultural fields, lakes, grasslands, and bottomland forest; and includes the East and West Ash Disposal Areas, McKellar Lake, President’s Island Wildlife Management Area north of McKellar Lake, T. O. Fuller State Park, the T. E. Maxson Wastewater Treatment Plant (WWTP), and other public and private lands in the vicinity of ALF. One of the few breeding populations of painted buntings in Tennessee is found in the Ensley Bottoms Complex, in the scrubby forested lands west of ALF and just south of the plant (TN IBA, 2018; eBird, 2018). According to the Tennessee Important Bird Areas Program website, the Ensley Bottoms complex is also the most important shorebird site in Tennessee and one of the most important inland shorebird sites in the southeast. In addition, waterfowl (ducks, geese, and swans) are common, and the Mississippi River is a major migration corridor for American White Pelicans, raptors, wading birds, gulls, and terns (TN IBA, 2018).

Wildlife communities associated with developed portions of the ALF generally consist of more common species that can easily adapt to disturbed or altered habitats. Therefore, these areas are not expected to routinely support unique or rare wildlife species. Some wildlife species are known to use man-made structures opportunistically. Common mammals, birds, and reptiles have been observed using parts of idle buildings or structures used infrequently by humans. Several species of bats commonly found in this region may roost in dark or quiet areas of buildings. Common species of bat in Tennessee known to use human structures include the big brown bat, evening bat, silver-haired bat, and southeastern bat (Bat Conservation International, 2019).

The mowed and early successional habitat in undeveloped portions of the ALF may provide some limited nesting and foraging habitat for common grassland and shrubland bird species and small mammals. Birds commonly observed in urban landscapes with early successional habitat interspersed with human infrastructure and dwellings include killdeer, indigo bunting, gray catbird, northern mockingbird, northern cardinal, eastern bluebird, American goldfinch, European starling, mourning dove, house sparrow, house finch, common grackle, song sparrow, field sparrow, and American robin. Red-tailed hawk and American kestrel also forage along road rights-of-way. Mammals routinely observed in this type of landscape include Virginia opossum, raccoon, eastern cottontail, white-tailed deer, eastern mole, woodchuck, and rodents such as white-footed mouse and hispid cotton rat. Common reptiles include black racer, black rat snake and eastern garter snake.

2.2.5.2 Aquatic

The ALF lies in the river floodplain along the southern shore of McKellar Lake, an oxbow lake that is connected to the Mississippi River. Fish are the top of the trophic ladder in most aquatic ecosystems and can be an indicator of biological integrity (Fausch, et al. 1990). The fish community in McKellar Lake has been repeatedly evaluated by TVA during electrofishing sampling in 1974 (TVA, 2007), entrainment monitoring in 1975 (as cited in TVA, 2014), impingement monitoring in 1974 to entrainment monitoring in 1975 (as cited in TVA, 2014), impingement monitoring in 1974 to 1976 (TVA, 2007), cove rotenone sampling in 1979 and 1980 (as cited in TVA, 2014), and additional impingement monitoring in 2004 to 2006 (TVA, 2007). These studies found that the fish community of McKellar Lake consisted primarily of warmwater species with a mix of both lake and riverine species due to the proximity and connectivity to the Mississippi River.

Prior sampling of larval fish and eggs at ALF in 1975 identified fishes belonging to seven families (as cited in TVA, 2014). Collections were dominated by fishes more typical of a riverine environment including shad, suckers, minnows, and freshwater drum. Rotenone sampling in the 1979 to 1980 timeframe produced a total catch of 45 species including 15 commercially valuable and 21 recreationally valuable species (as cited in TVA, 2014):

- Common centrarchid (sunfish) species present at ALF included black crappie, white crappie, bluegill, green sunfish, long ear sunfish, orange spotted sunfish, and warmouth.

- Benthic invertivore (primarily feed on invertebrates) species were dominated by freshwater drum, while gizzard shad was the dominant species by number and biomass.
- Top carnivore species present included white bass, yellow bass, striped bass, spotted bass, largemouth bass, black crappie, white crappie, sauger, spotted gar, bowfin, black bullhead catfish, walleye, yellow bullhead catfish, channel catfish, and flathead catfish (TVA, 1995).

Historical and recent analyses concluded that impingement at ALF did not adversely affect the aquatic communities of McKellar Lake or the adjacent Mississippi River. Additionally, the low collection rate of larval fish and eggs suggested that McKellar Lake is not an important spawning area for fish. Recent collections of nuisance species (e.g., Asian carp) are common throughout the Mississippi River and associated tributaries.

The fish community at McKellar Lake also included a large number of both prey and predator species, indicating a relatively balanced ecosystem. However, reduced water quality due to sedimentation and historic contamination from multiple industrial users has led to the listing of McKellar Lake in the State's CWA Section 303(d) list for impaired waterbodies (TDEC, 2018b). The entire lake is listed as impaired for fish consumption due to elevated levels of chlordane, other organics, and mercury (TDEC, 2018a). Sources of impairment may include storm water runoff from numerous industrial facilities and urban development in the area, sanitary sewer overflows, dredging for navigation channels, contaminated sediments, and discharges from MS4s (TVA, 2019a).

A review of the TVA Regional Natural Heritage database in December 2018 identified records for the blue sucker, designated as Rare by TDEC, within a ten-mile radius of the ALF.

2.2.5.3 Species of Conservation Concern

The Endangered Species Act of 1973 (ESA) provides broad protection for species of fish, wildlife and plants that are listed as threatened or endangered in the United States. The State of Tennessee provides protection for species considered threatened, endangered or deemed in need of management within the State other than those already federally listed under the ESA. A review of the TVA Regional Natural Heritage database in December 2018 indicated that no State- or federally-listed plant species or designated critical habitats have been documented within a 5-mile vicinity of ALF (TVA, 2019b).

A review of the TVA Natural Heritage Database in September 2015 revealed the occurrence of several federal- and State-listed wildlife species within a two-mile radius of ALF. Three federal-listed species, the bald eagle, the endangered Indiana bat and threatened northern long-eared bat, are known throughout the region and have the potential to occur near ALF. Within the two-mile vicinity around the ALF, occurrence records exist for two additional federal-listed species (interior least tern and piping plover), two State-listed species (lark sparrow and Mississippi kite), and one species tracked by the Tennessee Natural Heritage Program (striped whitelip).

The bald eagle, subject to protection under the Bald and Golden Eagle Protection Act, has been recorded from the area near ALF. One yellow-crowned night heron rookery is historically recorded within two miles of ALF near Riverside Park in Memphis. This rookery was last observed in 1979 and birds have since dispersed into scattered smaller nesting groups. No federal- or state-listed aquatic species and no federal- or state-listed plant species (or designated critical habitats) have been documented within a two-mile vicinity of ALF. Additionally, no federally listed plant species are known to occur in Shelby County, Tennessee.

The interior least tern nests on open shorelines, riverine sandbars and mudflats throughout the Mississippi and Missouri river drainages. Suitable nesting habitat is sparsely vegetated with sand or gravel substrate and located near an adequate food supply. Fidelity exhibited by terns across years to a particular site is strongly influenced by the dynamic nature of river hydrology, which may change island size and vegetative cover annually (USFWS, 2013). Least terns also have been documented using inland sites created by humans such as dredge spoil and stilling impoundments associated with coal plants, where site characteristics mimic (to some degree) natural habitat (Spear et al., 2007; Jenniges and Plettner, 2008). The interior least tern was listed as an endangered species by the USFWS in 1985 (USFWS, 1985a). It is a locally common summer resident in Tennessee along the Mississippi River and a rare migrant elsewhere in Tennessee. Individuals begin arriving in early May and are concentrated in the western half the state (Nicholson, 1997). Nesting colonies of least tern have been documented near ALF. Summer colonies have been documented along the Mississippi River (Jones, 2009), and along the banks of the EADA. Occurrence of nesting colonies at ALF typically coincides with high water levels along the nearby, Mississippi River, when the more suitable sandy islands, sand bars and riverbanks are rendered inaccessible due to high water levels. Adult individuals were observed perched along exposed ash and foraging in along the shoreline of the EADA during the May 29, 2014, field survey (TVA, 2014).

The piping plover is a small shorebird that was federally listed under the ESA in 1985 (USFWS, 1985b). Occurrence of piping plover is limited to fall and summer migration seasons within the Tennessee Valley Region, where the species is considered a rare fall migrant and extremely rare spring migrant (Henry, 2012). Adult female piping plovers typically migrate from summer to winter grounds during July; adult males and juveniles migrate between late August and early September (USFWS, 2003; Pompei, 2004). The frequency of observance of this species within this region has been less than annual, with time spent averaging two days per stay at interior stopover sites. Piping plovers are routinely observed on islands in the Mississippi River near Memphis. Studies of migration ecology suggest that piping plover does not concentrate in large numbers during migration and that most sightings were of individual birds. Although the species uses a variety of habitats, most interior sites used by piping plovers included reservoir shorelines. Piping plovers were noted to move quickly through the southern states during spring, often overflying southern states. The species appears to select stopover sites opportunistically (Pompei, 2004). One piping plover was observed foraging on an ash flat along the EADA in 2010. Given the infrequency of occurrence by this species in this region, occurrence of piping plover within the project area is rare. Ash impoundments are considered poor habitat for shorebirds as the water levels change frequently, preventing the development of suitable forage habitat (Henry, 2012). No use of the West Ash Impoundment by this species has been recorded or is expected to occur as this facility is completely vegetated and lacks open water and shoreline habitats.

The Indiana bat is listed as federally endangered by the USFWS (2007). The species overwinters in large numbers in caves and forms small colonies under loose bark of trees and snags in summer months (Barbour and Davis, 1974). Although females typically form small summer roosting colonies, males and juveniles may roost individually. Indiana bats disperse from wintering caves to areas throughout the eastern U.S. This species range extends from New York and New Hampshire in the north to Alabama, Georgia, and Mississippi in the south, and as far west as eastern Kansas and Oklahoma. The species favors mature forests interspersed with openings. The presence of snags with sufficient exfoliating bark represent suitable summer roosting habitat. Use of living trees with suitable roost characteristics in close proximity to suitable snags has also been documented. Multiple roost sites are generally selected. The availability of trees of a sufficient bark condition, size, and sun exposure is another important limiting factor in how large a population an area can sustain (Tuttle and Kennedy, 2002; Harvey, 2002; Kurta et al., 2002). There are no records of caves occurring within two miles of ALF. A December 2015 field review of the trees within the West Ash Impoundment determined that the trees on site do not represent suitable summer roosting habitat for Indiana bat. The closest summer record of Indiana bat to the project site occurs in Benton County, Mississippi, within Holly Springs National Forest, which is located approximately 50 miles to the southeast of the project area. This record is of a roost tree identified by tracking a female Indiana bat during spring migration from a cave in White County, Tennessee, in 2013. The closest winter record of Indiana bat to the project site is of a hibernaculum (suitable winter habitat) greater than 100 miles to the east in Tishomingo County, Mississippi. This hibernaculum is no longer thought to be active, however, due to the collapse of the mine in which it occurred. No Indiana bats have been observed at this location, however, since 1939 (TVA, 2014).

The northern long-eared bat is found in the U.S. from Maine to North Carolina on the Atlantic Coast, westward to eastern Oklahoma, and north through the Dakotas, reaching into eastern Montana and Wyoming, and extending southward to parts of southern states from Georgia to Louisiana. Hibernacula includes underground caves and cave-like structures (e.g., abandoned or active mines, railroad tunnels). These hibernacula typically have large passages with significant cracks and crevices for roosting; relatively constant, cool temperatures (32 to 48°F) and with high humidity and minimal air currents. During summer this species roosts singly or in colonies in cavities, underneath bark, crevices, or hollows of both live and dead trees (typical diameter ≥3 inches). Males and non-reproductive females may also roost in cooler places, like caves and mines. Northern long-eared bats forage in upland and lowland woodlots, tree-lined corridors, and water surfaces, feeding on insects. In general, habitat use by northern long-eared bats is thought to be similar to that used by Indiana bats, although northern long-eared bats appear to be more opportunistic in selection of summer habitat (USFWS, 2014). A December 2015 field review of the trees within the West Ash Impoundment determined that the trees on-site do not represent suitable summer roosting habitat for northern long-eared bat.

The lark sparrow is listed as threatened by the State of Tennessee and is a species occupying open habitats such as grasslands, roadsides, farmland, pasture, and forest edge, including disturbed sites with exposed soils, grazing, or recent fire (Martin and Parish, 2000). One occurrence record from 1993 exists within a two-mile radius of ALF, but recent occurrences on-site or in the vicinity of the plant are not known.

The Mississippi kite has a State rank of S2 (very rare and imperiled) and S3 (vulnerable) in Tennessee. Although abundant in the Great Plains, it is less common along the Mississippi River and areas further east. This kite may utilize a variety of habitat types but nests primarily in old-growth forests (Parker, 1999). Two occurrence records exist within a two-mile radius of ALF with the most recent being in 1993. More recent occurrences on-site or in the vicinity of the plant are not known.

3.0 CONCEPTUAL SITE MODEL

The development of a conceptual site model (CSM) is key to a properly develop risk-based screening levels. The CSM is used to describe potential sources of constituents of potential concern, mechanisms by which these constituents can be released from the source(s) to environmental media and transported to locations where exposure may occur, pathways by which receptors may come into direct contact with the constituent, and routes by which the constituents enter the bodies of the receptors. When all these elements are present, there is a complete, or potentially complete, pathway of exposure between the source of the constituents and the receptor(s). If any one of these elements is absent, the pathway is not complete, the receptor is not exposed, and there is no potential for risk. Although related, the CSM for evaluating potential risks to humans and the CSM for evaluating potential risks to ecological receptors are distinctly different with respect to the receptors and pathways of exposure. CSMs for human health and ecological risk assessments are dynamic and are typically developed based on preliminary findings of an environmental investigation. CSMs evolve over the course of an investigation as new information becomes available.

The following subsections describe the facility setting in the context of potential receptors and release mechanisms, and the manner in which human and ecological receptors could potentially be exposed to CCR-related constituents originating from the EADA.

3.1 FACILITY OPERATIONS AND LAND USE

As described in Section 1.1, the intended future use of the ALF property is for industrial operations, consistent with land uses of the surrounding area. The ALF is located within the Frank C. Pidgeon Industrial Park. This area is a zoned industrial park bounded on the north by McKellar Lake, on the west by the Mississippi River, on the east by the Canadian National Railroad, and the Mississippi State line on the south. Operations within the industrial park include the ALF plant, the T.E. Maxson WWTP, Nucor Steel, Electrolux, the City of Memphis Earth Complex, the CN/CSX intermodal facility, and other zoned industrial sites (Moon Inc., 2008). The WWTP is located on lands immediately west of ALF and discharges treated wastewater into the Mississippi River. The primary and waste activated sludge from the WWTP is sent to a covered lagoon system for anaerobic digestion; the digested sludge is dewatered and applied on-site at a location immediately southeast of ALF (City of Memphis, 2014). In addition to the existing facility, the City has reserved 120 acres immediately south of the WWTP for future expansion (Moon Inc., 2008).

The commercial Port of Memphis operations are a past, present, and future action within the project area immediately north of ALF. Port operations impose a variety of continuing stressors on the ecosystem of McKellar Lake and the adjoining Mississippi River ecosystem associated with barge movement and activities. These stressors typically include physical forces (i.e., shear, pressure), wave-induced shoreline erosion, drawdowns, entrainment mortality of planktonic life forms, and sediment re-suspension.

Outside of the industrial park, land use/land cover within the region is dominated by undeveloped lands with various vegetative cover types, including cultivated crops, woody wetlands, open water, and deciduous forest. Developed lands in the vicinity of ALF, other than the Industrial Park and the Port of Memphis, include non-industrial and residential uses in the neighborhoods of southeast Memphis (TVA, 2019b). T.O. Fuller State Park and the Chucalissa Archaeological Site are located within two miles of ALF. T.O. Fuller State Park consists of 1,138 acres of forest, including floodplains, wetlands, and six miles of hiking trails. Recreation facilities at the park include a picnic area, campground, swimming pool, and tennis courts. The Chucalissa Archaeological Site is located within the boundaries of the state park, and includes a Native American village, preserved archaeological excavations, and a modern museum (Tennessee State Parks, 2013). President’s Island Wildlife Management Area managed by the Tennessee Wildlife Resources Agency, is located north of the plant site on the opposite side of McKellar Lake. McKellar Lake in the immediate vicinity of ALF is part of the International Port of Memphis and is characterized by industrial rather than recreational use. Additional past recreational use of the area has included use by birders observing shorebirds known to frequent the area (TWRA 2015). Although the impoundment was not open to the public, TVA allowed birders to view the site from surrounding roadways; since dewatering has occurred this adjacent recreational use is not applicable.

3.2 RELEASE MECHANISMS OF CCR TO THE ENVIRONMENT

As described in Section 2.1, the EADA received CCR materials until 2018 when the plant ceased coal-firing operations. The EADA received the sluiced material from the west side of the facility; water was discharged from the EADA through a National Pollutant Discharge Elimination System (NPDES) outfall in the northeast corner of the pond. An isolated structural or operational failure could also have released CCR materials to surface soil in the adjacent environment during operation of the EADA. Constituents in CCR materials may have leached through the foundation of the EADA to contaminate the soil below; these constituents may have subsequently migrated to groundwater during operation of the ALF.

If elevated concentrations of CCR constituents are present in soil after excavation of the EADA, they may serve as a future source of CCR-related constituents to groundwater if the concentrations are high enough. The Memphis Aquifer is a regional aquifer and source of municipal drinking water. However, dissolved CCR constituents would need to move downward through at least 110 feet of alluvium and through 30 to 60 feet of the upper Claiborne confining unit (which is present under most of the EADA), before reaching the Memphis aquifer. In the southeast corner where the upper Claiborne confining unit is offset or missing, constituents would have to move through 225 feet of alluvium before reaching the Memphis aquifer. Also, groundwater flow in the Alluvial aquifer is primarily horizontal, not vertical. Under current conditions, most vertical gradients measured within the Alluvial aquifer are upward or neutral, and the upper Claiborne confining unit serves as a confining layer with a median hydraulic conductivity of 1.39×10^{-9} centimeters per second. Throughout the aquifer, natural attenuation processes (e.g. adsorption, transformation, dispersion) would be anticipated to reduce the concentrations and limit the potential transport in groundwater. Therefore, the assumption that CCR constituents in soil could impact a drinking water source (i.e., the Memphis aquifer) through the soil migration-to-groundwater pathway is conservative. Nevertheless, because the Memphis aquifer is such an important source of drinking water in the Memphis area, this potential migration and exposure pathway was evaluated (refer to Section 3.3) and is considered potentially complete.

Additionally, CCR-related constituents potentially present in groundwater after the excavation is completed may also migrate to adjacent surface water within McKellar Lake. There are water quality concerns with McKellar Lake not related to ALF, and neither McKellar Lake nor the Mississippi River within the vicinity of the ALF are used for potable supply.

CCR material may have been transported out of the EADA by disturbance (i.e., as windblown dust). During operation of the EADA, this transport pathway would have been minimal, as the EADA contained water and the CCR materials were saturated. However, such transport may occur during excavation of CCR materials from the EADA or following excavation of CCR materials from the EADA but prior to placement of fill material in the excavation.

Release of residual COCs in EADA soil or groundwater to above-ground ambient air through vapor migration is unlikely because chemical CCR-related constituents are not volatile. However, if radium-226 is present in EADA solid materials or groundwater, it could migrate to above ground ambient air as the volatile daughter radionuclide, radon-222.

3.3 HUMAN HEALTH CONCEPTUAL SITE MODEL

A human health CSM describes the relationships between the COC source, release mechanisms to a source media, transport mechanisms, exposure media, human exposure routes (i.e., inhalation, dermal absorption, ingestion, and external exposure from radioactive materials) and potential human receptors. As described above:

- The COC source evaluated in this report for the ALF is the EADA.
- The COCs are CCR-related constituents.
- The potential contaminant release mechanisms are described in Section 3.2 above.
- Transport mechanisms for CCR-related constituents in environmental media include further transport as windblown dust and migration with groundwater, including potential discharge to surface water

Additional details of the human health CSM for the EADA are described in the following subsections. These elements are combined into a graphical representation of the human health CSM for the EADA on **Figure 3**.

3.3.1 Receptor Selection

The human health CSM identifies potential representative receptors who may have contact with CCR solid materials and COCs released from the EADA. As described in Sections 3.1 and 3.2, land use at the ALF is expected to remain industrial, however, transport pathways may result in contamination of off-site media.

For the purposes of the human health CSM, human receptors have been broadly grouped as potential on-site receptors at the former ALF, and off-site receptors, who may be present on surrounding properties or may utilize McKellar Lake.

3.3.1.1 On-Site Receptors

Based on the future intended use of the property for industrial operations, two potential on-site receptors have been identified: a hypothetical future on-site industrial worker and a hypothetical future on-site utility or construction worker. A third receptor, a site visitor or trespasser, may also come in to contact with CCR-related constituents while on-site.

A hypothetical future on-site industrial worker may be exposed to residual concentrations of CCR-related constituents in surface soil. The EADA will be backfilled with clean fill; however, industrial worker exposures are included in the approach to ensure that any residual contamination in surface soil is not present at levels that could be harmful.

A hypothetical future on-site utility or construction worker may similarly be exposed to residual concentrations of CCR-related materials in surface soil; additionally, this receptor may need to work in excavations, resulting in potential exposure to subsurface soil.

The third potential receptor, a site visitor, could be a trespasser or an infrequent worker on the site (i.e., an environmental professional performing infrequent monitoring). This receptor will likely have minimal contact with surface soil at the site.

3.3.1.2 Off-Site Receptors

Based on adjacent land uses, three potential off-site receptors have been identified: an off-site industrial worker, a recreational user of McKellar Lake, and an off-site resident.

As described in Section 2.1, the ALF is adjacent to T.O. Fuller State Park and McKellar Lake. It is unlikely that recreational users of T.O. Fuller State Park would have any contact with CCR-related constituents, however, recreational users could contact CCR-related constituents in surface water. Fish consumption advisories have been issued for McKellar Lake, the Mississippi River and Nonconnah Creek, though fishing and consumption of fish may still occur. Other recreational uses of McKellar Lake include swimming and boating. Recreational users may include young children, adolescents, and adults.

No residential or commercial land uses occur in the immediate vicinity of ALF. The nearest single-family residential areas occur approximately 1.5 miles to the southeast of the site. As a result, off-site industrial and residential receptors are not expected to be exposed to residual CCR-related constituents in soil. Off-site residential and industrial receptors can be exposed to potable water from the Memphis Aquifer. As described in Section 3.2, site-related CCR constituents are unlikely to impact the Memphis aquifer. However, exposure to hypothetical CCR constituents in potable groundwater by off-site residential and industrial receptors was conservatively evaluated during RBSL development.

3.3.2 Exposure Pathways

Exposure pathways identified in the preliminary CSM for the ALF are classified as:

- Potentially Complete – It is likely that exposure will occur and may contribute meaningfully to risk.
- Potentially Complete but Insignificant – Exposure may occur but is not expected to contribute significantly to risk.
- Incomplete – Evidence indicates that exposure is unlikely to occur. Rationale for classifying the pathway as incomplete will be provided.

On-Site Receptors:

- *Hypothetical Future Industrial Worker – Potentially Complete:* A hypothetical future industrial worker may be exposed to residual CCR-related constituents in surface soil through inhalation of wind-blown dust, incidental ingestion, and dermal contact. Additionally, if radium is present in soil or groundwater, the receptor may be exposed to volatile decay products (e.g., radon-222) in ambient air following migration of this constituent from soil or groundwater, however, this pathway is considered negligible because exposure to ambient air is only a minor pathway when compared to other potentially complete exposure pathways.
- *Hypothetical Future Construction/Utility Worker – Potentially Complete:* A hypothetical future construction/utility worker may be exposed to residual CCR-related constituents in surface soil through inhalation of wind-blown dust, incidental ingestion, and dermal contact. Additionally, this receptor may be exposed to residual CCR-related constituents in subsurface soil in construction or utility excavations through the same pathways. Groundwater at the ALF occurs at depths as shallow as 10 feet below ground surface, however, excavations are not expected to be deeper than 10 feet below ground surface. Therefore, exposure to residual CCR-related constituents in the Alluvial aquifer is incomplete for this receptor. Additionally, if radium is present in soil or groundwater, this receptor may be exposed to volatile decay products (e.g., radon-222) in ambient air following migration of this constituent from soil or groundwater; however, this pathway is considered negligible because exposure to ambient air is only a minor pathway when compared to other potentially complete exposure pathways.
- *Site Visitor – Potentially Complete but Insignificant*: A site visitor may be exposed to residual CCR-related constituents in surface soil through inhalation of wind-blown dust, incidental ingestion, and dermal contact. These pathways are considered insignificant due to the expected short duration and/or infrequent nature of site visits. Additionally, if radium is present in soil or groundwater, this receptor may be exposed to decay products (e.g., radon-222) in ambient air following migration of this constituent from soil or groundwater; however, this pathway is considered insignificant because exposure to ambient air is only a minor pathway when compared to other potentially complete exposure pathways.

Off-Site Receptors:

- *Off-Site Resident – Potentially Complete but Insignificant*: An off-site resident may be exposed to potable groundwater from the Memphis Aquifer. As described in Section 3.2, transport of CCR-related constituents to drinking water supply wells is unlikely; however due to the importance of the Memphis Aquifer, this pathway is conservatively considered to be potentially complete. Potable use exposure pathways include inhalation of volatile CCR constituents in water vapor while showering, ingestion of potable water, and dermal contact. A resident is not expected to be exposed to CCR-related constituents in surface soil, as no residences are directly adjacent to the ALF and wind transport is unlikely to transport significant quantities of surface soil to off-site areas.
- *Off-Site Industrial Worker – Potentially Complete but Insignificant*: An off-site Industrial worker may be exposed to potable groundwater from the Memphis Aquifer. As described in Section 3.2, transport of CCR-related constituents to drinking water supply wells is unlikely; however due to the importance of the Memphis Aquifer, this pathway is conservatively considered to be potentially complete. Potable use exposure pathways include inhalation of volatile CCR constituents in water vapor while showering, ingestion of potable water, and dermal contact. An off-site industrial worker is not expected to be exposed to CCR-related constituents in surface soil, as wind transport is unlikely to transport significant quantities of surface soil to off-site areas.
- *Recreational User – Potentially Complete*: A recreational user of public spaces adjacent to the ALF could be exposed to CCR-related constituents in potable groundwater from the Memphis Aquifer at T.O. Fuller State Park campground; however, this exposure pathway is considered to be potentially complete but insignificant relative to potential residential exposures to potable groundwater. Exposure of recreational users to CCR-related constituents in McKellar Lake surface water, sediment, and biota are assumed to be potentially complete.

3.4 ECOLOGICAL CONCEPTUAL SITE MODEL

An ecological CSM describes the relationships between the COC source, release mechanisms to a source medium, transport mechanisms, exposure media, and routes of exposure to potential ecological receptors. As described above:

- The COC source evaluated in this report for the ALF is the EADA.
- The COCs the CCR-related constituents.
- The potential contaminant release mechanisms are described in Section 3.2 above.
- Transport mechanisms for CCR-related constituents in environmental media include further transport as windblown dust and migration with groundwater, including potential discharge to surface water.

The remaining portions of the ecological CSM for the EADA are described in the following subsections. Elements of the CSM are combined into a graphical representation of the ecological CSM for the EADA on **Figure 4**.

3.4.1 Ecological Receptor Selection

Ecological receptors evaluated are generally selected based on three selection criteria; applicable receptors should be:

- Indigenous to the area and potentially exposed to contaminated media;
- Representative of the various feeding guilds and trophic levels (e.g., aquatic carnivore, riparian herbivore, riparian insectivore); and
- Classified as being rare, threatened, or endangered (i.e., species of conservation concern), if applicable.

The ecological evaluation in this approach is a screening-level assessment; as such, dose modeling for specific representative ecological receptors is not conducted. Rather, constituent concentrations in post-excavation soil and groundwater samples will be compared to screening levels for generic receptor groups. As described in 2.2.5.3, no species of conservation concern have been documented at the ALF; therefore, it is not necessary to tailor the ecological evaluation for the protection of any individual organisms. Instead, applicable generic ecological receptor groups are selected for evaluation.

The ecological receptor groups considered in this approach are as follows:

<u>Terrestrial Receptors</u>

- Plants
- Invertebrates
- Birds
- Mammals

<u>Aquatic Receptors</u>

- Water column community
- Benthic invertebrates
- Amphibians
- Plants
- Aquatic-dependent birds
- Aquatic-dependent mammals

As described in Section 2.2.5.1, ecological habitat is available for a variety of terrestrial receptors in the vicinity of the ALF. However, the ALF itself does not provide attractive habitat for terrestrial receptors, relative to the surrounding environment, due to the disturbed nature of the ALF. Exposure of any onsite terrestrial ecological receptors to residual concentrations of CCR-related constituents in soil following excavation and fill of the EADA will be incomplete due to the presence of fill material overlying the post-excavation soils. Exposure of onsite terrestrial receptors to CCR-related constituents during excavation activities is also unlikely because terrestrial receptors will tend to avoid the area during active earth moving work. Therefore, onsite terrestrial ecological receptors are not a significant ecological receptor group, as described further in Section 3.4.2.

3.4.2 Exposure Pathways and Routes of Exposure

Ecological receptors can have direct contact with CCR constituents in sediment and surface water. They can also contact CCR constituents through food chain exposures (CCR residues in the tissues of forage or prey items). Ecological receptors at the EADA could have contact with CCR constituents through a variety of exposure pathways and routes of exposure. Potential exposure pathways and routes of exposure are presented in the ecological CSM (**Figure 4**) for future conditions. A description of potentially complete, potentially complete but insignificant, and incomplete exposure pathways are provided in this section.

Terrestrial receptors that could potentially be onsite include plants, invertebrates, birds and mammals. The site is surrounded by a chain link security fence, and as a result, only small mammals such as rodents could potentially be onsite. The future land use of the ALF is expected to be industrial, and as described in Section 2.2.5, the site is not expected to be routinely inhabited or used by wildlife-species except for species that are known to opportunistically use man-made structures. As described in Section 1.1, the EADA will be capped with clean fill material post-excavation, and as a result, exposure to CCR constituents in soil in the EADA by future onsite terrestrial receptors are expected to be incomplete. If radium is present in soil or groundwater, terrestrial receptors may be exposed to volatile decay products in ambient air following migration of this constituent from soil or groundwater; however, this pathway is considered negligible because exposure to ambient air is only a minor pathway.

As described in Section 3.2, CCR-related constituents in groundwater after the EADA excavation is completed could migrate to adjacent surface water and sediment within McKellar Lake via alluvial groundwater migration to surface water. The water column community within McKellar Lake could be exposed to CCR constituents in surface water. Benthic invertebrates, amphibians, aquatic plants, aquatic-dependent birds and aquatic-dependent mammals could be exposed to CCR constituents in surface water and sediment through direct contact pathways. In addition, benthic invertebrates, amphibians, aquatic-dependent birds and aquatic-dependent mammals may also be exposed to forage or prey items exposed to CCR constituents in surface water and/or sediment.

4.0 SCREENING LEVELS

As described in Section 1.1, this report describes an approach for evaluating soil and groundwater sampling results to be collected following excavation of the EADA. The derivation of soil and groundwater screening levels for use in the post-excavation evaluation are described in Sections 4.1 and 4.2, respectively. The manner in which the soil and groundwater screening levels will be used during the evaluation is described in Section 5.0.

4.1 SOIL

Soil screening levels (SSL) for use in the post-EADA excavation evaluation are described in the following subsections and summarized in **Table 1**. During the evaluation, post-EADA excavation soil sampling results will be compared to the following SSLs: site-specific soil background threshold values (BTV) derived for the ALF, RBSLs based on direct soil contact by future workers (i.e., a hypothetical future on-site industrial worker and a hypothetical future on-site utility/construction worker), and SSLs based on the potential soil migration-to-groundwater pathway (for groundwater that is a potential potable water source and for groundwater that is in communication with surface water). The derivation of these SSLs is described in the following subsections.

4.1.1 Background Threshold Values

A background soil evaluation was conducted to develop BTVs for constituents of interest. If a sample result is below the BTV, there is reasonable confidence that the constituent concentration is consistent with background. However, a single sample result above a BTV does not mean that it is not consistent with background, only that a difference cannot be statistically determined based on the available background dataset.

Table 2 provides data for the background soil samples used in the background evaluation. These data are for samples collected in August 2019. The sample locations are shown on **Figure 5**. A total of 30 background soil samples were collected from ten locations, plus five duplicates. The duplicate samples were treated similarly to other quality control samples and were reviewed but not included in this evaluation.

Table 3 presents summary statistics and the calculated BTVs for the background soil dataset. In accordance with EPA guidance, BTVs were calculated using EPA ProUCL Statistical Software for Environmental Applications version 5.1.002 (USEPA, 2016). The selected BTV is the 95% upper tolerance limit (UTL) with 95% coverage. **Attachment A** presents the ProUCL output sheets.

Descriptive statistics for constituents in the background soil dataset were computed and tabulated in **Table 3**. These include the frequency of detection, percent detects, range of non-detects (ND), mean, variance, standard deviation, coefficient of variation, 50th percentile, 95th percentile, and maximum detect. Information such as the requirement for a certain minimum number of samples and percent NDs were evaluated during this step.

As presented in **Table 3**, an analysis using Dixon's Outlier Test from EPA ProUCL software (USEPA, 2016) indicated the presence of some outliers in the data set. It is assumed that the background dataset used to estimate BTVs represents an unimpacted, single statistical population that is free from outliers. In this instance, however, the variability in the background dataset, and the associated outliers, likely represent natural variability within an industrialized site. Based on existing knowledge that these data are from background sampling locations not affected by CCR operations, as shown on **Figure 5**, no outliers were removed from the background dataset.

The BTVs were generated using EPA ProUCL software (USEPA, 2016), which also tests for normal, lognormal and gamma distributions to establish the appropriate distribution. If the ProUCL test statistics suggested the data follow normal, lognormal or gamma distributions, parametric methods were utilized to estimate BTV values. If the normality assumption was not met, the data were considered to be distribution free, and non-parametric statistical methods were used to estimate BTV values. The BTVs for the constituents were estimated as the appropriate parametric (normal, lognormal or gamma) or non-parametric UTL95-95.

A tolerance limit is a confidence limit on a specified proportion of the population rather than a confidence limit on the mean. A UTL95-95 is a value for which there is a 95% probability (i.e., with a Confidence Coefficient (CC) of 0.95) that 95% of current and future observations from the target population will be less than or equal to that value. Stated differently, the UTL95-95 represents a 95% upper confidence limit (UCL) of the 95th percentile of the data distribution. A UTL95-95 can be used as a BTV when there are numerous on-site observations. For moderately-to-highly-skewed data sets such as those with a high percentage of NDs, if the detected observations in the left-censored data set follow a gamma distribution, then upper limits using Kaplan-Meier (KM) estimates in gamma UTL equations provide better results.

The nonparametric upper limits (e.g., UTLs) are computed by the higher order statistics such as the largest, the second largest, the third largest, and so on of the background data. The order of the statistic used to compute a nonparametric upper limit depends on the sample size, coverage probability, and the desired CC. In practice, unless the sample size is large, non-parametric upper limits do not provide the desired coverage to the population parameter (upper threshold).

Table 3 presents the estimated BTVs and applicable methods used in estimating these values.

4.1.2 Direct Contact Soil Screening Levels

As described in Section 3.0, hypothetical future receptors include a hypothetical future industrial worker and a hypothetical future construction/utility worker. Published screening levels are available for the industrial worker from the EPA. A description of these screening levels is provided in Section 4.1.2.1. Published screening levels are not currently available for construction workers;

as a result, site-specific RBSLs were derived for a hypothetical future construction/utility worker as described in Section 4.1.2.2.

4.1.2.1 Industrial Soil Regional Screening Levels/Preliminary Remediation Goals

Table 1 presents EPA regional screening levels (RSLs) for Industrial Soil (USEPA, 2019a) and Preliminary Remediation Goals (PRGs) for radionuclides (USEPA, 2019b). The default RSL for the industrial worker exposure scenario assumes an exposures frequency of 250 days per year, 8 hours per day, for a 25-year working duration. Exposure routes include incidental ingestion, dermal contact, and inhalation of soil-derived dust. Because TVA is planning to close the EADA by excavating CCR and soils within the footprint of the former disposal area, followed by placement of clean fill material within the excavation, the post-excavation soils within the EADA will not be available for direct contact by hypothetical future on-site industrial workers on a daily basis. Therefore, using the EPA RSLs for Industrial Soil as screening levels in this evaluation is a very conservative approach.

Note that for all of the trace element constituents in **Table 1**, only arsenic is considered by the EPA to be carcinogenic by the ingestion route of exposure. In the federal Superfund program, the EPA evaluates potential carcinogenic risk using the target risk range of 1 in 1 million (10^{-6}) to 1 in ten thousand (10^{-4}). The EPA generally requires a remedy if a site risk is above the 10^{-4} risk level (USEPA, 1991). Therefore, for arsenic, the RSL selected for comparison (300 mg/kg) is the lower of the noncancer (480 mg/kg) and 10^{-4} cancer risk-based (300 mg/kg) concentrations.

4.1.2.2 Hypothetical Future Construction/Utility Worker Risk-Based Screening Levels

Table 1 provides calculated site-specific RBSLs for the hypothetical future on-site construction/utility worker scenario. It should be noted that the RBSL presented for arsenic is the lower of the noncancer RBSL (98.6 mg/kg) and the 10^{-4} target cancer-RBSL (9,200 mg/kg), which is 98.6 mg/kg. **Table 4** provides the exposure assumptions that were used for the hypothetical future on-site construction/utility worker RBSL calculations. Details of the hypothetical future on-site construction/utility worker RBSL calculations are provided in **Attachment B**.

Theoretical risks posed to hypothetical future on-site construction/utility workers are due to potential contact with constituents in post-excavation soil via incidental ingestion and dermal contact. Additionally, hypothetical future on-site construction/utility workers may inhale soil particulates entrained in air as dust. The hypothetical future on-site construction/utility worker scenario is intended to characterize potential risks associated with high-intensity, short-duration exposures to soil during subsurface intrusive activities. Such exposures are characterized using EPA national standardized exposure parameters for a hypothetical future on-site construction worker scenario, which allows for use of a site-specific exposure frequency. For this scenario, an exposure frequency of 60 days per year was used, assuming that a large-scale development project would involve soil excavation activities over a total of 12 weeks in a project that would take up to a year to complete. However, it is likely that any future excavation in the closed impoundment areas would be of much shorter duration; thus, the exposure assumptions used for this scenario are conservative.

4.1.3 Protection of Groundwater Soil Screening Levels

Table 5 presents the derivation of site-specific SSLs for the potential soil-to-groundwater leaching pathway for groundwater that is assumed to be used as drinking water. As shown in **Table 5**, EPA provides default MCL-based soil-to-groundwater SSLs (USEPA, 2019a). Where MCL-based soil-to-groundwater SSLs are unavailable, EPA default risk-based soil-to-groundwater SSLs are presented. EPA MCLs are primary drinking water standards that are enforceable for municipal drinking water supplies, and EPA Tapwater RSLs are RBSLs that are protective of residential receptor exposures to groundwater based on a target cancer risk of 1E-06 and a target hazard quotient of 1.

The EPA-provided default SSL values are based on a Dilution Attenuation Factor (DAF) of 1 (USEPA, 2019a). However, the EPA Supplemental Soil Guidance (USEPA, 2002) developed two default DAFs (DAF=1 and DAF= 20) that are appropriate for deriving generic SSLs. The EPA recommends that a DAF of one be used "assuming no dilution or attenuation between the source and the receptor well" and a DAF of 20 be used "to account for reductions in contaminant concentration due to natural processes occurring in the subsurface," (USEPA, 2002, Appendix A).

To account for natural attenuation processes at the site, the SSLs shown in **Table 5** were adjusted to use a default DAF of 20. These drinking water-based screening levels provide the first set of SSLs for the soil-to-groundwater pathway. The distribution of constituents in post-excavation soil will be evaluated after the excavation is complete to confirm whether screening levels based on a default DAF of 20 are representative of site conditions.

4.1.4 Protection of Surface Water Soil Screening Levels

As described in Section 3.2, CCR-related constituents potentially present in groundwater after the excavation is completed may migrate to adjacent surface water within McKellar Lake. McKellar Lake is designated for industrial water supply, fish and aquatic life, recreation and navigation uses (TDEC, 2013). Site-specific soil-to-groundwater SSLs protective of surface water are presented in **Table 6**. These screening levels were derived using the published human and ecological surface water screening levels described in Section 4.1.4.1, groundwater-to-surface water dilution attenuation modeling as described in Section 4.2.2.1, and a soil-to-groundwater leaching adjustment as described in Section 4.1.4.2.

4.1.4.1 Published Surface Water Screening Levels

Available human health recreational surface water screening levels are presented in **Table 7**. The selected human health surface water screening levels are derived using the following hierarchy:

- TDEC, Tennessee Board of Water Quality, Oil and Gas. General Water Quality Criteria Chapter 0400-40-03, values for Recreation Water and Organism, and Recreation Organism Only (TDEC, 2019a).
- EPA Ambient Water Quality Criteria (AWQC) Human Health Consumption of Water and Organism and Consumption of Organism Only (USEPA, 2019c).

Table 8 presents the available ecological surface water screening levels. Some screening levels apply only to total surface water concentrations, and some apply only to dissolved surface water concentrations. Values for both scenarios are provided. Ecological surface water screening levels also are available for two exposure durations:

- Chronic AWQC: The criterion continuous concentration (CCC) is the EPA national water quality criteria recommendation for the highest in-stream concentration of a toxicant or an effluent to which organisms can be exposed indefinitely without causing unacceptable effect; and
- Acute AWQC: The criterion maximum concentration (CMC) is the EPA national water quality criteria recommendation for the highest in-stream concentration of a toxicant or an effluent to which organisms can be exposed for a brief period of time (CMC derived using 48- to 96-hour toxicity tests) without causing an acute effect.

Selected chronic and acute ecological screening levels were derived from both TDEC and EPA sources as presented in the following hierarchy:

- TDEC Fish and Aquatic Life Criteria, acute and chronic (TDEC, 2019a).
- EPA acute and chronic AWQC (USEPA, 2019d); and
- EPA Region 4 Surface Water Screening Values, acute and chronic (USEPA, 2018).

4.1.4.2 Soil to Groundwater Screening Levels

Table 6 presents the derivation of site-specific SSLs for the potential soil-to-groundwater leaching pathway for the protection of surface water. Site-specific SSLs for the soil-to-groundwater leaching pathway for the protection of surface water represent post-EADA excavation soil concentrations that will not adversely affect human recreational users and aquatic organisms in McKellar Lake. Soil to groundwater SSLs for the protection of surface water were derived by first selecting the lowest of the surface water screening levels protective of human recreational uses (**Table 7**) or aquatic ecological receptors (**Table 8**). These values are termed ‘target surface water screening levels’ in **Table 9**. Target surface water screening levels were then converted to target groundwater screening levels that are protective of surface water (refer to **Table 9**) using a groundwater-to-surface water DAF, as described in Section 4.2.2.1. Finally, target groundwater screening levels that are protective of surface water were converted to site-specific soil-to-groundwater protection of surface water SSLs using a soil-to-groundwater equilibrium partitioning relationship incorporated in the development of the EPA's protection of groundwater SSLs. Because the EPA's protection of groundwater SSLs are drinking water-based, they can be divided by USEPA’s drinking water values to obtain a ratio that represents a chemical-specific soil-to-groundwater equilibrium partitioning factor (termed the 'Groundwater SSL/Drinking Water Ratio' in **Table 6)**. Target groundwater screening levels protective of surface water were multiplied by this ratio to derive site-specific SSLs for the protection of surface water, as shown in Footnote "c" of **Table 6**.

4.2 GROUNDWATER

Groundwater screening levels for use in the post-EADA excavation evaluation are presented in **Table 10**. Groundwater screening levels for use in the risk evaluation include potable groundwater screening levels (**Table 11**), recreational and ecological surface water screening levels (**Table 7 and 8**) and groundwater screening levels protective of surface water (**Table 9**). Derivation of these groundwater screening levels are described in the following subsections.

4.2.1 Background Threshold Values

A background groundwater evaluation was conducted as described in Appendix B of the Feasibility Study: East Ash Disposal Area Report. **Table 10** presents the groundwater BTVs that were developed during the background evaluation. As described in **Appendix B**, background groundwater data collected from background monitoring wells between September 2017 and September 2019 were evaluated for potential outliers. Confirmed statistical outliers were excluded from the groundwater BTV datasets. Groundwater BTVs for each constituent were derived as the 95% UTL with 95% coverage.

4.2.2 Potable Use Groundwater Screening Levels

Available human health potable groundwater screening levels are presented in **Table 11**. The selected potable groundwater screening levels are derived using the following hierarchy:

- TDEC, Tennessee Board of Water Quality, Oil and Gas. General Water Quality Criteria Chapter 0400-40-03, values for Human Health Domestic Water Supply (TDEC, 2019a).
- EPA National Primary Drinking Water Regulation Maximum Contaminant Levels (USEPA, 2019e).
- EPA Regional Screening Levels (RSLs), November 2019, Values for Tap Water (USEPA, 2019a).
- EPA National Primary Drinking Water Regulation. Secondary Maximum Contaminant Levels (USEPA, 2019e).

4.2.3 Groundwater Screening Levels for Protection of Surface Water

Two sets of groundwater screening levels protective of surface water will be used in the post-EADA excavation evaluation. The first set of groundwater screening levels protective of surface water consists of the lowest available recreational and ecological surface water screening levels from **Tables 7 and 8** as described in Section 4.1.4.1. These are conservative screening levels for the evaluation of groundwater because they are direct surface water screening levels that do not account of dilution and attenuation. As a result, a second set of groundwater screening levels protective of surface water were derived as described in Section 4.2.2.1.

4.2.3.1 Groundwater to Surface Water Screening Levels

A groundwater concentration above a surface water screening level does not necessarily mean that surface water will be adversely impacted by the groundwater. Dilution and attenuation mechanisms can occur as groundwater moves to and mixes with surface water. This section describes the approach to evaluating the magnitude of dilution effects resulting from the mixing of groundwater that may flow from beneath the EADA to surface water in McKellar Lake.

The release mechanism for CCR constituents to enter groundwater has not been determined at this time. However, it appears that the primary driving force responsible for historical migration of constituents from CCR material to groundwater is infiltration of pond water through the vadose zone to groundwater. Previous groundwater monitoring indicates that groundwater beneath the site generally flows north towards McKellar Lake, but flow reversals often occur due to the rise and fall of the Mississippi River and McKellar Lake, which is connected to the Mississippi River.

To make conservative estimates of the potential impacts of CCR-derived constituents in groundwater to McKellar Lake, a surface water dilution and attenuation factors (SW-DAF) was calculated for the EADA. The SW-DAF describes the effect of groundwater-surface water mixing on constituent concentrations expected for the surface water body potentially receiving the impacted groundwater.

A site-specific groundwater flow model for the ALF was used to estimate a SW-DAF between groundwater and surface water (McKellar Lake) hydraulically down gradient of the EADA. The evaluation took into account estimated groundwater discharges from the EADA and surface water flows in McKellar Lake. The details of SW-DAF development and results are provided in **Attachment C**. For groundwater that may flow from the EADA to McKellar Lake, the conservatively calculated SW-DAF is 167.

The assumptions used to calculate the SW-DAF are conservative and were based on standard hydrogeological practices. The following conservative assumptions were used to calculate the SW-DAF for the EADA:

- Groundwater discharges to McKellar Lake were estimated during a period when McKellar Lake was at a seasonal low (October 2017) and groundwater discharges from the EADA were inferred to be near maximum.
- Although the EADA is constructed into the upper alluvium, only groundwater discharges represent estimated discharges from the full thickness of the alluvial aquifer.

Surface water flows and groundwater discharges in this area are affected by the behavior of McKellar Lake. The derivation of the SW-DAF using site-specific data may be further updated if site conditions change or additional information becomes available.

5.0 EVALUATION OF FUTURE SITE CONDITIONS

This section describes a tiered approach for evaluating post-excavation soil and groundwater sample results for the potentially complete exposure pathways summarized in Section 3.0 using the screening levels presented in Section 4.0.

As described in Section 3.0, hypothetical future receptors may be exposed to CCR-related constituents in soil remaining after the excavation is completed. Soil may also serve as a continuing source of CCR-related constituents to groundwater, if the soil concentrations are high enough. To evaluate these potential exposures, post-excavation soil sample results will be compared to the soil BTVs, risk-based SSLs and soil migration-to-groundwater SSLs presented in Section 4.0, using the tiered approach described in Section 5.1. Groundwater will also be evaluated using a tiered approach to evaluate potentially complete groundwater and surface water exposure pathways described in Section 3.0. Post-closure groundwater sample results will be compared to the potable groundwater screening levels, recreational and ecological surface water screening levels, and groundwater-to-surface water screening levels presented in Section 4.0, using the tiered approach described in Section 5.2.

Additional data may be available by the time the post-excavation sampling is conducted that can be used to inform or modify the screening levels as appropriate, with TDEC review and approval of significant modifications. Some of these data may provide context for the derived screening levels (for example, surface water and/or groundwater data may be available to show whether the EADA in its current configuration is posing an adverse impact to human health and/or the environment). Such data will be reviewed with TDEC prior to finalizing the evaluation.

5.1 SOIL REMAINING POST-EXCAVATION

After CCR removal, composite soil samples from the floor of the excavation area will be analyzed for CCR constituents. The comparison of soil data to screening levels will be conducted in two parts: 1) direct contact screening, and 2) soil-to-groundwater (S-GW) pathway screening. For the first part, soil data are compared to BTVs and to direct contact RSLs for a hypothetical future on-site industrial worker and to RBSLs for a hypothetical future on-site construction/utility worker. For the second part, soil data are compared to BTVs and to SSLs for the soil-to-groundwater pathway for a potential drinking water scenario and the protection of surface water pathway. Soil screening levels presented in **Table 12** will be used in the evaluation using the methodology described in the following subsections. While post-excavation soil concentrations will be compared to direct contact screening levels, the primary post-excavation pathway of concern per TDEC is the S-GW pathway.

5.1.1 Direct Contact Screening

For direct contact screening, analytical results for potentially CCR-related constituents from confirmatory composite soil samples collected on a grid after completion of the EADA excavation will be evaluated using the following steps and SSLs presented in **Table 12**:

1. Direct Contact and S-GW Tier 1 – BTVs developed for background soils;
2. Direct Contact Tier 2 – Industrial Soil RSLs (USEPA, 2019a) and PRGs for Radionuclides (USEPA, 2019b); and
3. Direct Contact Tier 3 – Hypothetical future on-site construction/utility worker RBSLs/PRGs.

In summary, CCR constituent concentrations in post-excavation composite soil samples will be compared to soil BTVs (Direct Contact and S-GW Tier 1); results less than or equal to their respective BTVs will be considered to be acceptable, and no further evaluation will be conducted for those constituents.

Constituent concentrations above their respective soil BTVs will be compared to RSLs/PRGs for Industrial Soil (Direct Contact Tier 2); results less than or equal to the RSLs/PRGs will be considered to be acceptable, and no further evaluation will be conducted for the direct contact pathway for those constituents.

Constituent concentrations above both their respective soil BTVs and industrial soil RSLs/PRGs will be compared to RBSLs for the hypothetical future on-site construction/utility worker scenario (Direct Contact Tier 3); results less than or equal to their respective RBSLs will be considered to be acceptable, and no further evaluation will be conducted for the direct contact pathway for those constituents.

Constituents that have post-excavation soil concentrations above both their respective soil BTVs and hypothetical future on-site construction/utility worker RBSLs will be considered for further evaluation or action.

5.1.2 Protection of Groundwater and Surface Water Screening

For the protection of groundwater and surface water screening, analytical results for potentially CCR-related constituents from confirmatory composite soil samples collected on a grid after completion of the EADA excavation will be evaluated using the following steps (as requested by TDEC) and SSLs presented in **Table 12**:

S-GW Tier 1 – BTVs developed for background soils; and

S-GW Tier 2 – Site-specific SSL for the potential soil-to-groundwater leaching pathway:

  a. Site-specific soil-to-groundwater SSL for the drinking water pathway; and
  b. Site-specific soil-to-groundwater SSL for the protection of surface water for recreational and ecological use.

In summary, constituent concentrations in post-excavation composite soil samples will be compared to BTVs (Direct Contact and S-GW Tier 1); results less than or equal to their respective BTVs will be considered to be acceptable, and no further evaluation will be conducted for those constituents.

Constituent concentrations above their respective BTVs will be compared to site-specific soil-to-groundwater SSL for the drinking water pathway (S-GW Tier 2a); results less than or equal to their respective SSL will be considered to be acceptable, and no further evaluation will be conducted for those constituents.

Constituents concentrations above both their respective BTVs and soil-to-groundwater SSL for the drinking water pathway will be compared to the site-specific soil-to-groundwater SSL for the protection of surface water (S-GW Tier 2b). Results less than or equal to their respective screening levels will be considered to be acceptable, and no further evaluation will be conducted for those constituents.

Constituents that have post-excavation soil concentrations above their respective BTVs, site-specific soil-to-groundwater SSL for the drinking water pathway, and site-specific soil-to-groundwater SSL for the protection of surface water will be considered for further evaluation.

5.2 GROUNDWATER REMAINING POST EXCAVATION

After CCR removal, post-closure groundwater data collected from the EADA will be compared to screening levels in three parts: 1) background screening 2) potable groundwater screening, and 3) protection of surface water screening. For the first part, groundwater data are compared to groundwater BTVs. For the second part, groundwater data are compared to potable groundwater screening levels. For the third part, groundwater data are compared to surface water screening levels and groundwater-to-surface water screening levels. Groundwater screening levels presented in **Table 13** will be used in the evaluation using the methodology described in this section.

For groundwater screening, analytical results for potentially CCR-related constituents from post-closure groundwater data will be evaluated using the following steps and SSLs presented in **Table 13**:

1. Groundwater Tier 1 – BTVs developed for background groundwater;
2. Groundwater Tier 2 – Potable groundwater screening levels;
3. Groundwater Tier 3 – Lowest published recreational and ecological surface water screening levels; and
4. Groundwater Tier 4 – Groundwater-to-surface water screening levels for the protection of recreational and ecological surface water use.

As the first step in the groundwater evaluation process, CCR constituent concentrations in groundwater will be compared to groundwater BTVs (Groundwater Tier 1); results less than or equal to their respective BTVs will be considered to be acceptable, and no further evaluation will be conducted for those constituents.

As the second step in the groundwater evaluation process, groundwater concentrations will be compared to potable groundwater screening levels (Groundwater Tier 2). This is a conservative screening step as the on-site groundwater is not used as a source of drinking water. Results less than or equal to their respective potable groundwater screening levels will be considered to be acceptable, and no further evaluation will be conducted for those constituents.

Constituent concentrations above their respective potable groundwater screening levels will be compared to surface water screening levels (Groundwater Tier 3). This is a conservative screening step as the on-site groundwater undergoes significant dilution and attenuation before entering surface waters, and there is no direct exposure to groundwater by human or ecological receptors. Results less than or equal to their respective surface water screening levels will be considered to be acceptable, and no further evaluation will be conducted for those constituents.

Constituent concentrations above their respective groundwater BTVs, potable groundwater screening levels and surface water screening levels will be compared to groundwater-to-surface water screening levels adjusted for dilution and attenuation (Groundwater Tier 4). Results less than or equal to their respective groundwater-to-surface water screening levels will be considered to be acceptable, and no further evaluation will be conducted for those constituents. If there are concentrations of CCR constituents in post-closure groundwater data that are above the screening levels, the specific instances will be evaluated in more detail. For example, background levels of some constituents in McKellar Lake are available from U.S. Geological Survey (USGS) sources, and these background levels can be used to put the screening levels into context. Additional evaluation of the SW-DAF can also be conducted based on the results of ongoing groundwater sampling and modeling.

It is important to note here that groundwater data collected for the EADA during the remedial investigation represent current conditions and past use of the EADA. These data will not represent post-closure groundwater conditions. Groundwater concentrations of CCR-related constituents will decrease once the source area ash is removed, and with operation of the groundwater interim response action which is a groundwater extraction and treatment system. This will be confirmed by future, post-closure groundwater monitoring.

6.0 REFERENCES

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TABLES

Table 1
Soil Screening Levels Summary Table
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

Analyte	CAS	Units	Background Threshold Value [a]	Industrial Soil RSL / PRG [b]	Hypothetical Future On-Site Construction/ Utility Worker RBSL / PRG [c]	Site-Specific Soil-to-Groundwater SSL for the Protection of Groundwater DAF = 20 [d]	Site-Specific Soil-to-Groundwater SSL for the Protection of Surface Water [e]
Antimony	7440-36-0	mg/kg	0.63	470 [f]	136	5.4	29,000
Arsenic	7440-38-2	mg/kg	9.6	300	99	5.8	973
Barium	7440-39-3	mg/kg	219	220,000	40,600	1,648	30,000
Beryllium	7440-41-7	mg/kg	1.1	2,300	326	63	29,000
Boron	7440-42-8	mg/kg	10	230,000	58,100	256	77,000
Cadmium	7440-43-9	mg/kg	0.69	980	121	7.5	180
Calcium	7440-70-2	mg/kg	20,528	-	-	-	-
Chloride	16887-00-6	mg/kg	5.2	-	-	-	-
Chromium	7440-47-3	mg/kg	19	1,800,000 [g]	509,000	3,600,000	440,000,000
Cobalt	7440-48-4	mg/kg	10	350	289	5.4	2,900
Copper	7440-50-8	mg/kg	26	47,000	13,600	916	1,057
Fluoride	16984-48-8	mg/kg	5.8	47,000	12,900	12,020	1,400,000
Lead	7439-92-1	mg/kg	28	800	- [h]	270	7,600
Lithium	7439-93-2	mg/kg	17	2,300	679	240	440,000
Mercury	7439-97-6	mg/kg	0.13	350 [i]	610	2.1	8.8
Molybdenum	7439-98-7	mg/kg	1.3	5,800	1,700	40	53,000
Nickel	7440-02-0	mg/kg	25	22,000 [j]	2,530	512	11,000
Radium-226	13982-63-3	pCi/g	2.5	0.020	2.1	0.000011	34,000
Radium-226+228	13982-63-3/15262-20-1	pCi/g	4.1	0.015 [k]	1.6 [k]	0.000011	11,000
Radium-228	15262-20-1	pCi/g	1.9	0.015	1.6	0.000026	26,000
Selenium	7782-49-2	mg/kg	1.4	5,800	1,690	5.2	26
Silver	7440-22-4	mg/kg	1.3	5,800	1,700	16	1.7
Sulfate	14808-79-8	mg/kg	183	-	-	-	-
Thallium	7440-28-0	mg/kg	0.57	12 [l]	14	2.8	111
Vanadium	7440-62-2	mg/kg	26	5,800	1,270	1,728	90,000
Zinc	7440-66-6	mg/kg	89	350,000	102,000	7,460	25,000

Table 1
Soil Screening Levels Summary Table
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

Analyte	CAS	Units	Background Threshold Value [a]	Industrial Soil RSL / PRG [b]	Hypothetical Future On-Site Construction/ Utility Worker RBSL / PRG [c]	Site-Specific Soil-to-Groundwater SSL for the Protection of Groundwater DAF = 20 [d]	Site-Specific Soil-to-Groundwater SSL for the Protection of Surface Water [e]

Notes:

"-" - not available
CAS - Chemical Abstracts Service registry number
DAF - dilution attenuation factor
mg/kg - milligrams per kilogram
pCi/g - picocuries per gram
PRG - preliminary remediation goal
RBSL - risk-based screening level
RSL - regional screening level
SSL - soil screening level
USEPA - United States Environmental Protection Agency

[a] Background threshold value as presented in Table 3.

[b] November 2019 USEPA RSLs for industrial soil based on a target carcinogenic risk and noncancer hazard quotient (HQ) of $1x10^{-4}$ and 1, respectively. PRGs for radionuclides developed using the PRG calculator for a default composite worker scenario and a target carcinogenic risk of $1x10^{-4}$ as presented in

[c] Soil RBSLs for a hypothetical future on-site construction/utility worker based on a target carcinogenic risk and noncancer HQ of $1x10^{-4}$ and 1, respectively, derived using the exposure assumptions presented in Table 4 and toxicity values and equations presented in Attachment B. PRGs for radionuclides developed using the PRG calculator for the construction worker soil - other construction activities scenario with the exposure assumptions presented in Table 4 and a target carcinogenic risk of $1x10^{-4}$ as presented in Attachment B.

[d] Site-specific soil-to-groundwater SSL for protection of groundwater as presented in Table 5.

[e] Site-specific soil-to-groundwater SSL for the protection of surface water as presented in Table 6.

[f] RSL for antimony (metallic) presented.

[g] RSL for chromium (III) used as a surrogate.

[h] USPEA Industrial Soil RSL value used.

[i] RSL for mercuric chloride used as a surrogate.

[j] RSL for nickel soluble salts presented.

[k] PRG for radium-228 used as a surrogate.

[l] RSL for thallium soluble salts presented.

Table 2
Summary of Background Soil Quality Data
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

		Sample Location	**ALF-BG01**				**ALF-BG02**	
		Sample Date	**6-Aug-19**	**6-Aug-19**	**6-Aug-19**	**6-Aug-19**	**15-Aug-19**	**15-Aug-19**
		Sample ID	**ALF-BS-BG01-0.0/0.5-20190806**	**ALF-BS-DUP01-20190806**	**ALF-BS-BG01-1.0/3.0-20190806**	**ALF-BS-BG01-6.0/8.0-20190806**	**ALF-BS-BG02-0.0/0.5-20190815**	**ALF-BS-DUP03-20190815**
		Sample Depth	**0 - 0.5 ft**		**1 - 3 ft**	**6 - 8 ft**	**0 - 0.5 ft**	
		Sample Type	**Normal**	**Field Duplicate**	**Normal**	**Normal**	**Normal**	**Field Duplicate**
Analyte	**CAS**	**Units**						
Metals								
Antimony	7440-36-0	mg/kg	0.11 J	0.113 J	0.0861 J	0.102 J	0.182 J	0.193 J
Arsenic	7440-38-2	mg/kg	2.43	1.73	2.05	3.04	2.32	3.15
Barium	7440-39-3	mg/kg	47	47	50.7	65.6	53.5	51
Beryllium	7440-41-7	mg/kg	0.545	0.602	0.173	0.272	0.279	0.276
Boron	7440-42-8	mg/kg	6.49 J	6.95 J	1.89 J	2.35 J	2.93 J	2.76 J
Cadmium	7440-43-9	mg/kg	0.0744 J	0.0715 J	0.0907 J	0.15	0.273	0.228
Calcium	7440-70-2	mg/kg	2,670 J	2,920 J	3,770 J	4,150 J	4,370 J	1,830 J
Chromium	7440-47-3	mg/kg	8.43	8.09	4.56	5.43	6.94	5.31
Cobalt	7440-48-4	mg/kg	2.23	2.12	3.03	4.84	3.34	3.98
Copper	7440-50-8	mg/kg	4.26	3.98	2.44	3.64	8.4 J	4.71 J
Lead	7439-92-1	mg/kg	4.06	4.2	4.77	7.02	7.86	6.27
Lithium	7439-93-2	mg/kg	4.25	4.5	3.36	3.84	3.53	3.27
Mercury	7439-97-6	mg/kg	<0.0165	<0.0136	0.0157 J	<0.0162	<0.0171	<0.0155
Molybdenum	7439-98-7	mg/kg	0.653	0.705	0.389 J	0.454 J	0.541 J	0.354 J
Nickel	7440-02-0	mg/kg	7.4	6.58	7.55	10.8	8.87	8.66
Selenium	7782-49-2	mg/kg	0.282 J	0.251 J	0.454 J	0.534 J	0.412 J	0.352 J
Silver	7440-22-4	mg/kg	<0.0328	<0.0293	<0.0291	<0.0291	0.0382 J	<0.0327
Thallium	7440-28-0	mg/kg	0.0668 J	0.0696 J	0.109	0.118	0.132	0.134
Vanadium	7440-62-2	mg/kg	9.52	9.86	6.8	8.26	8.73	7.86
Zinc	7440-66-6	mg/kg	16.2 J	16.2 J	17.7 J	22.4 J	35.5 J	85.9 J
General Chemistry								
Chloride	16887-00-6	mg/kg	<4.37	<4.12	<4.15	<4.1	<4.63	<4.66
Fluoride	16984-48-8	mg/kg	0.927 J	1.08	0.988 J	2.53	0.855 J	<0.818
Sulfate	14808-79-8	mg/kg	<7.64	<7.2	<7.26	<7.18	11.7 J	12.1
pH (lab)	PH	SU	7.8	7.7	8.1	8.5	7.5	7.4
Radiological								
Radium-226	13982-63-3	pCi/g	3.27 +/-(0.441)	3.71 +/-(0.499)	0.566 +/-(0.147)	0.827 +/-(0.239)	0.595 +/-(0.143)J	0.933 +/-(0.206)J
Radium-228	15262-20-1	pCi/g	1.74 +/-(0.291)J	1.39 +/-(0.352)J	0.565 +/-(0.223)J	0.776 +/-(0.247)J	0.716 +/-(0.161)	0.543 +/-(0.236)
Radium-226+228	RA226/228	pCi/g	5.01 +/-(0.528)J	5.10 +/-(0.611)J	1.13 +/-(0.267)J	1.60 +/-(0.344)J	1.31 +/-(0.215)J	1.48 +/-(0.313)J
% Ash								
% ASH	%ASH	%	<1	-	-	-	1	-

Table 2
Summary of Background Soil Quality Data
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

		Sample Location	**ALF-BG02**		**ALF-BG03**			**ALF-BG04**
		Sample Date	**15-Aug-19**	**14-Aug-19**	**8-Aug-19**	**8-Aug-19**	**7-Aug-19**	**14-Aug-19**
		Sample ID	**ALF-BS-BG02-1.5/3.5-20190815**	**ALF-BS-BG02-6.5/8.5-20190814**	**ALF-BS-BG03-0.0/0.5-20190808**	**ALF-BS-BG03-1.0/3.0-20190808**	**ALF-BS-BG03-6.0/8.0-20190807**	**ALF-BS-BG04-0.0/0.5-20190814**
		Sample Depth	**1.5 - 3.5 ft**	**6.5 - 8.5 ft**	**0 - 0.5 ft**	**1 - 3 ft**	**6 - 8 ft**	**0 - 0.5 ft**
		Sample Type	**Normal**	**Normal**	**Normal**	**Normal**	**Normal**	**Normal**
Analyte	**CAS**	**Units**						
Metals								
Antimony	7440-36-0	mg/kg	0.144 J	<0.0775	0.185 J	0.0696 J	0.461	0.359
Arsenic	7440-38-2	mg/kg	2.54	1.79	3.13	1.62	5.6	4.56
Barium	7440-39-3	mg/kg	61.3	44.2	67.4	24.1	171	72.4
Beryllium	7440-41-7	mg/kg	0.218	0.219	0.306	0.145	0.697 J	0.271
Boron	7440-42-8	mg/kg	2.36 J	1.82 J	2.3 J	<1.51	6.95 J	2.74 J
Cadmium	7440-43-9	mg/kg	0.129	0.081 J	0.159	0.106 J	0.352	0.47
Calcium	7440-70-2	mg/kg	3,590 J	3,560	1,800 J	845 J	5,040 J	1,470
Chromium	7440-47-3	mg/kg	5.11	4.08	5.91	3.02	11.2	12.4
Cobalt	7440-48-4	mg/kg	3.39	2.97	3.62	2.4	6.76	2.56
Copper	7440-50-8	mg/kg	4.41	2.4	5.92	2.24	14.6	16.3
Lead	7439-92-1	mg/kg	5.9	3.84	11.2	3.72	12.5 J	27.7
Lithium	7439-93-2	mg/kg	3.69	3.38	4.11	1.88	10.4	3.96
Mercury	7439-97-6	mg/kg	<0.0142	<0.017	0.0151 J	<0.0128	0.0592	0.193
Molybdenum	7439-98-7	mg/kg	0.359 J	0.273 J	0.345 J	<0.182	0.673 J	1.01
Nickel	7440-02-0	mg/kg	8.44	7.07	8.5	5.94	17.1	6.23
Selenium	7782-49-2	mg/kg	0.479 J	0.454 J	0.549 J	0.272 J	1.09	0.743
Silver	7440-22-4	mg/kg	<0.0293	<0.0338	<0.0332	<0.0301	0.0613 J	1.25
Thallium	7440-28-0	mg/kg	0.152	0.114 U*	0.131	0.0555 J	0.558 J	0.238 U*
Vanadium	7440-62-2	mg/kg	8.32	6.96	9.56	5.75	20.6	10.4
Zinc	7440-66-6	mg/kg	19.8 J	14.4	30.2 J	11.3 J	47.7 J	52.8
General Chemistry								
Chloride	16887-00-6	mg/kg	<4.25	<4.72	<4.71	<4.23	<5.2	<4.79
Fluoride	16984-48-8	mg/kg	0.977 J	<0.827	1.79	1.58	3.95	1.12 J
Sulfate	14808-79-8	mg/kg	<7.43	<8.26	<8.24	9.28 J	34.5	10.8 J
pH (lab)	PH	SU	8.2	8.3	6.6	7.8	7.9	6.2
Radiological								
Radium-226	13982-63-3	pCi/g	0.588 +/-(0.168)	0.750 +/-(0.189)	0.894 +/-(0.180)	0.622 +/-(0.155)	1.53 +/-(0.280)	0.803 +/-(0.193)
Radium-228	15262-20-1	pCi/g	0.591 +/-(0.150)	0.769 +/-(0.214)	0.738 +/-(0.214)	0.634 +/-(0.152)	1.40 +/-(0.287)J	0.565 +/-(0.318)
Radium-226+228	RA226/228	pCi/g	1.18 +/-(0.225)	1.52 +/-(0.286)	1.63 +/-(0.280)	1.26 +/-(0.217)	2.93 +/-(0.401)J	1.37 +/-(0.372)
% Ash								
% ASH	%ASH	%	-	-	<1	-	-	2

Table 2
Summary of Background Soil Quality Data
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

		Sample Location	**ALF-BG04**		**ALF-BG05**			
		Sample Date	**13-Aug-19**	**13-Aug-19**	**13-Aug-19**	**13-Aug-19**	**12-Aug-19**	**12-Aug-19**
		Sample ID	**ALF-BS-BG04-0.5/2.5-20190813**	**ALF-BS-BG04-6.5/8.5-20190813**	**ALF-BS-BG05-0.0/0.5-20190813**	**ALF-BS-DUP02-20190813**	**ALF-BS-BG05-1.2/3.2-20190812**	**ALF-BS-BG05-6.2/8.2-20190812**
		Sample Depth	**0.5 - 2.5 ft**	**6.5 - 8.5 ft**	**0 - 0.5 ft**		**1.2 - 3.2 ft**	**6.2 - 8.2 ft**
		Sample Type	**Normal**	**Normal**	**Normal**	**Field Duplicate**	**Normal**	**Normal**
Analyte	**CAS**	**Units**						
Metals								
Antimony	7440-36-0	mg/kg	0.129 J	0.308 J	0.392 J	0.321 J	0.205 J	0.267 J
Arsenic	7440-38-2	mg/kg	2.93	5.74	6.04	5.01	3.83	4.73
Barium	7440-39-3	mg/kg	77.5	198	136	117	98.3	137
Beryllium	7440-41-7	mg/kg	0.306	0.757	0.462	0.441	0.423	0.76
Boron	7440-42-8	mg/kg	2.79 J	7.15 J	4.84 J	4.17 J	3.71 J	7.68 J
Cadmium	7440-43-9	mg/kg	0.207	0.505	0.424	0.388	0.291	0.338
Calcium	7440-70-2	mg/kg	2,210	16,900	3,100	2,960	2,980	6,480
Chromium	7440-47-3	mg/kg	5.71	12	13.7	11.1	7.37	11.6
Cobalt	7440-48-4	mg/kg	3.41	6.66	5.54	4.52	4.71	5.56
Copper	7440-50-8	mg/kg	6.21	14.7	18.6	15.1	7.83	13.8
Lead	7439-92-1	mg/kg	7.42	13	28.4	23.8	11.7	15.8
Lithium	7439-93-2	mg/kg	4.54	11	7.54	6.68	6.38	10.9
Mercury	7439-97-6	mg/kg	0.0193 J	0.0265 J	0.144	0.109	<0.018	0.0221 J
Molybdenum	7439-98-7	mg/kg	0.318 J	0.77	0.819	0.667	0.551	0.532 J
Nickel	7440-02-0	mg/kg	8.66	19.3	13	10.9	10.6	14.3
Selenium	7782-49-2	mg/kg	0.598	0.898	0.945	0.638	0.615	0.864
Silver	7440-22-4	mg/kg	0.0636 J	0.0805 J	0.592	0.507	0.117	0.0684 J
Thallium	7440-28-0	mg/kg	0.12	0.314	0.211	0.195	0.157	0.278
Vanadium	7440-62-2	mg/kg	9.44	21.7	17.8	14.3	11.2	19.5
Zinc	7440-66-6	mg/kg	26 J	48.9 J	63.2 J	50.4 J	34.4 J	53.2 J
General Chemistry								
Chloride	16887-00-6	mg/kg	<4.28	<5.46	<4.88	<4.5	<4.41	<5.25
Fluoride	16984-48-8	mg/kg	1.19 J	4.4 J	4.39 J	3.02 J	2.06 J	3.02 J
Sulfate	14808-79-8	mg/kg	<7.48	14.1	49.9	42.3	75.5	104
pH (lab)	PH	SU	7.7	8.2	7	6.8	7.1	7.6
Radiological								
Radium-226	13982-63-3	pCi/g	0.872 +/-(0.178)	1.64 +/-(0.355)	1.14 +/-(0.238)	1.23 +/-(0.259)	0.813 +/-(0.257)	1.42 +/-(0.310)
Radium-228	15262-20-1	pCi/g	1.12 +/-(0.301)	1.29 +/-(0.526)	1.28 +/-(0.250)	1.05 +/-(0.237)	1.23 +/-(0.282)	1.36 +/-(0.394)
Radium-226+228	RA226/228	pCi/g	1.99 +/-(0.350)	2.93 +/-(0.635)	2.42 +/-(0.345)	2.28 +/-(0.351)	2.04 +/-(0.382)	2.78 +/-(0.501)
% Ash								
% ASH	%ASH	%	-	-	1	-	-	-

Table 2
Summary of Background Soil Quality Data
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

		Sample Location	**ALF-BG08**				**ALF-BG09**	
		Sample Date	**20-Aug-19**	**20-Aug-19**	**19-Aug-19**	**19-Aug-19**	**16-Aug-19**	**16-Aug-19**
		Sample ID	**ALF-BS-BG08-0.0/0.5-20190820**	**ALF-BS-DUP04-20190820**	**ALF-BS-BG08-1.5/3.5-20190819**	**ALF-BS-BG08-6.5/8.5-20190819**	**ALF-BS-BG09-0.0/0.5-20190816**	**ALF-BS-BG09-1.5/3.5-20190816**
		Sample Depth	**0 - 0.5 ft**		**1.5 - 3.5 ft**	**6.5 - 8.5 ft**	**0 - 0.5 ft**	**1.5 - 3.5 ft**
		Sample Type	**Normal**	**Field Duplicate**	**Normal**	**Normal**	**Normal**	**Normal**
Analyte	**CAS**	**Units**						
Metals								
Antimony	7440-36-0	mg/kg	0.332 J	0.29	0.255	0.283	0.296 J	0.467 J
Arsenic	7440-38-2	mg/kg	7.08	8.51	5.65	10.5	6.38	3.59
Barium	7440-39-3	mg/kg	150	145	144	180	110	121
Beryllium	7440-41-7	mg/kg	0.681	0.643	0.716	0.926	0.707	0.68
Boron	7440-42-8	mg/kg	7.13 J	5.99 J	4.42 J	5.83 J	6.35 J	6.6 J
Cadmium	7440-43-9	mg/kg	0.432	0.447	0.346	0.663	0.213	0.374
Calcium	7440-70-2	mg/kg	5,630	4,860	5,100	5,530	4,060 J	5,140 J
Chromium	7440-47-3	mg/kg	11.7	11.9	11.8	13.7	12.9	12.9
Cobalt	7440-48-4	mg/kg	6.33	6.57	7.35	7.24	5.49	6.93
Copper	7440-50-8	mg/kg	15.9	15.9	16.4	19.3	14.1	11.5
Lead	7439-92-1	mg/kg	16.2	16.2	15.6	15.4	10	12.6
Lithium	7439-93-2	mg/kg	9.12	10.7	11.2	13.8	8.44	9.81
Mercury	7439-97-6	mg/kg	0.0605	0.0569	0.0451 U*	0.0406 U*	<0.0173	<0.0179
Molybdenum	7439-98-7	mg/kg	0.915	0.751	0.686	0.895	0.802	0.742
Nickel	7440-02-0	mg/kg	16	16.8	17.6	23.3	13.9	16.6
Selenium	7782-49-2	mg/kg	1.1	0.998	1.01	0.701	0.853	1.06
Silver	7440-22-4	mg/kg	0.2	0.176	0.0643 J	0.072 J	0.0402 J	0.0536 J
Thallium	7440-28-0	mg/kg	0.256	0.238	0.333	0.334	0.207	0.474
Vanadium	7440-62-2	mg/kg	17.7	17.5	17.2	19.6	19.6	20.4
Zinc	7440-66-6	mg/kg	68	66.8	53.2	62.8	39 J	52.8 J
General Chemistry								
Chloride	16887-00-6	mg/kg	<4.51	<4.6	<4.84	<5.21	<4.77	<4.68
Fluoride	16984-48-8	mg/kg	1.1 J	1.16 J	2.1	5.4	1.48	3.42
Sulfate	14808-79-8	mg/kg	19	13.4	22	21.4	9.37 J	15.8
pH (lab)	PH	SU	7.3	7.5	8	7.9	7.8	8
Radiological								
Radium-226	13982-63-3	pCi/g	1.13 +/-(0.261)	1.22 +/-(0.293)	1.32 +/-(0.257)	1.35 +/-(0.298)	1.88 +/-(0.392)	1.09 +/-(0.270)
Radium-228	15262-20-1	pCi/g	1.17 +/-(0.340)	1.24 +/-(0.406)	1.20 +/-(0.261)	1.45 +/-(0.343)	1.68 +/-(0.409)	0.902 +/-(0.284)
Radium-226+228	RA226/228	pCi/g	2.30 +/-(0.429)	2.46 +/-(0.501)	2.52 +/-(0.366)	2.80 +/-(0.454)	3.56 +/-(0.567)	1.99 +/-(0.392)
% Ash								
% ASH	%ASH	%	<1	-	-	-	1	-

Table 2
Summary of Background Soil Quality Data
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

		Sample Location	**ALF-BG09**	**ALF-BG10**			**ALF-BG12**	
		Sample Date	**16-Aug-19**	**22-Aug-19**	**22-Aug-19**	**22-Aug-19**	**22-Aug-19**	**22-Aug-19**
		Sample ID	**ALF-BS-BG09-6.5/8.5-20190816**	**ALF-BS-BG10-0.0/0.5-20190822**	**ALF-BS-BG10-0.9/2.9-20190822**	**ALF-BS-BG10-6.5/8.5-20190822**	**ALF-BS-BG12-0.0/0.5-20190822**	**ALF-BS-DUP05-20190822**
		Sample Depth	**6.5 - 8.5 ft**	**0 - 0.5 ft**	**0.9 - 2.9 ft**	**6.5 - 8.5 ft**	**0 - 0.5 ft**	
		Sample Type	**Normal**	**Normal**	**Normal**	**Normal**	**Normal**	**Field Duplicate**
Analyte	**CAS**	**Units**						
Metals								
Antimony	7440-36-0	mg/kg	0.282 J	0.289 J	0.311 J	0.422 J	0.716 J	0.625 J
Arsenic	7440-38-2	mg/kg	4.6	5.86	6.16	8.47	5.66	5.6
Barium	7440-39-3	mg/kg	127	122	138	177	129	129
Beryllium	7440-41-7	mg/kg	0.491	0.567	0.532	0.912	0.629	0.66
Boron	7440-42-8	mg/kg	5.08 J	5.72 J	5.4 J	7.99 J	6.47 J	6.08 J
Cadmium	7440-43-9	mg/kg	0.187	0.406	0.388	0.365	0.448	0.483
Calcium	7440-70-2	mg/kg	13,200 J	25,100 J	7,840 J	5,500 J	5,700	5,780
Chromium	7440-47-3	mg/kg	8.19	11.6	11.8	15.8	13.3	12.4
Cobalt	7440-48-4	mg/kg	4.38	5.94	7.42	10.4	6.39	6.33
Copper	7440-50-8	mg/kg	9.66	13.8	13.3	20.4	16.7	16.5
Lead	7439-92-1	mg/kg	8.22	17.9	16.2	17.5	16.7	17.2
Lithium	7439-93-2	mg/kg	6.88	9.55	9.7	14.9	10.1	10
Mercury	7439-97-6	mg/kg	<0.0181	0.0709 U*	0.061	0.0531	0.112	0.089 U*
Molybdenum	7439-98-7	mg/kg	0.613 J	0.677	0.728	0.883	0.711	0.738
Nickel	7440-02-0	mg/kg	11.6	14.9	17.4	21.1	15.7	15.7
Selenium	7782-49-2	mg/kg	0.447 J	0.646	0.932	1.34	0.766	0.9
Silver	7440-22-4	mg/kg	0.038 J	0.268	0.0974 J	0.0889 J	0.42	0.399
Thallium	7440-28-0	mg/kg	0.299	0.235	0.401	0.543	0.232 J	0.479 J
Vanadium	7440-62-2	mg/kg	14.1	17.2	19.4	25.9	20.3	18
Zinc	7440-66-6	mg/kg	31.2 J	55.9	56.2	70.9	60.2 J	59.6 J
General Chemistry								
Chloride	16887-00-6	mg/kg	<5.08	<4.22	<4.61	<5.23	<4.56	<4.62
Fluoride	16984-48-8	mg/kg	3.49	3.48 J	3.02 J	3.54 J	0.978 J	1.01 J
Sulfate	14808-79-8	mg/kg	13.9	63	215	35.6	14.4	18.7
pH (lab)	PH	SU	7.9	8.2	8	7.4	7.9	7.9
Radiological								
Radium-226	13982-63-3	pCi/g	1.15 +/-(0.275)	1.05 +/-(0.308)	1.39 +/-(0.365)	1.26 +/-(0.273)	1.09 +/-(0.290)J	1.94 +/-(0.362)J
Radium-228	15262-20-1	pCi/g	1.40 +/-(0.415)	0.920 +/-(0.325)	0.982 +/-(0.376)	1.13 +/-(0.478)	1.06 +/-(0.502)	1.60 +/-(0.347)
Radium-226+228	RA226/228	pCi/g	2.55 +/-(0.498)	1.97 +/-(0.448)	2.37 +/-(0.524)	2.39 +/-(0.550)	2.15 +/-(0.580)J	3.54 +/-(0.501)J
% Ash								
% ASH	%ASH	%	-	<1	-	-	1	-

Table 2
Summary of Background Soil Quality Data
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

		Sample Location	ALF-BG12		ALF-BG13		
		Sample Date	22-Aug-19	22-Aug-19	21-Aug-19	21-Aug-19	21-Aug-19
		Sample ID	ALF-BS-BG12-1.5/3.5-20190822	ALF-BS-BG12-6.5/8.5-20190822	ALF-BS-BG13-0.0/0.5-20190821	ALF-BS-BG13-1.5/3.5-20190821	ALF-BS-BG13-6.5/8.5-20190821
		Sample Depth	1.5 - 3.5 ft	6.5 - 8.5 ft	0 - 0.5 ft	1.5 - 3.5 ft	6.5 - 8.5 ft
		Sample Type	Normal	Normal	Normal	Normal	Normal
Analyte	**CAS**	**Units**					
Metals							
Antimony	7440-36-0	mg/kg	0.274 J	0.332 J	0.449 J	0.605 J	0.338 J
Arsenic	7440-38-2	mg/kg	5.67	6.53	6.45	6.47	6.11
Barium	7440-39-3	mg/kg	127	167	142	157	136
Beryllium	7440-41-7	mg/kg	0.536	0.956	0.905	1	0.883
Boron	7440-42-8	mg/kg	5.52 J	8.43 J	7.56 J	8.21 J	8.05 J
Cadmium	7440-43-9	mg/kg	0.271	0.309	0.8	0.365	0.306
Calcium	7440-70-2	mg/kg	7,460 J	5,490 J	4,310	6,720	4,460
Chromium	7440-47-3	mg/kg	10.3	15.7	16.8	14.9	15.9
Cobalt	7440-48-4	mg/kg	6.56	7.76	8.52	8.12	7.3
Copper	7440-50-8	mg/kg	13.2	20.8	23.8	16.3	15
Lead	7439-92-1	mg/kg	15.5	17	26.4	17	12.8
Lithium	7439-93-2	mg/kg	10.1	15.6	11.7	13.9	13.5
Mercury	7439-97-6	mg/kg	0.0549 U*	0.0439 U*	0.0881 U*	0.0646 U*	0.0346 U*
Molybdenum	7439-98-7	mg/kg	0.597 J	0.771	1.16	1.74	0.726
Nickel	7440-02-0	mg/kg	14.6	21.3	18.4	18.8	20.2
Selenium	7782-49-2	mg/kg	0.628 J	0.837	1.06	1.19	0.769
Silver	7440-22-4	mg/kg	0.0599 J	0.103 J	0.56	0.109 J	0.0691 J
Thallium	7440-28-0	mg/kg	0.24	0.325	0.288	0.545	0.397
Vanadium	7440-62-2	mg/kg	17.6	26.3	23	24.5	26.2
Zinc	7440-66-6	mg/kg	45.2	66.1	91.1	55.9	50.4
General Chemistry							
Chloride	16887-00-6	mg/kg	<4.86	<5.15	<5.04	<4.76	<4.87
Fluoride	16984-48-8	mg/kg	3.39 J	5.36 J	1.78	3.17	5.21
Sulfate	14808-79-8	mg/kg	12.1 J	24.8	21.4	35.2	36.7
pH (lab)	PH	SU	8.2	8.1	6.8	8	7.9
Radiological							
Radium-226	13982-63-3	pCi/g	1.18 +/-(0.297)	1.49 +/-(0.321)	1.47 +/-(0.301)	1.47 +/-(0.326)	1.39 +/-(0.286)
Radium-228	15262-20-1	pCi/g	1.23 +/-(0.364)	1.25 +/-(0.363)	1.61 +/-(0.305)	1.10 +/-(0.333)	1.70 +/-(0.377)
Radium-226+228	RA226/228	pCi/g	2.41 +/-(0.470)	2.74 +/-(0.485)	3.08 +/-(0.429)	2.57 +/-(0.466)	3.09 +/-(0.473)
% Ash							
% ASH	%ASH	%	-	-	<1	-	-

Table 2
Summary of Background Soil Quality Data
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

Notes:

% - percent
<RL - analyte was not detected at a concentration greater than the laboratory reporting limit (RL)
CAS - Chemical Abstracts Service registry number
n/v - no standard/guideline value
"-" - parameter not analyzed / not available
J - quantitation is approximate due to limitations identified during data validation
pCi/g - picocuries per gram
U* - This result should be considered “not detected” because it was detected in an associated field or laboratory blank at a similar level
mg/kg - milligrams per kilogram
SU - Standard Units

Table 3
Background Data Statistical Evaluation
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

Analyte	CAS	Units	Number of Samples	Number of Detections	Detection Frequency (%)	Minimum Detected Concentration	Maximum Detected Concentration	Minimum Reporting Limit for Non-Detects	Maximum Reporting Limit for Non-Detects	Mean Detected Concentration	Standard Deviation of Detects	95th Percentile	Number of Statistical Outliers [a]	Number of Outliers Removed	95-95 UTL [b]	Method	BTV [c]	Basis
Antimony	7440-36-0	mg/kg	30	29	97	0.070	0.72	0.078	0.078	0.30	0.15	0.54	0	0	0.63	95% Normal UTL with 95% Coverage	0.63	95-95 UTL
Arsenic	7440-38-2	mg/kg	30	30	100	1.6	11	-	-	4.9	2.1	7.8	0	0	9.6	95% Normal UTL with 95% Coverage	9.6	95-95 UTL
Barium	7440-39-3	mg/kg	30	30	100	24	198	-	-	114	47	179	0	0	219	95% Normal UTL with 95% Coverage	219	95-95 UTL
Beryllium	7440-41-7	mg/kg	30	30	100	0.15	1.0	-	-	0.57	0.26	0.94	0	0	1.1	95% Normal UTL with 95% Coverage	1.1	95-95 UTL
Boron	7440-42-8	mg/kg	30	29	97	1.8	8.4	1.5	1.5	5.3	2.2	8.1	0	0	10	95% Normal UTL with 95% Coverage	10	95-95 UTL
Cadmium	7440-43-9	mg/kg	30	30	100	0.074	0.80	-	-	0.32	0.17	0.59	1	0 [d]	0.69	95% Normal UTL with 95% Coverage	0.69	95-95 UTL
Calcium	7440-70-2	mg/kg	30	30	100	845	25,100	-	-	5,806	4,855	15,235	3	0 [d]	20,528	95% Lognormal UTL with 95% Coverage	20,528	95-95 UTL
Chloride	16887-00-6	mg/kg	30	0	0	-	-	4.1	5.5	-	-	5.2	0	0	-	-	5.2	95th Percentile
Chromium	7440-47-3	mg/kg	30	30	100	3.0	17	-	-	10	4.0	16	0	0	19	95% Normal UTL with 95% Coverage	19	95-95 UTL
Cobalt	7440-48-4	mg/kg	30	30	100	2.2	10	-	-	5.6	2.1	8.3	0	0	10	95% Normal UTL with 95% Coverage	10	95-95 UTL
Copper	7440-50-8	mg/kg	30	30	100	2.2	24	-	-	12	6.1	21	0	0	26	95% Normal UTL with 95% Coverage	26	95-95 UTL
Fluoride	16984-48-8	mg/kg	30	29	97	0.86	5.4	0.83	0.83	2.6	1.5	5.3	0	0	5.8	95% Normal UTL with 95% Coverage	5.8	95-95 UTL
Lead	7439-92-1	mg/kg	30	30	100	3.7	28	-	-	13	6.6	27	1	0 [d]	28	95% Normal UTL with 95% Coverage	28	95-95 UTL
Lithium	7439-93-2	mg/kg	30	30	100	1.9	16	-	-	8.4	4.0	14	0	0	17	95% Normal UTL with 95% Coverage	17	95-95 UTL
Mercury	7439-97-6	mg/kg	30	12	40	0.015	0.19	0.013	0.088	0.065	0.057	0.13	0	0 [e]	0.13	95% Approx. Gamma UTL with 95% Coverage	0.13	95-95 UTL
Molybdenum	7439-98-7	mg/kg	30	29	97	0.27	1.7	0.18	0.18	0.70	0.29	1.1	1	0 [d]	1.3	95% Normal UTL with 95% Coverage	1.3	95-95 UTL
Nickel	7440-02-0	mg/kg	30	30	100	5.9	23	-	-	14	5.1	21	0	0	25	95% Normal UTL with 95% Coverage	25	95-95 UTL
Radium-226	13982-63-3	pCi/g	30	30	100	0.57	3.3	-	-	1.2	0.52	1.8	1	0 [d]	2.5	95% Approx. Gamma UTL with 95% Coverage	2.5	95-95 UTL
Radium-226+228	13982-63-3/ 15262-20-1	pCi/g	30	30	100	1.1	5.0	-	-	2.3	0.82	3.3	1	0 [d]	4.1	95% Normal UTL with 95% Coverage	4.1	95-95 UTL
Radium-228	15262-20-1	pCi/g	30	30	100	0.57	1.7	-	-	1.1	0.35	1.7	0	0	1.9	95% Normal UTL with 95% Coverage	1.9	95-95 UTL
Selenium	7782-49-2	mg/kg	30	30	100	0.27	1.3	-	-	0.75	0.28	1.1	0	0	1.4	95% Normal UTL with 95% Coverage	1.4	95-95 UTL
Silver	7440-22-4	mg/kg	30	23	77	0.038	1.3	0.029	0.034	0.20	0.28	0.58	6	0 [d]	1.3	Nonparametric 95% UTL with 95% Coverage	1.3	95-95 UTL
Sulfate	14808-79-8	mg/kg	30	23	77	9.3	215	7.2	8.3	38	45	91	4	0 [d]	183	95% Approx. Gamma UTL with 95% Coverage	183	95-95 UTL
Thallium	7440-28-0	mg/kg	30	28	93	0.056	0.56	0.11	0.24	0.27	0.14	0.54	0	0	0.57	95% Normal UTL with 95% Coverage	0.57	95-95 UTL
Vanadium	7440-62-2	mg/kg	30	30	100	5.8	26	-	-	16	6.5	26	0	0	26	Nonparametric 95% UTL with 95% Coverage	26	95-95 UTL
Zinc	7440-66-6	mg/kg	30	30	100	11	91	-	-	45	20	70	0	0	89	95% Normal UTL with 95% Coverage	89	95-95 UTL

Notes:

"-" - not applicable
% - percent
BTV - background threshold value
CAS - Chemical Abstracts Service registry number
mg/kg - milligrams per kilogram
pCi/g - picocuries per gram
RSL - regional screening level

[a] Potential outliers identified using visual inspection of quantile-quantile (QQ) plots were tested using Dixon's test or Rosner's test, which are available in ProUCL 5.1 (USEPA, 2016). Supporting information is included in Attachment A.

[b] 95% upper tolerance limit with 95% coverage (95-95 UTL) calculated using ProUCL 5.1 (USEPA, 2016). ProUCL outputs are provided in Attachment A.

[c] For detected analytes, the BTV is equal to the 95-95 UTL. For non-detect analytes, the BTV is equal to the 95th percentile of reporting limits.

[d] The variability in the background dataset, and the associated outlier, likely represent natural variability within an industrialized site. Based on existing knowledge that these data are from background sample locations, no outliers were removed from the background dataset.

[e] Due to the high number of non-detect results, the outlier analysis was conducted both with and without non-detect results. When non-detect results were excluded from the outlier test, no statistical outliers are present.

Table 4
Human Health Exposure Parameters for the Calculation of Soil RBSLs/PRGs
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

Parameter	Units	Hypothetical Future On-Site Industrial Worker [a]	Rationale	Hypothetical Future On-Site Construction/ Utility Worker [a]	Rationale
Standard Parameters					
BW = body weight	kg	na		80	USEPA, 2014[b]
EF = exposure frequency	days/year	250	USEPA, 2014[b]	60	Site-specific - 12 week excavation
ED = exposure duration	years	25	USEPA, 2014[b]	1	USEPA, 2002[c]
ATc = averaging time for carcinogens	days	na		25,550	70 year lifetime x 365 days/year
ATnc = averaging time for non-carcinogens	days	na		84	7 days/week for 12 weeks
Incidental Ingestion of Soil					
IR = soil ingestion rate	mg/day	100	USEPA, 2014[b]	330	USEPA, 2002[c]
RBA = relative bioavailability factor	unitless	na		0.6 for arsenic; 1.0 for other inorganics	USEPA, 2019a[d]
Dermal Contact with Soil					
SA = exposed skin surface area	cm^2	na		3,527	USEPA, 2014[b]
ABS_d = dermal absorption factor	unitless	na		0.03 for arsenic; 0.001 for cadmium; 1.0 for other inorganics	USEPA, 2004[e]
AF = soil adherence factor	mg/cm^2	na		0.3	USEPA, 2002[c]
Particulate Inhalation					
IRA = inhalation rate	m^3/day	60	USEPA, 2019b[f]	na	
ET = exposure time	hours/day	8	USEPA, 2014[b]	8	USEPA, 2014[b]
PEF = particulate emission factor	m^3/kg	3.11E+10	Site-specific[g]	4.81E+06	Site-specific[g]

Notes:

cm^2 - square centimeters
kg - kilogram(s)
mg/day - milligram(s) per day
m^3/day - cubic meter(s) per day
m^3/kg - cubic meter(s) per kilogram
mg/cm^2 - milligram(s) per square centimeter
na - not applicable
PRG - preliminary remediation goals
RBSL - Risk-based screening level
USEPA - United States Environmental Protection Agency

[a] Hypothetical future on-site industrial worker exposure parameters are only used to derive soil PRGs for radionuclides. Hypothetical future on-site construction/utility worker exposure parameters are used to derive soil RBSLs and PRGs for chemicals and radionuclides, respectively.

[b] USEPA, 2014 - Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER 9200.1-120. February 6, 2014.

[c] USEPA, 2002 - Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OWSWER 9355.4-24. December.

[d] USEPA, 2019a - USEPA Regional Screening Level for Chemical Contaminant at Superfund Sites. Accessed September. https://www.epa.gov/risk/regional-screening-levels-rsls

[e] USEPA, 2004 - Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. OSWER 9285.7-02EP. July.

[f] USEPA, 2019b - USEPA Preliminary Remediation Goals for Radionuclide Contaminants at Superfund Sites. Accessed September. https://epa-prgs.ornl.gov/radionuclides/

[g] The PEF calculations are provided in Attachment B, Tables B-5 and B-7.

Table 5
Derivation of Site-Specific Soil-to-Groundwater Soil Screening Levels for the Drinking Water Pathway East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority Memphis, Tennessee

		USEPA RSL Table-Based [a]			Site-Specific Soil-to-Groundwater SSL for the Protection of Groundwater DAF = 20 [d] (mg/kg or pCi/g)
Analyte	**CAS**	**Drinking Water Value [b] (mg/L or pCi/L)**		**Protection of Groundwater SSL [c] (mg/kg or pCi/g)**	
Antimony	7440-36-0	0.0060 [e]	MCL	0.27 [e]	5.4
Arsenic	7440-38-2	0.010	MCL	0.29	5.8
Barium	7440-39-3	2.0	MCL	82	1,648
Beryllium	7440-41-7	0.0040	MCL	3.2	63
Boron	7440-42-8	4.0	RSL	13	256
Cadmium	7440-43-9	0.0050	MCL	0.38	7.5
Calcium	7440-70-2	-	-	-	-
Chloride	16887-00-6	-	-	-	-
Chromium	7440-47-3	0.10	MCL	180,000	3,600,000
Cobalt	7440-48-4	0.0060	RSL	0.27	5.4
Copper	7440-50-8	1.3	MCL	46	916
Fluoride	16984-48-8	4.0	MCL	601	12,020
Lead	7439-92-1	0.015	MCL	14	270
Lithium	7439-93-2	0.040	RSL	12	240
Mercury	7439-97-6	0.0020 [f]	MCL	0.10	2.1
Molybdenum	7439-98-7	0.10	RSL	2.0	40
Nickel	7440-02-0	0.39 [g]	RSL	26 [g]	512
Radium-226	13982-63-3	0.00043	-	0.00000053	0.000011
Radium-226+228	13982-63-3/15262-20-1	0.0011	-	0.00000053	0.000011
Radium-228	15262-20-1	0.0011	-	0.0000013	0.000026
Selenium	7782-49-2	0.050	MCL	0.26	5.2
Silver	7440-22-4	0.094	RSL	0.80	16
Sulfate	14808-79-8	-	-	-	-
Thallium	7440-28-0	0.0020 [h]	MCL	0.14 [h]	2.8
Vanadium	7440-62-2	0.086	RSL	86	1,728
Zinc	7440-66-6	6.0	RSL	373	7,460

Notes:

"-" - not available
CAS - Chemical Abstracts Service registry number
MCL - maximum contaminant level
mg/kg - milligrams per kilogram
mg/L - milligrams per liter
pCi/g - picocuries per gram
pCi/L - picocuries per liter
RSL - regional screening level
SSL - soil screening level
USEPA - United States Environmental Protection Agency

Table 5
Derivation of Site-Specific Soil-to-Groundwater Soil Screening Levels for the Drinking Water Pathway
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

		USEPA RSL Table-Based [a]		Site-Specific Soil-to-Groundwater SSL for the Protection of Groundwater DAF = 20 [d] (mg/kg or pCi/g)
Analyte	**CAS**	**Drinking Water Value [b] (mg/L or pCi/L)**	**Protection of Groundwater SSL [c] (mg/kg or pCi/g)**	

[a] November 2019 USEPA RSL Table.

[b] MCLs are presented when MCLs are available. Where MCLs are not available, November 2019 USEPA tapwater RSLs based on a target carcinogenic risk and hazard quotient (HQ) of $1x10^{-6}$ and 1, respectively, are presented.

[c] MCL-based protection of groundwater SSL presented when a MCL is available for an analyte. Risk-based protection of groundwater SSLs are presented for all other analytes.

[d] A dilution attenuation factor (DAF) of 20 was used to adjust the default protection of groundwater SSLs (DAF=1). Site-specific soil-to-groundwater SSL (DAF=20) = Default SSL (DAF=1) * DAF of 20.

[e] RSL/SSL for antimony (metallic) presented.

[f] RSL for mercuric chloride used as a surrogate.

[g] RSL/SSL for nickel soluble salts presented.

[h] RSL/SSL for thallium soluble salts presented.

Table 6
Derivation of Site-Specific Soil-to-Groundwater Soil Screening Levels for the Protection of Surface Water Pathway
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

				Soil-to-Groundwater Conversion Factor [c]			
Analyte	CAS	Target Surface Water Screening Levels [a] (mg/L or pCi/L)	Target Groundwater Screening Levels Protective of Surface Water [b] (mg/L or pCi/L)	Protection of Groundwater SSL DAF = 20 (mg/kg or pCi/g)	Drinking Water Value (mg/L or pCi/L)	Groundwater SSL/ Drinking Water Ratio (L/kg)	Site-Specific SSLs for the Protection of Surface Water [d] (mg/kg or pCi/g)
Antimony	7440-36-0	0.19	31.7	5.4 [e]	0.0060 [e]	903	29,000
Arsenic	7440-38-2	0.010	1.7	5.8	0.010	584	973
Barium	7440-39-3	0.22	37	1,648	2.0	824	30,000
Beryllium	7440-41-7	0.011	1.83	63	0.0040	15,800	29,000
Boron	7440-42-8	7.2	1,200	256	4.0	64	77,000
Cadmium	7440-43-9	0.00072	0.12	7.5	0.0050	1,504	180
Calcium	7440-70-2	116	19,000	-	-	-	-
Chloride	16887-00-6	230	38,000	-	-	-	-
Chromium	7440-47-3	0.074	12	3,600,000	0.10	36,000,000	440,000,000
Cobalt	7440-48-4	0.019	3.2	5.4	0.0060	903	2,900
Copper	7440-50-8	0.0090	1.5	916	1.3	705	1,057
Fluoride	16984-48-8	2.7	450	12,020	4.0	3,005	1,400,000
Lead	7439-92-1	0.0025	0.42	270	0.015	18,000	7,600
Lithium	7439-93-2	0.44	73.3	240	0.040	6,000	440,000
Mercury	7439-97-6	0.000051	0.0085	2.1	0.0020 [f]	1,040	8.8
Molybdenum	7439-98-7	0.80	130	40	0.10	404	53,000
Nickel	7440-02-0	0.052	8.7	512 [g]	0.39 [g]	1,313	11,000
Radium-226	13982-63-3	8,110	1,400,000	0.000011	0.00043	0.025	34,000
Radium-226+228	13982-63-3/15262-20-1	6,780	1,100,000	0.000011	0.0011	0.0099	11,000
Radium-228	15262-20-1	6,780	1,100,000	0.000026	0.0011	0.024	26,000
Selenium	7782-49-2	0.0015	0.25	5.2	0.050	104	26
Silver	7440-22-4	0.000060	0.010	16	0.094	170	1.7
Sulfate	14808-79-8	-	-	-	-	-	-
Thallium	7440-28-0	0.00047	0.078	2.8 [h]	0.0020 [h]	1,420	111
Vanadium	7440-62-2	0.027	4.5	1,728	0.086	20,093	90,000
Zinc	7440-66-6	0.12	20	7,460	6.0	1,243	25,000

Table 6
Derivation of Site-Specific Soil-to-Groundwater Soil Screening Levels for the Protection of Surface Water Pathway
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

				Soil-to-Groundwater Conversion Factor [c]			
		Target Surface Water Screening Levels [a]	Target Groundwater Screening Levels Protective of Surface Water [b]	Protection of Groundwater SSL DAF = 20	Drinking Water Value	Groundwater SSL/ Drinking Water Ratio	Site-Specific SSLs for the Protection of Surface Water [d]
Analyte	**CAS**	**(mg/L or pCi/L)**	**(mg/L or pCi/L)**	**(mg/kg or pCi/g)**	**(mg/L or pCi/L)**	**(L/kg)**	**(mg/kg or pCi/g)**

Notes:

"-" - not available
CAS - Chemical Abstracts Service registry number
DAF - dilution attenuation factor
L/kg - liter per kilogram
MCL - maximum contaminant level
mg/kg - milligrams per kilogram
mg/L - milligrams per liter
pCi/g - picocuries per gram
pCi/L - picocuries per liter
RSL - regional screening level
SSL - soil screening level
USEPA - United States Environmental Protection Agency

[a] The target surface water screening levels are equal to the lowest recreational and ecological screening levels presented in Tables 7 and 8.

[b] Target groundwater screening levels protective of surface water as presented in Table 9.

[c] November 2019 USEPA tapwater RSL table-based screening levels as presented and derived in Table 5. MCLs are presented when MCLs are available. Where MCLs are not available, November 2019 USEPA tapwater RSLs based on a target carcinogenic risk and hazard quotient (HQ) of $1x10^{-6}$ and 1, respectively, are presented.

[d] USEPA's protection of groundwater SSLs are derived using the tapwater RSLs and a partitioning equation to model migration to groundwater from soil. A description of equations and parameters used can be found in USEPA's RSL User's Guide. Site-specific protection of surface water SSL provided herein are derived using the ratio between USEPA's tapwater RSL and protection of groundwater SSL as follows:

$$\text{Site−Specific SSL} = \text{Target Groundwater Screening Level} \times \text{Soil−to−Groundwater Conversion Factor}\left(\frac{\text{USEPA Protection of Groundwater SSL}}{\text{USEPA Drinking Water Value}}\right)$$

[e] RSL/SSL for antimony (metallic) presented.

[f] RSL for mercuric chloride used as a surrogate.

[g] RSL/SSL for nickel soluble salts presented.

[h] RSL/SSL for thallium soluble salts presented.

Table 7
Selection of Recreational Surface Water Screening Levels
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

			Recreational Screening Levels				Selected Recreational Surface Water Screening Levels [c]
Analyte	CAS	Units	TDEC Recreation Water and Organism Only [a]	TDEC Recreation Organism Only [a]	USEPA AWQC Consumption of Water and Organism Only [b]	USEPA AWQC Consumption of Organism Only [b]	
Antimony	7440-36-0	mg/L	0.0056	0.64	0.0056	0.64	0.64
Arsenic	7440-38-2	mg/L	0.010	0.010 [d]	0.000018	0.00014	0.010
Barium	7440-39-3	mg/L	-	-	1.0	-	-
Beryllium	7440-41-7	mg/L	-	-	-	-	-
Boron	7440-42-8	mg/L	-	-	-	-	-
Cadmium	7440-43-9	mg/L	-	-	-	-	-
Calcium	7440-70-2	mg/L	-	-	-	-	-
Chloride	16887-00-6	mg/L	-	-	-	-	-
Chromium	7440-47-3	mg/L	-	-	-	-	-
Cobalt	7440-48-4	mg/L	-	-	-	-	-
Copper	7440-50-8	mg/L	-	-	1.3	-	-
Fluoride	16984-48-8	mg/L	-	-	-	-	-
Lead	7439-92-1	mg/L	-	-	-	-	-
Lithium	7439-93-2	mg/L	-	-	-	-	-
Mercury	7439-97-6	mg/L	0.000050	0.000051	-	-	0.000051
Molybdenum	7439-98-7	mg/L	-	-	-	-	-
Nickel	7440-02-0	mg/L	0.61	4.6	0.61	4.6	4.6
Radium-226	13982-63-3	pCi/L	-	-	-	-	-
Radium-226+228	13982-63-3/15262-20-1	pCi/L	-	-	-	-	-
Radium-228	15262-20-1	pCi/L	-	-	-	-	-
Selenium	7782-49-2	mg/L	0.17	4.2	0.17	4.2	4.2
Silver	7440-22-4	mg/L	-	-	-	-	-
Sulfate	14808-79-8	mg/L	-	-	-	-	-
Thallium	7440-28-0	mg/L	0.00024	0.00047	0.00024	0.00047	0.00047
Vanadium	7440-62-2	mg/L	-	-	-	-	-
Zinc	7440-66-6	mg/L	7.4	26	7.4	26	26

Notes:

"-" - not available
AWQC - ambient water quality criteria
CAS - Chemical Abstracts Service registry number
mg/L - milligrams per liter
pCi/L - picocuries per liter
TDEC - Tennessee Department of Environment and Conservation
USEPA - United States Environmental Protection Agency

[a] Rules of the TDEC Chapter 0400-40-03 General Water Quality Criteria. Criteria for the use of recreation. September, 2019 (Revised). https://publications.tnsosfiles.com/rules/0400/0400-40/0400-40-03.20190911.pdf

[b] USEPA National Ambient Water Quality Criteria - Human Health Criteria Table. https://www.epa.gov/wqc/national-recommended-water-quality-criteria-human-health-criteria-table. Accessed September, 2019.

[c] Recreational surface water screening levels were selected using the following hierarchy:

1. TDEC Recreation Criteria - Organisms Only
2. USEPA AWQC - Organism Only

[d] TDEC assumed a target risk level of 1x10^{-5} for developing criteria for carcinogenic chemicals.

Table 8
Selection of Ecological Surface Water Screening Levels
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

			USEPA AWQC Aquatic Life CMC [a] (Acute)		USEPA AWQC Aquatic Life CCC [a] (Chronic)		Level I BCGs for Generic Aquatic Animals [b]		TDEC Fish and Aquatic Life CMC [c] (Acute)		TDEC Fish and Aquatic Life CCC [c] (Chronic)		USEPA Region 4 Freshwater Screening Level [d] (Acute)		USEPA Region 4 Freshwater Screening Level [d] (Chronic)		Selected Ecological Screening Level [e] (Acute)		Selected Ecological Screening Level [f] (Chronic)	
Analyte	**CAS**	**Units**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**
Antimony	7440-36-0	mg/L	-	-	-	-	-	-	-	-	-	-	-	0.90	-	0.19	-	0.90	-	0.19
Arsenic	7440-38-2	mg/L	0.34	0.34 [g]	0.15	0.15 [g]	-	-	0.34	-	0.15	-	0.34	0.34 [g]	0.15	0.15 [g]	0.34	0.34	0.15	0.15
Barium	7440-39-3	mg/L	-	-	-	-	-	-	-	-	-	-	-	2.0	-	0.22	-	2.0	-	0.22
Beryllium	7440-41-7	mg/L	-	-	-	-	-	-	-	-	-	-	-	0.093	-	0.011	-	0.093	-	0.011
Boron	7440-42-8	mg/L	-	-	-	-	-	-	-	-	-	-	-	34	-	7.2	-	34	-	7.2
Cadmium	7440-43-9	mg/L	0.0018	0.0019 [g, h]	0.00072	0.00079 [g, h]	-	-	0.0018	0.0019 [g, h]	0.00072	0.00079 [g, h]	0.00094	0.0010 [g, h]	0.00043	0.00045 [g, h]	0.0018	0.002	0.00072	0.0008
Calcium	7440-70-2	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	116	-	-	-	116
Chloride	16887-00-6	mg/L	860	860	230	230	-	-	-	-	-	-	-	860	-	230	860	860	230	230
Chromium	7440-47-3	mg/L	0.57	1.8 [g, i]	0.074	0.086 [g, i]	-	-	0.57	1.8 [g, j]	0.074	0.086 [g, j]	0.32	1.0 [g, i]	0.042	0.049 [g, i]	0.57	1.8	0.074	0.086
Cobalt	7440-48-4	mg/L	-	-	-	-	-	-	-	-	-	-	-	0.12	-	0.019	-	0.12	-	0.019
Copper	7440-50-8	mg/L	-	-	-	-	-	-	0.013	0.014 [g]	0.0090	0.0094 [g]	0.0070	0.0073 [g]	0.0050	0.0052 [g]	0.013	0.014	0.0090	0.0094
Fluoride	16984-48-8	mg/L	-	-	-	-	-	-	-	-	-	-	-	9.8	-	2.7	-	9.8	-	2.7
Lead	7439-92-1	mg/L	0.065	0.082 [g, h]	0.0025	0.0032 [g, h]	-	-	0.065	0.082 [g, h]	0.0025	0.0032 [g, h]	0.030	0.032 [g, h]	0.0012	0.0013 [g, h]	0.065	0.082	0.0025	0.0032
Lithium	7439-93-2	mg/L	-	-	-	-	-	-	-	-	-	-	-	0.91	-	0.44	-	0.91	-	0.44
Mercury	7439-97-6	mg/L	0.0014	0.0016 [g]	0.00077	0.00091 [g]	-	-	0.0014	-	0.00077	-	0.0014	0.0016 [g]	0.00077	0.00091 [g]	0.0014	0.002	0.00077	0.00091
Molybdenum	7439-98-7	mg/L	-	-	-	-	-	-	-	-	-	-	-	7.2	-	0.80	-	7.2	-	0.80
Nickel	7440-02-0	mg/L	0.47	0.47 [g]	0.052	0.052 [g]	-	-	0.47	0.47 [g]	0.052	0.052 [g]	0.26	0.26 [g]	0.029	0.029 [g]	0.47	0.47	0.052	0.052
Radium-226	13982-63-3	pCi/L	-	-	-	-	8,110	8,110	-	-	-	-	-	-	-	-	-	-	8,110	8,110
Radium-226+228	13982-63-3 /15262-20-1	pCi/L	-	-	-	-	6,780	6,780	-	-	-	-	-	-	-	-	-	-	6,780	6,780
Radium-228	15262-20-1	pCi/L	-	-	-	-	6,780	6,780	-	-	-	-	-	-	-	-	-	-	6,780	6,780
Selenium	7782-49-2	mg/L	-	-	0.0015	- [j]	-	-	0.020	-	0.0015	-	-	0.020	-	0.0050	0.020	0.020	0.0015	0.0050
Silver	7440-22-4	mg/L	0.0032	0.0038 [g]	-	-	-	-	0.0032	0.0038 [g]	-	-	0.00098	0.0012 [g]	0.000060	-	0.0032	0.004	0.000060	-
Sulfate	14808-79-8	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium	7440-28-0	mg/L	-	-	-	-	-	-	-	-	-	-	-	0.054	-	0.0060	-	0.054	-	0.0060
Vanadium	7440-62-2	mg/L	-	-	-	-	-	-	-	-	-	-	-	0.079	-	0.027	-	0.079	-	0.027
Zinc	7440-66-6	mg/L	0.12	0.12 [g]	0.12	0.12 [g]	-	-	0.12	0.12 [g]	0.12	0.12 [g]	0.065	0.067 [g]	0.066	0.067 [g]	0.12	0.12	0.12	0.12

Notes:

"-" - not available
AWQC - ambient water quality criteria
CAS - Chemical Abstracts Service registry number
CCC - criterion continuous concentration
CMC - criterion maximum concentration

DOE - Department of Energy
mg/L - milligrams per liter
pCi/L - picocuries per liter
TDEC - Tennessee Department of Environment and Conservation
USEPA - United States Environmental Protection Agency

[a] USEPA National Ambient Water Quality Criteria - Aquatic Life Criteria Table. https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table#table. Accessed September, 2019.

[b] Level 1 biota concentration guides (BCGs) for generic aquatic animals from RESRAD BIOTA 1.8 (DOE, 2016).

[c] Rules of the TDEC Chapter 0400-40-03 General Water Quality Criteria. Criteria for the use of fish and aquatic life. September, 2019 (Revised). https://publications.tnsosfiles.com/rules/0400/0400-40/0400-40-03.20190911.pdf

[d] USEPA Region 4 Surface Water Screening Values for Hazardous Waste Sites. Ecological Risk Assessment Supplemental Guidance. March, 2018 Update. https://www.epa.gov/risk/regional-ecological-risk-assessment-era-supplemental-guidance

[e] Acute ecological screening levels were selected using the following hierarchy:
1. TDEC Fish and Aquatic Life CMC (Acute)
2. USEPA AWQC Aquatic Life CMC (Acute)
3. USEPA Region 4 Freshwater Screening Level (Acute)

[f] Chronic ecological screening levels were selected using the following hierarchy:
1. TDEC Fish and Aquatic Life CCC (Chronic)
2. USEPA AWQC Aquatic Life CCC (Chronic)
3. USEPA Region 4 Freshwater Screening Level (Chronic)

[g] Total or dissolved screening levels derived using published total or dissolved values and conversion factors from the respective sources.

[h] Criteria are hardness-dependent. USEPA AWQC and TDEC fish and aquatic life criteria were normalized to a hardness of 100 mg/L as $CaCO_3$. USEPA Region 4 freshwater screening levels were normalized to a hardness of 50 mg/L as calcium carbonate ($CaCO_3$).

[i] Chromium (III) used as a surrogate.

[j] USEPA Office of Water. Final Criterion: Aquatic Life Ambient Water Quality Criterion for Selenium - Freshwater. 30 June 2016. Accessed September 2019. Freshwater value for chronic (30 day) water column concentration of dissolved selenium in lentic (still) surface water. https://www.epa.gov/sites/production/files/2016-07/documents/aquatic_life_awqc_for_selenium_-_freshwater_2016.pdf

Table 9
Derivation of Target Groundwater Screening Levels Protective of Surface Water
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

			Surface Water Screening Levels						Target Groundwater Screening Levels
			Human Health [a]	Ecological (Acute) [b]		Ecological (Chronic) [b]			
Analyte	CAS	Units	Recreational Surface Water	Dissolved	Total	Dissolved	Total	Target Surface Water Screening Level [c]	Groundwater Screening Levels Protective of Surface Water [d]
Antimony	7440-36-0	mg/L	0.64	-	0.90	-	0.19	0.19	32
Arsenic	7440-38-2	mg/L	0.010	0.34	0.34	0.15	0.15	0.010	1.7
Barium	7440-39-3	mg/L	-	-	2.0	-	0.22	0.22	37
Beryllium	7440-41-7	mg/L	-	-	0.093	-	0.011	0.011	1.8
Boron	7440-42-8	mg/L	-	-	34	-	7.2	7.2	1,200
Cadmium	7440-43-9	mg/L	-	0.0018	0.0019	0.00072	0.00079	0.00072	0.12
Calcium	7440-70-2	mg/L	-	-	-	-	116	116	19,000
Chloride	16887-00-6	mg/L	-	860	860	230	230	230	38,000
Chromium	7440-47-3	mg/L	-	0.57	1.8	0.074	0.086	0.074	12
Cobalt	7440-48-4	mg/L	-	-	0.12	-	0.019	0.019	3.2
Copper	7440-50-8	mg/L	-	0.013	0.014	0.0090	0.0094	0.0090	1.5
Fluoride	16984-48-8	mg/L	-	-	9.8	-	2.7	2.7	450
Lead	7439-92-1	mg/L	-	0.065	0.082	0.0025	0.0032	0.0025	0.42
Lithium	7439-93-2	mg/L	-	-	0.91	-	0.44	0.44	73
Mercury	7439-97-6	mg/L	0.000051	0.0014	0.0016	0.00077	0.00091	0.000051	0.0085
Molybdenum	7439-98-7	mg/L	-	-	7.2	-	0.80	0.80	130
Nickel	7440-02-0	mg/L	4.6	0.47	0.47	0.052	0.052	0.052	8.7
Radium-226	13982-63-3	pCi/L	-	-	-	8,110	8,110	8,110	1,400,000
Radium-226+228	13982-63-3/15262-20-1	pCi/L	-	-	-	6,780	6,780	6,780	1,100,000
Radium-228	15262-20-1	pCi/L	-	-	-	6,780	6,780	6,780	1,100,000
Selenium	7782-49-2	mg/L	4.2	0.020	0.020	0.0015	0.0050	0.0015	0.25
Silver	7440-22-4	mg/L	-	0.0032	0.0038	0.000060	-	0.000060	0.010
Sulfate	14808-79-8	mg/L	-	-	-	-	-	-	-
Thallium	7440-28-0	mg/L	0.00047	-	0.054	-	0.0060	0.00047	0.078
Vanadium	7440-62-2	mg/L	-	-	0.079	-	0.027	0.027	4.5
Zinc	7440-66-6	mg/L	26	0.12	0.12	0.12	0.12	0.12	20

Notes:

"-" - not available
CAS - Chemical Abstracts Service registry number
mg/L - milligrams per liter
pCi/L - picocuries per liter

[a] Selected recreational surface water screening levels as presented in Table 7.

[b] Selected ecological screening levels as presented in Table 8.

[c] The target surface water screening levels are equal to the lowest presented human health and ecological screening levels.

[d] Target groundwater screening level based on surface water exposure is equal to the target surface water screening levels adjusted with a dilution attenuation factor (DAF) of 166.67 for discharge to McKellar Lake from the East Ash Disposal Area.

Table 10
Groundwater Screening Levels Summary Table
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

Analyte	CAS	Units	Groundwater Screening Levels Protective of Drinking Water [a]	Groundwater Screening Levels Protective of Surface Water [b]
Antimony	7440-36-0	mg/L	0.0060	32
Arsenic	7440-38-2	mg/L	0.010	1.7
Barium	7440-39-3	mg/L	2.0	37
Beryllium	7440-41-7	mg/L	0.0040	1.8
Boron	7440-42-8	mg/L	4.0	1,200
Cadmium	7440-43-9	mg/L	0.0050	0.12
Calcium	7440-70-2	mg/L	-	19,000
Chloride	16887-00-6	mg/L	250	38,000
Chromium	7440-47-3	mg/L	0.10	12
Cobalt	7440-48-4	mg/L	0.0060	3.2
Copper	7440-50-8	mg/L	1.3	1.5
Fluoride	16984-48-8	mg/L	4.0	450
Lead	7439-92-1	mg/L	0.0050	0.42
Lithium	7439-93-2	mg/L	0.040	73
Mercury	7439-97-6	mg/L	0.0020	0.0085
Molybdenum	7439-98-7	mg/L	0.10	130
Nickel	7440-02-0	mg/L	0.10	8.7
Radium-226	13982-63-3	pCi/L	0.00043	1,400,000
Radium-226+228	13982-63-3/15262-20-1	pCi/L	5.0	1,100,000
Radium-228	15262-20-1	pCi/L	0.00107	1,100,000
Selenium	7782-49-2	mg/L	0.050	0.25
Silver	7440-22-4	mg/L	0.094	0.010
Sulfate	14808-79-8	mg/L	250	-
Thallium	7440-28-0	mg/L	0.0020	0.078
Vanadium	7440-62-2	mg/L	0.086	4.5
Zinc	7440-66-6	mg/L	6.0	20

Notes:

"-" - not available
CAS - Chemical Abstracts Service registry number
mg/L - milligrams per liter
pCi/L - picocuries per liter

[a] Selected potable groundwater screening levels as presented in Table 11.

[b] Target groundwater screening levels as presented in Table 9.

Table 11
Selection of Potable Groundwater Screening Levels
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

			Potable Water Screening Levels				Selected Potable Groundwater Screening Levels [e]
Analyte	**CAS**	**Units**	**TDEC Domestic Water Supply [a]**	**USEPA MCL [b]**	**USEPA Tapwater RSL / PRG [c]**	**USEPA SMCL [d]**	
Antimony	7440-36-0	mg/L	0.0060	0.0060	0.0078	-	0.0060
Arsenic	7440-38-2	mg/L	0.010	0.010	0.000052	-	0.010
Barium	7440-39-3	mg/L	2.0	2.0	3.8	-	2.0
Beryllium	7440-41-7	mg/L	0.0040	0.0040	0.025	-	0.0040
Boron	7440-42-8	mg/L	-	-	4.0	-	4.0
Cadmium	7440-43-9	mg/L	0.0050	0.0050	0.0092	-	0.0050
Calcium	7440-70-2	mg/L	-	-	-	-	-
Chloride	16887-00-6	mg/L	-	-	-	250	250
Chromium	7440-47-3	mg/L	0.10	0.10	22 [f]	-	0.10
Cobalt	7440-48-4	mg/L	-	-	0.0060	-	0.0060
Copper	7440-50-8	mg/L	-	1.3 [g]	0.80	1.0	1.3
Fluoride	16984-48-8	mg/L	-	4.0	0.80	2.0	4.0
Lead	7439-92-1	mg/L	0.0050	0.015 [g]	0.015	-	0.0050
Lithium	7439-93-2	mg/L	-	-	0.040	-	0.040
Mercury	7439-97-6	mg/L	0.0020	0.0020 [h]	0.0057 [i]	-	0.0020
Molybdenum	7439-98-7	mg/L	-	-	0.10	-	0.10
Nickel	7440-02-0	mg/L	0.10	-	0.39	-	0.10
Radium-226	13982-63-3	pCi/L	-	-	0.00043	-	0.00043
Radium-226+228	13982-63-3/15262-20-1	pCi/L	-	5.0	0.0011 [j]	-	5.0
Radium-228	15262-20-1	pCi/L	-	-	0.0011	-	0.0011
Selenium	7782-49-2	mg/L	0.050	0.050	0.10	-	0.050
Silver	7440-22-4	mg/L	-	-	0.094	0.10	0.094
Sulfate	14808-79-8	mg/L	-	-	-	250	250
Thallium	7440-28-0	mg/L	0.0020	0.0020	0.00020	-	0.0020
Vanadium	7440-62-2	mg/L	-	-	0.086	-	0.086
Zinc	7440-66-6	mg/L	-	-	6.0	5.0	6.0

Notes:

"-" - not available
CAS - Chemical Abstracts Service registry number
MCL - maximum contaminant level
mg/L - milligrams per liter
pCi/L - picocuries per liter
PRG - preliminary remediation goal
RSL - regional screening level
SMCL - secondary maximum contaminant level
TDEC - Tennessee Department of Environment and Conservation
USEPA - United States Environmental Protection Agency

[a] Rules of the TDEC Chapter 0400-40-03 General Water Quality Criteria. Criteria for the use of domestic water supply. September, 2019 (Revised). https://publications.tnsosfiles.com/rules/0400/0400-40/0400-40-03.20190911.pdf

[b] USEPA National Primary Drinking Water Regulation MCLs. Accessed September, 2019. https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

[c] November 2019 USEPA tapwater RSLs based on a target carcinogenic risk and noncancer hazard quotient (HQ) of $1x10^{-6}$ and 1, respectively. PRGs for radionuclides developed using the PRG calculator for a default residential tap water scenario and a target carcinogenic risk of $1x10^{-6}$ as presented in Attachment B.

[d] USEPA National Secondary Drinking Water Regulation secondary MCLs. Accesed September 2019. https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals

[e] Potable groundwater screening levels were selected using the following hierarchy:

1. TDEC General Water Quality Criteria - Domestic Water Supply
2. USEPA MCL
3. USEPA Tapwater RSL
4. USEPA SMCL

[f] Chromium (III) used as a surrogate.

[g] Copper and lead action levels.

[h] MCL for inorganic mercury.

[i] RSL for mercuric chloride used as a surrogate.

[j] PRG for Radium-228 used as a surrogate.

Table 12
Soil Screening Levels for Tiered Risk Based Closure Approach
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

		Soil Tier:	*Direct Contact and S-GW Tier 1*	*Direct Contact Tier 2*	*Direct Contact Tier 3*	*S-GW Tier 2a*	*S-GW Tier 2b*
Analyte	**CAS**	**Units**	**Background Threshold Value [a]**	**Industrial Soil RSL / PRG [b]**	**Hypothetical Future On-Site Construction/ Utility Worker RBSL / PRG [c]**	**Site-Specific Soil-to-Groundwater SSL for the Protection of Groundwater DAF = 20 [d]**	**Site-Specific Soil-to-Groundwater SSL for the Protection of Surface Water [e]**
Antimony	7440-36-0	mg/kg	0.63	470 [f]	136	5.4	29,000
Arsenic	7440-38-2	mg/kg	9.6	300	99	5.8	973
Barium	7440-39-3	mg/kg	219	220,000	40,600	1,648	30,000
Beryllium	7440-41-7	mg/kg	1.1	2,300	326	63	29,000
Boron	7440-42-8	mg/kg	10	230,000	58,100	256	77,000
Cadmium	7440-43-9	mg/kg	0.69	980	121	7.5	180
Calcium	7440-70-2	mg/kg	20,528	-	-	-	-
Chloride	16887-00-6	mg/kg	5.2	-	-	-	-
Chromium	7440-47-3	mg/kg	19	1,800,000 [g]	509,000	3,600,000	440,000,000
Cobalt	7440-48-4	mg/kg	10	350	289	5.4	2,900
Copper	7440-50-8	mg/kg	26	47,000	13,600	916	1,057
Fluoride	16984-48-8	mg/kg	5.8	47,000	12,900	12,020	1,400,000
Lead	7439-92-1	mg/kg	28	800	- [h]	270	7,600
Lithium	7439-93-2	mg/kg	17	2,300	679	240	440,000
Mercury	7439-97-6	mg/kg	0.13	350 [i]	610	2.1	8.8
Molybdenum	7439-98-7	mg/kg	1.3	5,800	1,700	40	53,000
Nickel	7440-02-0	mg/kg	25	22,000 [j]	2,530	512	11,000
Radium-226	13982-63-3	pCi/g	2.5	0.020	2.1	0.000011	34,000
Radium-226+228	13982-63-3/15262-20-1	pCi/g	4.1	0.015 [k]	1.6 [k]	0.000011	11,000
Radium-228	15262-20-1	pCi/g	1.9	0.015	1.6	0.000026	26,000
Selenium	7782-49-2	mg/kg	1.4	5,800	1,690	5.2	26
Silver	7440-22-4	mg/kg	1.3	5,800	1,700	16	1.7
Sulfate	14808-79-8	mg/kg	183	-	-	-	-
Thallium	7440-28-0	mg/kg	0.57	12 [l]	14	2.8	111
Vanadium	7440-62-2	mg/kg	26	5,800	1,270	1,728	90,000
Zinc	7440-66-6	mg/kg	89	350,000	102,000	7,460	25,000

Table 12
Soil Screening Levels for Tiered Risk Based Closure Approach
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

		Soil Tier:	*Direct Contact and S-GW Tier 1*	*Direct Contact Tier 2*	*Direct Contact Tier 3*	*S-GW Tier 2a*	*S-GW Tier 2b*
Analyte	**CAS**	**Units**	**Background Threshold Value [a]**	**Industrial Soil RSL / PRG [b]**	**Hypothetical Future On-Site Construction/ Utility Worker RBSL / PRG [c]**	**Site-Specific Soil-to-Groundwater SSL for the Protection of Groundwater DAF = 20 [d]**	**Site-Specific Soil-to-Groundwater SSL for the Protection of Surface Water [e]**

Notes:

"-" - not available
CAS - Chemical Abstracts Service registry number
DAF - dilution attenuation factor
mg/kg - milligrams per kilogram
pCi/g - picocuries per gram
PRG - preliminary remediation goal
RBSL - risk-based screening level
RSL - regional screening level
S-GW - soil to groundwater
SSL - soil screening level
USEPA - United States Environmental Protection Agency

[a] Background threshold value as presented in Table 3.

[b] November 2019 USEPA RSLs for industrial soil based on a target carcinogenic risk and noncancer hazard quotient (HQ) of 1x10^{-4} and 1, respectively. PRGs for radionuclides developed using the PRG calculator for a default composite worker scenario and a target carcinogenic risk of 1x10^{-4} as presented in

[c] Soil RBSLs for a hypothetical future on-site construction/utility worker based on a target carcinogenic risk and noncancer HQ of 1x10^{-4} and 1, respectively, derived using the exposure assumptions presented in Table 4 and toxicity values and equations presented in Attachment B. PRGs for radionuclides developed using the PRG calculator for the construction worker soil - other construction activities scenario with the exposure assumptions presented in Table 4 and a target carcinogenic risk of 1x10^{-4} as presented in Attachment B.

[d] Site-specific soil-to-groundwater SSL for protection of groundwater as presented in Table 5.

[e] Site-specific soil-to-groundwater SSL for the protection of surface water as presented in Table 6.

[f] RSL for antimony (metallic) presented.

[g] RSL for chromium (III) used as a surrogate.

[h] USPEA Industrial Soil RSL value used.

[i] RSL for mercuric chloride used as a surrogate.

[j] RSL for nickel soluble salts presented.

[k] PRG for radium-228 used as a surrogate.

[l] RSL for thallium soluble salts presented.

FIGURES

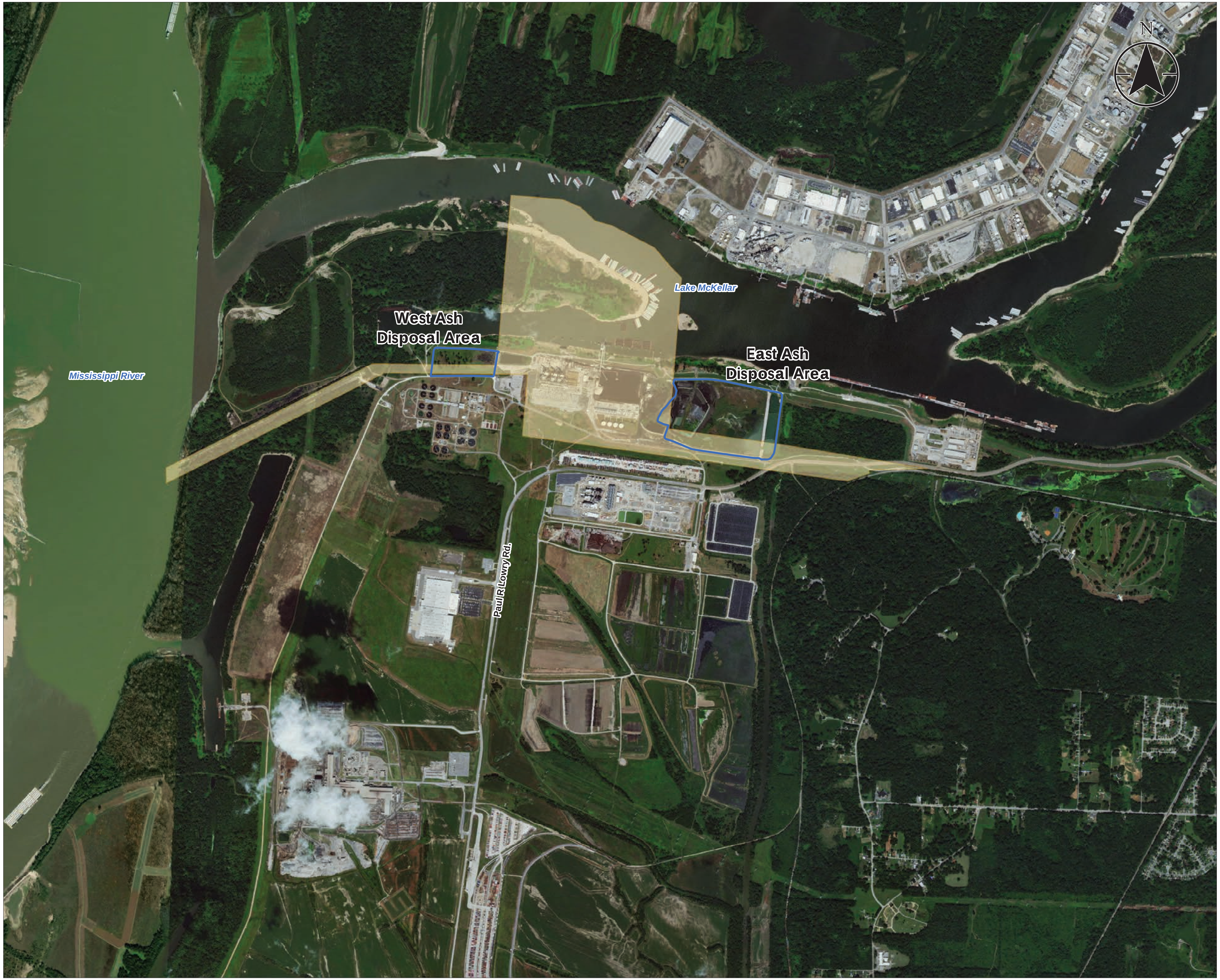

Figure No.
1

Title

Facility Location

Client/Project

Tennessee Valley Authority
Allen Fossil Plant

Project Location
Memphis, Tennessee

175568282
Prepared by LMB on 2020-02-27
Technical Review by BT on 2020-02-27

0 1,000 2,000 3,000 4,000 Feet

1:12,000 (At original document size of 22x34)

Legend

▭	East & West Ash Disposal Area
▨	TVA Property Boundary

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA dated 3/15/2018 and 6/4/2019

Stantec
TVA

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Figure No.
2

Title

Coal Ash Mangement Units

Client/Project
Tennessee Valley Authority
Allen Fossil Plant

Project Location
Memphis, Tennessee

175568282
Prepared by LMB on 2020-02-27
Technical Review by BT on 2020-02-27

0 400 800 1,200 1,600 Feet

1:3,600 (At original document size of 22x34)

Legend

▭	East & West Ash Disposal Area
▭	2019 Imagery Boundary
▨	TVA Property Boundary

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA dated 3/15/2018 and 6/4/2019

Stantec TVA

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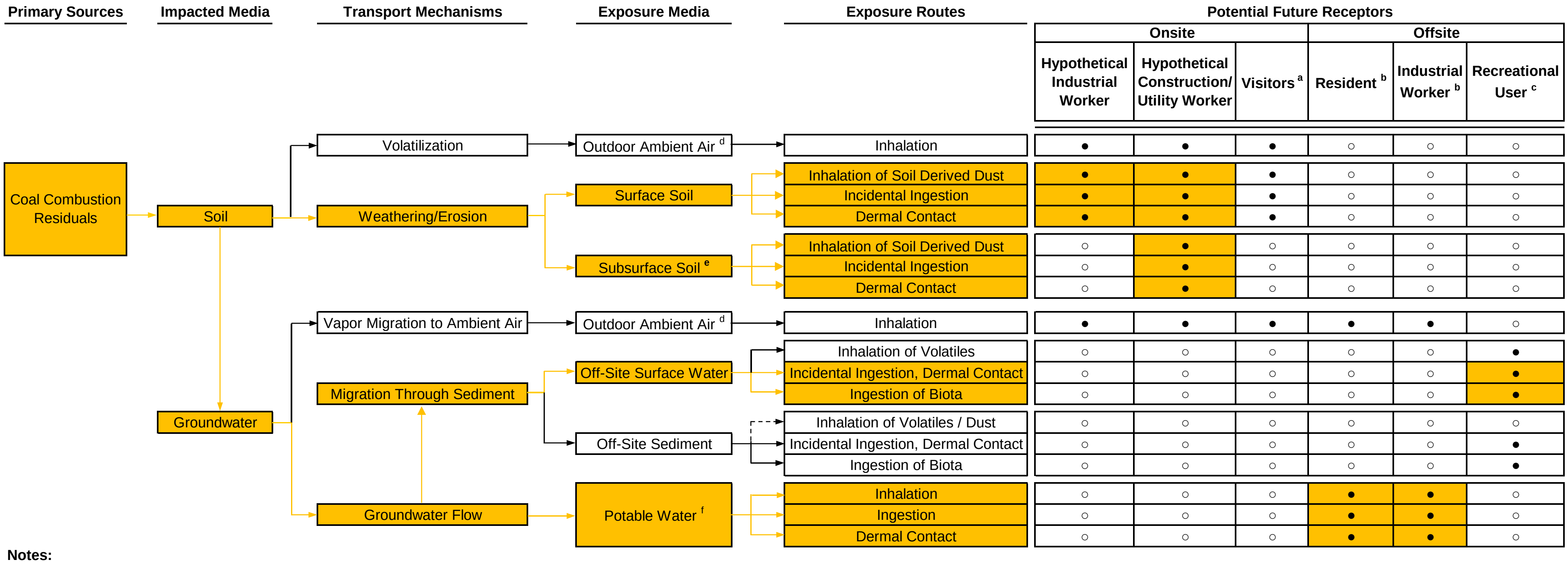
Figure 3
Human Health Conceptual Site Model
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee



Exposure Media	Exposure Routes	Potential Future Receptors					
		Onsite			Offsite		
		Hypothetical Industrial Worker	Hypothetical Construction/ Utility Worker	Visitors[a]	Resident[b]	Industrial Worker[b]	Recreational User[c]
Outdoor Ambient Air[d]	Inhalation	●	●	●	○	○	○
Surface Soil	Inhalation of Soil Derived Dust	●	●	●	○	○	○
	Incidental Ingestion	●	●	●	○	○	○
	Dermal Contact	●	●	●	○	○	○
Subsurface Soil[e]	Inhalation of Soil Derived Dust	○	●	○	○	○	○
	Incidental Ingestion	○	●	○	○	○	○
	Dermal Contact	○	●	○	○	○	○
Outdoor Ambient Air[d]	Inhalation	●	●	●	●	●	○
Off-Site Surface Water	Inhalation of Volatiles	○	○	○	○	○	●
	Incidental Ingestion, Dermal Contact	○	○	○	○	○	●
	Ingestion of Biota	○	○	○	○	○	●
Off-Site Sediment	Inhalation of Volatiles / Dust	○	○	○	○	○	○
	Incidental Ingestion, Dermal Contact	○	○	○	○	○	●
	Ingestion of Biota	○	○	○	○	○	●
Potable Water[f]	Inhalation	○	○	○	●	●	○
	Ingestion	○	○	○	●	●	○
	Dermal Contact	○	○	○	●	●	○

Notes:

→ Complete Exposure Pathway
→ Potentially Complete but Insignificant Pathway
⇢ Incomplete Pathway

● Complete Exposure Pathway
● Potentially Complete but Insignificant Pathway
○ Incomplete Exposure Pathway

[a] Site visitors include receptors that are only onsite briefly. As a result, exposure to site media are either incomplete or potentially complete but insignificant.

[b] No industrial or residential land uses occur in the immediate vicinity of Allen Fossil Plant where wind transport of residual soil or ash from the East Ash Disposal Area could be of significant concern. As a result, offsite residents and industrial workers are limited to those receptors with potential exposure to Memphis Aquifer groundwater.

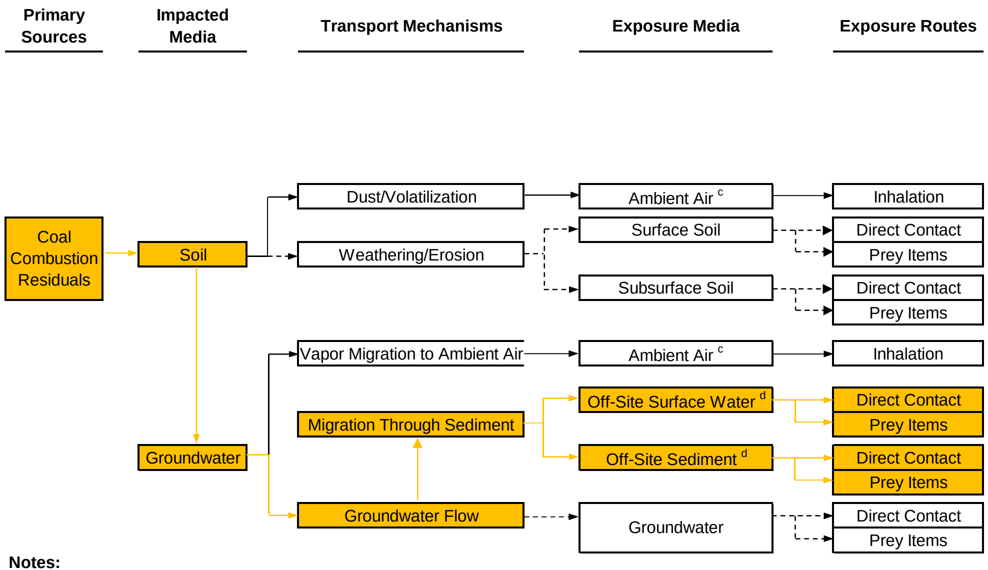
[c] Recreational users are assumed to use the McKellar Lake for recreational activities including the capture and subsequent consumption of aquatic biota (e.g., fish).

[d] If radium is present in soil and groundwater, volatilization of radon from soil and groundwater to ambient air is a potentially complete but insignificant exposure pathway because exposure to ambient air is only a minor pathway when compared to other potentially complete exposure pathways.

[e] Subsurface soil is only a potential exposure medium for hypothetical future construction/utility workers to account for possible future construction/utility activities. Hypothetical future onsite industrial workers are unlikely to be exposed to

[f] Migration of constituents in soil to the Alluvial aquifer and through the upper Claiborne Confining unit to the Memphis Aquifer is highly unlikely as described in Section 3.2. However, this potential migration pathway was conservatively assumed to be complete. As a result, exposure to site-related constituents in potable groundwater is potentially complete for offsite residential and industrial receptors.

Figure 4
Ecological Conceptual Site Model
East Ash Disposal Area, Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee



Receptors

Exposure Media	Exposure Routes	Terrestrial [a]				Aquatic					
		Plants	Invertebrates	Birds	Mammals [b]	Water Column Community	Benthic Invertebrates	Amphibians	Plants	Aquatic Dependent Birds	Aquatic Dependent Mammals
Ambient Air [c]	Inhalation	○	○	●	●	○	○	○	○	○	○
Surface Soil	Direct Contact	○	○	○	○	○	○	○	○	○	○
	Prey Items	○	○	○	○	○	○	○	○	○	○
Subsurface Soil	Direct Contact	○	○	○	○	○	○	○	○	○	○
	Prey Items	○	○	○	○	○	○	○	○	○	○
Ambient Air [c]	Inhalation	○	○	●	●	○	○	○	○	○	○
Off-Site Surface Water [d]	Direct Contact	○	○	○	○	🟨●	🟨●	🟨●	🟨●	🟨●	🟨●
	Prey Items	○	○	○	○	🟨●	○	🟨●	○	🟨●	🟨●
Off-Site Sediment [d]	Direct Contact	○	○	○	○	○	🟨●	🟨●	🟨●	🟨●	🟨●
	Prey Items	○	○	○	○	○	🟨●	🟨●	○	🟨●	🟨●
Groundwater	Direct Contact	○	○	○	○	○	○	○	○	○	○
	Prey Items	○	○	○	○	○	○	○	○	○	○

Notes:

🟨→	Complete Exposure Pathway
→	Potentially Complete but Insignificant Pathway
- - -→	Incomplete Pathway

🟨●	Complete Exposure Pathway
●	Potentially Complete but Insignificant Pathway
○	Incomplete Exposure Pathway

[a] The reasonably foreseeable future land use of the Allen Fossil Plant (ALF) is industrial/commercial. Wildlife communities associated with developed portions of the ALF generally consist of more common species that can easily adapt to disturbed or altered habitats. Therefore, these areas are not expected to routinely support unique or rare wildlife species.

[b] The ALF is surrounded by a chain link security fence, and as a result, only small mammals are expected to be present within the ALF. Following excavation and back-filling of the East Ash Disposal Area, potential exposure pathways between onsite terrestrial receptors and residual CCR constituents in soil are incomplete or potentially complete but insignificant.

[c] The inhalation pathway is minor relative to the incidental ingestion pathway and there is a lack of relevant toxicological information to evaluate the inhalation pathway in ecological receptors.

[d] Potential exposure to surface water and sediment in McKellar Lake.

Figure No.
5

Title

Background Soil Sampling Locations

Client/Project

Tennessee Valley Authority
Allen Fossil Plant

Project Location

Memphis, Tennessee

175568282
Prepared by LMB on 2020-02-27
Technical Review by BT on 2020-02-27

0 400 800 1,200 1,600
Feet

1:4,800 (At original document size of 22x34)

Legend

●	Background Soil Sample Location (Survey 9/10/2019 & 02/14/2020)
▭	East & West Ash Disposal Area
▭	2019 Imagery Boundary
▨	TVA Property Boundary

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA dated 3/15/2018 and 6/4/2019
3. Background soil sampling locations surveyed by the R.L.S. Group on September 10, 2019 & February 14th, 2020

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ATTACHMENTS

Attachment A
Risk-Based Screening Level Calculations

```
                                    Background Statistics for Data Sets with Non-Detects
                      User Selected Options
             Date/Time of Computation   ProUCL 5.110/14/2019 2:06:15 PM
                            From File   ProUCL_Input_Chem.xls
                       Full Precision   OFF
               Confidence Coefficient   95%
                             Coverage   95%
      Different or Future K Observations   1
          Number of Bootstrap Operations   2000

 Antimony

                                                  General Statistics
                  Total Number of Observations   30                     Number of Missing Observations   0
               Number of Distinct Observations   29
                             Number of Detects   29                              Number of Non-Detects   1
                    Number of Distinct Detects   28                     Number of Distinct Non-Detects   1
                                Minimum Detect   0.0696                            Minimum Non-Detect   0.0775
                                Maximum Detect    0.716                            Maximum Non-Detect   0.0775
                             Variance Detected   0.0229                           Percent Non-Detects   3.333%
                                 Mean Detected    0.298                                   SD Detected    0.151
                   Mean of Detected Logged Data  -1.351                        SD of Detected Logged Data    0.574

                                    Critical Values for Background Threshold Values (BTVs)
                     Tolerance Factor K (For UTL)   2.22                                d2max (for USL)    2.745

                                              Normal GOF Test on Detects Only
                      Shapiro Wilk Test Statistic   0.948                   Shapiro Wilk GOF Test
                   5% Shapiro Wilk Critical Value   0.926     Detected Data appear Normal at 5% Significance Level
                         Lilliefors Test Statistic   0.121                    Lilliefors GOF Test
                      5% Lilliefors Critical Value   0.161     Detected Data appear Normal at 5% Significance Level
                                   Detected Data appear Normal at 5% Significance Level

                              Kaplan Meier (KM) Background Statistics Assuming Normal Distribution
                                          KM Mean   0.291                                         KM SD    0.152
                             95% UTL95% Coverage   0.628                               95% KM UPL (t)    0.553
                            90% KM Percentile (z)   0.485                         95% KM Percentile (z)    0.54
                            99% KM Percentile (z)   0.644                                    95% KM USL    0.707

                              DL/2 Substitution Background Statistics Assuming Normal Distribution
                                             Mean   0.29                                             SD    0.156
                             95% UTL95% Coverage   0.636                                  95% UPL (t)    0.559
                               90% Percentile (z)   0.49                            95% Percentile (z)    0.546
                               99% Percentile (z)   0.653                                       95% USL    0.718
                  DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons
```

```
                                Gamma GOF Tests on Detected Observations Only
                        A-D Test Statistic     0.413                  Anderson-Darling GOF Test
                     5% A-D Critical Value     0.751    Detected data appear Gamma Distributed at 5% Significance Level
                        K-S Test Statistic     0.143                  Kolmogorov-Smirnov GOF
                     5% K-S Critical Value     0.164    Detected data appear Gamma Distributed at 5% Significance Level
                          Detected data appear Gamma Distributed at 5% Significance Level

                                     Gamma Statistics on Detected Data Only
                               k hat (MLE)     3.704                       k star (bias corrected MLE)     3.344
                           Theta hat (MLE)     0.0805                  Theta star (bias corrected MLE)     0.0892
                              nu hat (MLE)     214.8                           nu star (bias corrected)    193.9
                    MLE Mean (bias corrected)  0.298
                      MLE Sd (bias corrected)  0.163               95% Percentile of Chisquare (2kstar)    13.61

                                  Gamma ROS Statistics using Imputed Non-Detects
               GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
       GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)
                      For such situations, GROS method may yield incorrect values of UCLs and BTVs
                                   This is especially true when the sample size is small.
             For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates
                                   Minimum     0.0622                                            Mean     0.29
                                   Maximum     0.716                                           Median     0.286
                                        SD     0.155                                               CV     0.533
                               k hat (MLE)     3.246                       k star (bias corrected MLE)     2.944
                           Theta hat (MLE)     0.0895                  Theta star (bias corrected MLE)     0.0987
                              nu hat (MLE)     194.8                           nu star (bias corrected)    176.6
                    MLE Mean (bias corrected)  0.29                             MLE Sd (bias corrected)    0.169
        95% Percentile of Chisquare (2kstar)   12.42                                   90% Percentile     0.517
                            95% Percentile     0.613                                   99% Percentile     0.82
                    The following statistics are computed using Gamma ROS Statistics on Imputed Data
                        Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods
                                        WH        HW                                        WH        HW
  95% Approx. Gamma UTL with 95% Coverage     0.769     0.805         95% Approx. Gamma UPL     0.625     0.642
                            95% Gamma USL     0.946     1.011

                                   Estimates of Gamma Parameters using KM Estimates
                                 Mean (KM)     0.291                                          SD (KM)     0.152
                             Variance (KM)     0.0231                                 SE of Mean (KM)     0.0282
                                k hat (KM)     3.666                                       k star (KM)     3.321
                               nu hat (KM)     219.9                                       nu star (KM)    199.3
                            theta hat (KM)     0.0793                                   theta star (KM)    0.0875
                  80% gamma percentile (KM)    0.41                         90% gamma percentile (KM)     0.505
                  95% gamma percentile (KM)    0.593                        99% gamma percentile (KM)     0.783
```

```
                    The following statistics are computed using gamma distribution and KM estimates
                     Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods
                                              WH        HW                                          WH        HW
   95% Approx. Gamma UTL with 95% Coverage    0.753     0.786                  95% Approx. Gamma UPL    0.614     0.63
              95% KM Gamma Percentile         0.593     0.607                        95% Gamma USL    0.923     0.983

                                 Lognormal GOF Test on Detected Observations Only
                       Shapiro Wilk Test Statistic    0.947                 Shapiro Wilk GOF Test
                    5% Shapiro Wilk Critical Value    0.926    Detected Data appear Lognormal at 5% Significance Level
                        Lilliefors Test Statistic     0.179                  Lilliefors GOF Test
                       5% Lilliefors Critical Value   0.161         Data Not Lognormal at 5% Significance Level
                          Detected Data appear Approximate Lognormal at 5% Significance Level

           Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects
                           Mean in Original Scale     0.291                               Mean in Log Scale    -1.39
                             SD in Original Scale     0.154                                 SD in Log Scale     0.604
                          95% UTL95% Coverage         0.953                       95% BCA UTL95% Coverage     0.716
               95% Bootstrap (%) UTL95% Coverage      0.716                                    95% UPL (t)    0.707
                              90% Percentile (z)      0.54                               95% Percentile (z)    0.673
                              99% Percentile (z)      1.016                                        95% USL    1.309

                    Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution
                           KM Mean of Logged Data    -1.394               95% KM UTL (Lognormal)95% Coverage    0.945
                             KM SD of Logged Data     0.603                          95% KM UPL (Lognormal)    0.702
                   95% KM Percentile Lognormal (z)    0.668                          95% KM USL (Lognormal)    1.297

                                Background DL/2 Statistics Assuming Lognormal Distribution
                           Mean in Original Scale     0.29                                Mean in Log Scale    -1.414
                             SD in Original Scale     0.156                                 SD in Log Scale     0.662
                          95% UTL95% Coverage         1.057                                    95% UPL (t)    0.763
                              90% Percentile (z)      0.568                              95% Percentile (z)    0.723
                              99% Percentile (z)      1.135                                        95% USL    1.497
                   DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.

                                    Nonparametric Distribution Free Background Statistics
                               Data appear to follow a Discernible Distribution at 5% Significance Level

                  Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)
                               Order of Statistic, r    30                           95% UTL with95% Coverage    0.716
                  Approx, f used to compute achieved CC    1.579   Approximate Actual Confidence Coefficient achieved by UTL    0.785
    Approximate Sample Size needed to achieve specified CC    59                                       95% UPL    0.655
                                           95% USL    0.716                                95% KM Chebyshev UPL    0.963

           Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
            Therefore, one may use USL to estimate a BTV only when the data set represents a background data set  free of outliers
```

and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Arsenic

General Statistics

Total Number of Observations	30	Number of Distinct Observations	30
Minimum	1.62	First Quartile	3.063
Second Largest	8.47	Median	5.625
Maximum	10.5	Third Quartile	6.148
Mean	4.918	SD	2.094
Coefficient of Variation	0.426	Skewness	0.367
Mean of logged Data	1.492	SD of logged Data	0.479

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

Normal GOF Test

Shapiro Wilk Test Statistic	0.942	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.161	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.159	Data Not Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Background Statistics Assuming Normal Distribution

95% UTL with 95% Coverage	9.567	90% Percentile (z)	7.602
95% UPL (t)	8.535	95% Percentile (z)	8.363
95% USL	10.67	99% Percentile (z)	9.79

Gamma GOF Test

A-D Test Statistic	0.86	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.746	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.206	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.16	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	5.122	k star (bias corrected MLE)	4.632
Theta hat (MLE)	0.96	Theta star (bias corrected MLE)	1.062
nu hat (MLE)	307.3	nu star (bias corrected)	277.9
MLE Mean (bias corrected)	4.918	MLE Sd (bias corrected)	2.285

Background Statistics Assuming Gamma Distribution

95% Wilson Hilferty (WH) Approx. Gamma UPL	9.318	90% Percentile	7.978

95% Hawkins Wixley (HW) Approx. Gamma UPL	9.487	95% Percentile	9.177
95% WH Approx. Gamma UTL with 95% Coverage	11.09	99% Percentile	11.72
95% HW Approx. Gamma UTL with 95% Coverage	11.43		
95% WH USL	13.21	95% HW USL	13.81

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.925	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.218	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.159	Data Not Lognormal at 5% Significance Level

Data Not Lognormal at 5% Significance Level

Background Statistics assuming Lognormal Distribution

95% UTL with 95% Coverage	12.88	90% Percentile (z)	8.218
95% UPL (t)	10.17	95% Percentile (z)	9.781
95% USL	16.57	99% Percentile (z)	13.56

Nonparametric Distribution Free Background Statistics

Data appear Approximate Normal at 5% Significance Level

Nonparametric Upper Limits for Background Threshold Values

Order of Statistic, r	30	95% UTL with 95% Coverage	10.5
Approx, f used to compute achieved CC	1.579	Approximate Actual Confidence Coefficient achieved by UTL	0.785
		Approximate Sample Size needed to achieve specified CC	59
95% Percentile Bootstrap UTL with 95% Coverage	10.5	95% BCA Bootstrap UTL with 95% Coverage	10.5
95% UPL	9.384	90% Percentile	6.585
90% Chebyshev UPL	11.3	95% Percentile	7.845
95% Chebyshev UPL	14.2	99% Percentile	9.911
95% USL	10.5		

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Barium

General Statistics

Total Number of Observations	30	Number of Distinct Observations	28
Minimum	24.1	First Quartile	68.65
Second Largest	180	Median	127
Maximum	198	Third Quartile	143.5
Mean	114.4	SD	47.25
Coefficient of Variation	0.413	Skewness	-0.247

```
                              Mean of logged Data    4.63                           SD of logged Data    0.519

                             Critical Values for Background Threshold Values (BTVs)
                       Tolerance Factor K (For UTL)   2.22                          d2max (for USL)    2.745

                                              Normal GOF Test
                        Shapiro Wilk Test Statistic    0.946                  Shapiro Wilk GOF Test
                     5% Shapiro Wilk Critical Value    0.927       Data appear Normal at 5% Significance Level
                          Lilliefors Test Statistic    0.156                   Lilliefors GOF Test
                       5% Lilliefors Critical Value    0.159       Data appear Normal at 5% Significance Level
                                 Data appear Normal at 5% Significance Level

                              Background Statistics Assuming Normal Distribution
                     95% UTL with   95% Coverage   219.3                        90% Percentile (z)    174.9
                                      95% UPL (t)   196                         95% Percentile (z)    192.1
                                         95% USL   244.1                        99% Percentile (z)    224.3

                                              Gamma GOF Test
                                 A-D Test Statistic    1.062            Anderson-Darling Gamma GOF Test
                              5% A-D Critical Value    0.747      Data Not Gamma Distributed at 5% Significance Level
                                 K-S Test Statistic    0.209           Kolmogorov-Smirnov Gamma GOF Test
                              5% K-S Critical Value    0.16       Data Not Gamma Distributed at 5% Significance Level
                            Data Not Gamma Distributed at 5% Significance Level

                                              Gamma Statistics
                                       k hat (MLE)    4.713                  k star (bias corrected MLE)    4.264
                                   Theta hat (MLE)   24.26               Theta star (bias corrected MLE)   26.82
                                      nu hat (MLE)   282.8                     nu star (bias corrected)   255.9
                          MLE Mean (bias corrected)   114.4                      MLE Sd (bias corrected)    55.38

                              Background Statistics Assuming Gamma Distribution
          95% Wilson Hilferty (WH) Approx. Gamma UPL   221.6                           90% Percentile    188.6
          95% Hawkins Wixley (HW) Approx. Gamma UPL   227.3                            95% Percentile    218
       95% WH Approx. Gamma UTL with   95% Coverage   265.2                            99% Percentile    280.6
       95% HW Approx. Gamma UTL with   95% Coverage   275.9
                                        95% WH USL   317.5                                95% HW USL    335.9

                                             Lognormal GOF Test
                        Shapiro Wilk Test Statistic    0.89             Shapiro Wilk Lognormal GOF Test
                     5% Shapiro Wilk Critical Value    0.927       Data Not Lognormal at 5% Significance Level
                          Lilliefors Test Statistic    0.226              Lilliefors Lognormal GOF Test
                       5% Lilliefors Critical Value    0.159       Data Not Lognormal at 5% Significance Level
                                 Data Not Lognormal at 5% Significance Level

                             Background Statistics assuming Lognormal Distribution
```

95% UTL with 95% Coverage	324.2	90% Percentile (z)	199.2
95% UPL (t)	251.1	95% Percentile (z)	240.6
95% USL	425.8	99% Percentile (z)	342.6

Nonparametric Distribution Free Background Statistics

Data appear Normal at 5% Significance Level

Nonparametric Upper Limits for Background Threshold Values

Order of Statistic, r	30	95% UTL with 95% Coverage	198
Approx, f used to compute achieved CC	1.579	Approximate Actual Confidence Coefficient achieved by UTL	0.785
		Approximate Sample Size needed to achieve specified CC	59
95% Percentile Bootstrap UTL with 95% Coverage	198	95% BCA Bootstrap UTL with 95% Coverage	198
95% UPL	188.1	90% Percentile	171.6
90% Chebyshev UPL	258.5	95% Percentile	178.7
95% Chebyshev UPL	323.7	99% Percentile	192.8
95% USL	198		

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Beryllium

General Statistics

Total Number of Observations	30	Number of Distinct Observations	29
Minimum	0.145	First Quartile	0.306
Second Largest	0.956	Median	0.556
Maximum	1	Third Quartile	0.747
Mean	0.565	SD	0.261
Coefficient of Variation	0.462	Skewness	-0.00548
Mean of logged Data	-0.701	SD of logged Data	0.555

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

Normal GOF Test

Shapiro Wilk Test Statistic	0.94	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.14	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.159	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Background Statistics Assuming Normal Distribution

```
              95% UTL with   95% Coverage     1.144                             90% Percentile (z)     0.899
                             95% UPL (t)      1.016                             95% Percentile (z)     0.994
                                 95% USL      1.281                             99% Percentile (z)     1.172

                                          Gamma GOF Test
                       A-D Test Statistic     0.723              Anderson-Darling Gamma GOF Test
                    5% A-D Critical Value     0.749      Detected data appear Gamma Distributed at 5% Significance Level
                       K-S Test Statistic     0.141             Kolmogorov-Smirnov Gamma GOF Test
                    5% K-S Critical Value     0.161      Detected data appear Gamma Distributed at 5% Significance Level
                        Detected data appear Gamma Distributed at 5% Significance Level

                                          Gamma Statistics
                              k hat (MLE)     4.007                      k star (bias corrected MLE)     3.628
                          Theta hat (MLE)     0.141                  Theta star (bias corrected MLE)     0.156
                             nu hat (MLE)   240.4                           nu star (bias corrected)   217.7
                MLE Mean (bias corrected)     0.565                           MLE Sd (bias corrected)     0.297

                             Background Statistics Assuming Gamma Distribution
    95% Wilson Hilferty (WH) Approx. Gamma UPL     1.146                                  90% Percentile     0.963
     95% Hawkins Wixley (HW) Approx. Gamma UPL     1.174                                  95% Percentile     1.125
 95% WH Approx. Gamma UTL with   95% Coverage     1.388                                  99% Percentile     1.471
 95% HW Approx. Gamma UTL with   95% Coverage     1.444
                               95% WH USL     1.681                                      95% HW USL     1.781

                                          Lognormal GOF Test
               Shapiro Wilk Test Statistic     0.911               Shapiro Wilk Lognormal GOF Test
          5% Shapiro Wilk Critical Value     0.927           Data Not Lognormal at 5% Significance Level
                 Lilliefors Test Statistic     0.15                  Lilliefors Lognormal GOF Test
             5% Lilliefors Critical Value     0.159           Data appear Lognormal at 5% Significance Level
                          Data appear Approximate Lognormal at 5% Significance Level

                            Background Statistics assuming Lognormal Distribution
              95% UTL with   95% Coverage     1.701                             90% Percentile (z)     1.011
                             95% UPL (t)      1.294                             95% Percentile (z)     1.236
                                 95% USL      2.276                             99% Percentile (z)     1.804

                             Nonparametric Distribution Free Background Statistics
                                 Data appear Normal at 5% Significance Level

                           Nonparametric Upper Limits for Background Threshold Values
                     Order of Statistic, r    30                        95% UTL with   95% Coverage     1
          Approx, f used to compute achieved CC     1.579    Approximate Actual Confidence Coefficient achieved by UTL     0.785
                                                         Approximate Sample Size needed to achieve specified CC    59
  95% Percentile Bootstrap UTL with   95% Coverage     1                95% BCA Bootstrap UTL with   95% Coverage     1
                                 95% UPL      0.976                                  90% Percentile     0.913
```

90% Chebyshev UPL	1.36	95% Percentile	0.943
95% Chebyshev UPL	1.721	99% Percentile	0.987
95% USL	1		

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Boron

General Statistics

Total Number of Observations	30	Number of Missing Observations	0
Number of Distinct Observations	30		
Number of Detects	29	Number of Non-Detects	1
Number of Distinct Detects	29	Number of Distinct Non-Detects	1
Minimum Detect	1.82	Minimum Non-Detect	1.51
Maximum Detect	8.43	Maximum Non-Detect	1.51
Variance Detected	4.696	Percent Non-Detects	3.333%
Mean Detected	5.337	SD Detected	2.167
Mean of Detected Logged Data	1.572	SD of Detected Logged Data	0.492

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.913	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.926	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.142	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.161	Detected Data appear Normal at 5% Significance Level

Detected Data appear Approximate Normal at 5% Significance Level

Kaplan Meier (KM) Background Statistics Assuming Normal Distribution

KM Mean	5.209	KM SD	2.203
95% UTL95% Coverage	10.1	95% KM UPL (t)	9.015
90% KM Percentile (z)	8.033	95% KM Percentile (z)	8.833
99% KM Percentile (z)	10.33	95% KM USL	11.26

DL/2 Substitution Background Statistics Assuming Normal Distribution

Mean	5.184	SD	2.288
95% UTL95% Coverage	10.26	95% UPL (t)	9.135
90% Percentile (z)	8.116	95% Percentile (z)	8.947
99% Percentile (z)	10.51	95% USL	11.46

DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	1.211	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.748	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.157	**Kolmogorov-Smirnov GOF**
5% K-S Critical Value	0.163	Detected data appear Gamma Distributed at 5% Significance Level

Detected data follow Appr. Gamma Distribution at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	5.05	k star (bias corrected MLE)	4.551
Theta hat (MLE)	1.057	Theta star (bias corrected MLE)	1.173
nu hat (MLE)	292.9	nu star (bias corrected)	263.9
MLE Mean (bias corrected)	5.337		
MLE Sd (bias corrected)	2.502	95% Percentile of Chisquare (2kstar)	17.06

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	1.587	Mean	5.212
Maximum	8.43	Median	5.62
SD	2.237	CV	0.429
k hat (MLE)	4.486	k star (bias corrected MLE)	4.06
Theta hat (MLE)	1.162	Theta star (bias corrected MLE)	1.284
nu hat (MLE)	269.2	nu star (bias corrected)	243.6
MLE Mean (bias corrected)	5.212	MLE Sd (bias corrected)	2.587
95% Percentile of Chisquare (2kstar)	15.68	90% Percentile	8.678
95% Percentile	10.06	99% Percentile	13.02

The following statistics are computed using Gamma ROS Statistics on Imputed Data

Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods

	WH	HW		WH	HW
95% Approx. Gamma UTL with 95% Coverage	12.3	12.78	95% Approx. Gamma UPL	10.24	10.49
95% Gamma USL	14.79	15.62			

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	5.209	SD (KM)	2.203
Variance (KM)	4.855	SE of Mean (KM)	0.409
k hat (KM)	5.589	k star (KM)	5.052
nu hat (KM)	335.3	nu star (KM)	303.1
theta hat (KM)	0.932	theta star (KM)	1.031
80% gamma percentile (KM)	6.994	90% gamma percentile (KM)	8.311
95% gamma percentile (KM)	9.512	99% gamma percentile (KM)	12.05

```
                    The following statistics are computed using gamma distribution and KM estimates
                       Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods
                                              WH        HW                                   WH        HW
  95% Approx. Gamma UTL with 95% Coverage   12.17     12.64           95% Approx. Gamma UPL  10.15     10.39
             95% KM Gamma Percentile         9.836    10.04                  95% Gamma USL  14.61     15.42

                              Lognormal GOF Test on Detected Observations Only
                       Shapiro Wilk Test Statistic   0.868           Shapiro Wilk GOF Test
                   5% Shapiro Wilk Critical Value    0.926    Data Not Lognormal at 5% Significance Level
                          Lilliefors Test Statistic  0.178             Lilliefors GOF Test
                      5% Lilliefors Critical Value   0.161    Data Not Lognormal at 5% Significance Level
                                 Data Not Lognormal at 5% Significance Level

        Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects
                           Mean in Original Scale    5.208                          Mean in Log Scale   1.533
                             SD in Original Scale    2.242                            SD in Log Scale   0.528
                           95% UTL95% Coverage      14.97                   95% BCA UTL95% Coverage     8.43
                95% Bootstrap (%) UTL95% Coverage    8.43                                95% UPL (t)   11.54
                              90% Percentile (z)     9.12                         95% Percentile (z)   11.05
                              99% Percentile (z)    15.84                                    95% USL   19.76

              Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution
                           KM Mean of Logged Data    1.534          95% KM UTL (Lognormal)95% Coverage  14.66
                             KM SD of Logged Data    0.519                     95% KM UPL (Lognormal)  11.35
                  95% KM Percentile Lognormal (z)   10.88                      95% KM USL (Lognormal)  19.24

                         Background DL/2 Statistics Assuming Lognormal Distribution
                           Mean in Original Scale    5.184                          Mean in Log Scale   1.511
                             SD in Original Scale    2.288                            SD in Log Scale   0.59
                           95% UTL95% Coverage      16.77                                95% UPL (t)   12.54
                              90% Percentile (z)     9.644                        95% Percentile (z)   11.95
                              99% Percentile (z)    17.86                                    95% USL   22.86
          DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.

                            Nonparametric Distribution Free Background Statistics
                          Data appear to follow a Discernible Distribution at 5% Significance Level

            Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)
                               Order of Statistic, r   30                        95% UTL with95% Coverage    8.43
                  Approx, f used to compute achieved CC  1.579  Approximate Actual Confidence Coefficient achieved by UTL  0.785
  Approximate Sample Size needed to achieve specified CC  59                                     95% UPL    8.309
                                         95% USL     8.43                            95% KM Chebyshev UPL  14.97

      Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
       Therefore, one may use USL to estimate a BTV only when the data set represents a background data set  free of outliers
```

and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Cadmium

General Statistics

Total Number of Observations	30	Number of Distinct Observations	29
Minimum	0.0744	First Quartile	0.192
Second Largest	0.663	Median	0.324
Maximum	0.8	Third Quartile	0.402
Mean	0.317	SD	0.168
Coefficient of Variation	0.53	Skewness	0.787
Mean of logged Data	-1.305	SD of logged Data	0.61

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

Normal GOF Test

Shapiro Wilk Test Statistic	0.941	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.0854	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.159	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Background Statistics Assuming Normal Distribution

95% UTL with 95% Coverage	0.691	90% Percentile (z)	0.533
95% UPL (t)	0.608	95% Percentile (z)	0.594
95% USL	0.779	99% Percentile (z)	0.709

Gamma GOF Test

A-D Test Statistic	0.496	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.751	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.129	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.161	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	3.335	k star (bias corrected MLE)	3.023
Theta hat (MLE)	0.0952	Theta star (bias corrected MLE)	0.105
nu hat (MLE)	200.1	nu star (bias corrected)	181.4
MLE Mean (bias corrected)	0.317	MLE Sd (bias corrected)	0.183

Background Statistics Assuming Gamma Distribution

95% Wilson Hilferty (WH) Approx. Gamma UPL	0.677	90% Percentile	0.562

95% Hawkins Wixley (HW) Approx. Gamma UPL	0.696	95% Percentile	0.665
95% WH Approx. Gamma UTL with 95% Coverage	0.832	99% Percentile	0.887
95% HW Approx. Gamma UTL with 95% Coverage	0.87		
95% WH USL	1.021	95% HW USL	1.089

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.935	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.166	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.159	Data Not Lognormal at 5% Significance Level

Data appear Approximate Lognormal at 5% Significance Level

Background Statistics assuming Lognormal Distribution

95% UTL with 95% Coverage	1.05	90% Percentile (z)	0.593
95% UPL (t)	0.778	95% Percentile (z)	0.739
95% USL	1.446	99% Percentile (z)	1.12

Nonparametric Distribution Free Background Statistics

Data appear Normal at 5% Significance Level

Nonparametric Upper Limits for Background Threshold Values

Order of Statistic, r	30	95% UTL with 95% Coverage	0.8
Approx, f used to compute achieved CC	1.579	Approximate Actual Confidence Coefficient achieved by UTL	0.785
		Approximate Sample Size needed to achieve specified CC	59
95% Percentile Bootstrap UTL with 95% Coverage	0.8	95% BCA Bootstrap UTL with 95% Coverage	0.8
95% UPL	0.725	90% Percentile	0.474
90% Chebyshev UPL	0.83	95% Percentile	0.592
95% Chebyshev UPL	1.063	99% Percentile	0.76
95% USL	0.8		

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Calcium

General Statistics

Total Number of Observations	30	Number of Distinct Observations	30
Minimum	845	First Quartile	3568
Second Largest	16900	Median	4750
Maximum	25100	Third Quartile	5683
Mean	5806	SD	4855
Coefficient of Variation	0.836	Skewness	2.753

Mean of logged Data	8.437	SD of logged Data	0.672

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

Normal GOF Test

Shapiro Wilk Test Statistic	0.691	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.275	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.159	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Background Statistics Assuming Normal Distribution

95% UTL with 95% Coverage	16584	90% Percentile (z)	12028
95% UPL (t)	14191	95% Percentile (z)	13792
95% USL	19133	99% Percentile (z)	17100

Gamma GOF Test

A-D Test Statistic	1.044	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.756	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.19	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.162	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.33	k star (bias corrected MLE)	2.119
Theta hat (MLE)	2491	Theta star (bias corrected MLE)	2739
nu hat (MLE)	139.8	nu star (bias corrected)	127.2
MLE Mean (bias corrected)	5806	MLE Sd (bias corrected)	3988

Background Statistics Assuming Gamma Distribution

95% Wilson Hilferty (WH) Approx. Gamma UPL	13654	90% Percentile	11139
95% Hawkins Wixley (HW) Approx. Gamma UPL	13779	95% Percentile	13522
95% WH Approx. Gamma UTL with 95% Coverage	17279	99% Percentile	18789
95% HW Approx. Gamma UTL with 95% Coverage	17744		
95% WH USL	21792	95% HW USL	22851

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.957	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.143	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.159	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Background Statistics assuming Lognormal Distribution

95% UTL with 95% Coverage	20528	90% Percentile (z)	10923
95% UPL (t)	14739	95% Percentile (z)	13945
95% USL	29220	99% Percentile (z)	22050

Nonparametric Distribution Free Background Statistics

Data appear Lognormal at 5% Significance Level

Nonparametric Upper Limits for Background Threshold Values

Order of Statistic, r	30	95% UTL with 95% Coverage	25100
Approx, f used to compute achieved CC	1.579	Approximate Actual Confidence Coefficient achieved by UTL	0.785
		Approximate Sample Size needed to achieve specified CC	59
95% Percentile Bootstrap UTL with 95% Coverage	25100	95% BCA Bootstrap UTL with 95% Coverage	25100
95% UPL	20590	90% Percentile	8376
90% Chebyshev UPL	20611	95% Percentile	15235
95% Chebyshev UPL	27318	99% Percentile	22722
95% USL	25100		

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Chloride

General Statistics

Total Number of Observations	30	Number of Missing Observations	0
Number of Distinct Observations	30		
Number of Detects	0	Number of Non-Detects	30
Number of Distinct Detects	0	Number of Distinct Non-Detects	30
Minimum Detect	N/A	Minimum Non-Detect	4.1
Maximum Detect	N/A	Maximum Non-Detect	5.46
Variance Detected	N/A	Percent Non-Detects	100%
Mean Detected	N/A	SD Detected	N/A
Mean of Detected Logged Data	N/A	SD of Detected Logged Data	N/A

Warning: All observations are Non-Detects (NDs), therefore all statistics and estimates should also be NDs!
Specifically, sample mean, UCLs, UPLs, and other statistics are also NDs lying below the largest detection limit!
The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

The data set for variable Chloride was not processed!

Chromium

General Statistics

Total Number of Observations	30	Number of Distinct Observations	26
Minimum	3.02	First Quartile	7.048
Second Largest	15.9	Median	11.65
Maximum	16.8	Third Quartile	13.2
Mean	10.49	SD	3.983
Coefficient of Variation	0.38	Skewness	-0.324
Mean of logged Data	2.261	SD of logged Data	0.462

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

Normal GOF Test

Shapiro Wilk Test Statistic	0.935	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.176	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.159	Data Not Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Background Statistics Assuming Normal Distribution

95% UTL with 95% Coverage	19.33	90% Percentile (z)	15.6
95% UPL (t)	17.37	95% Percentile (z)	17.04
95% USL	21.43	99% Percentile (z)	19.76

Gamma GOF Test

A-D Test Statistic	1.114	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.746	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.217	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.16	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	5.74	k star (bias corrected MLE)	5.188
Theta hat (MLE)	1.828	Theta star (bias corrected MLE)	2.022
nu hat (MLE)	344.4	nu star (bias corrected)	311.3
MLE Mean (bias corrected)	10.49	MLE Sd (bias corrected)	4.606

Background Statistics Assuming Gamma Distribution

95% Wilson Hilferty (WH) Approx. Gamma UPL	19.32	90% Percentile	16.66
95% Hawkins Wixley (HW) Approx. Gamma UPL	19.72	95% Percentile	19.03
95% WH Approx. Gamma UTL with 95% Coverage	22.8	99% Percentile	24.05
95% HW Approx. Gamma UTL with 95% Coverage	23.56		
95% WH USL	26.96	95% HW USL	28.25

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.888	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.231	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.159	Data Not Lognormal at 5% Significance Level

Data Not Lognormal at 5% Significance Level

Background Statistics assuming Lognormal Distribution

95% UTL with 95% Coverage	26.76	90% Percentile (z)	17.34
95% UPL (t)	21.31	95% Percentile (z)	20.51
95% USL	34.11	99% Percentile (z)	28.11

Nonparametric Distribution Free Background Statistics

Data appear Approximate Normal at 5% Significance Level

Nonparametric Upper Limits for Background Threshold Values

Order of Statistic, r	30	95% UTL with 95% Coverage	16.8
Approx, f used to compute achieved CC	1.579	Approximate Actual Confidence Coefficient achieved by UTL	0.785
		Approximate Sample Size needed to achieve specified CC	59
95% Percentile Bootstrap UTL with 95% Coverage	16.8	95% BCA Bootstrap UTL with 95% Coverage	16.8
95% UPL	16.31	90% Percentile	15.71
90% Chebyshev UPL	22.64	95% Percentile	15.86
95% Chebyshev UPL	28.14	99% Percentile	16.54
95% USL	16.8		

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Cobalt

General Statistics

Total Number of Observations	30	Number of Distinct Observations	30
Minimum	2.23	First Quartile	3.463
Second Largest	8.52	Median	5.75
Maximum	10.4	Third Quartile	7.163
Mean	5.572	SD	2.092
Coefficient of Variation	0.375	Skewness	0.0893
Mean of logged Data	1.64	SD of logged Data	0.419

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

```
                                         Normal GOF Test
           Shapiro Wilk Test Statistic    0.956                Shapiro Wilk GOF Test
        5% Shapiro Wilk Critical Value    0.927       Data appear Normal at 5% Significance Level
             Lilliefors Test Statistic    0.125                  Lilliefors GOF Test
           5% Lilliefors Critical Value   0.159       Data appear Normal at 5% Significance Level
                       Data appear Normal at 5% Significance Level

                      Background Statistics Assuming Normal Distribution
        95% UTL with   95% Coverage    10.22                           90% Percentile (z)    8.252
                           95% UPL (t)  9.185                           95% Percentile (z)    9.012
                            95% USL    11.31                           99% Percentile (z)    10.44

                                         Gamma GOF Test
                     A-D Test Statistic   0.721              Anderson-Darling Gamma GOF Test
                    5% A-D Critical Value 0.746   Detected data appear Gamma Distributed at 5% Significance Level
                     K-S Test Statistic   0.145             Kolmogorov-Smirnov Gamma GOF Test
                   5% K-S Critical Value  0.16    Detected data appear Gamma Distributed at 5% Significance Level
                 Detected data appear Gamma Distributed at 5% Significance Level

                                        Gamma Statistics
                         k hat (MLE)    6.566                      k star (bias corrected MLE)    5.931
                     Theta hat (MLE)    0.849                  Theta star (bias corrected MLE)    0.939
                        nu hat (MLE)   393.9                         nu star (bias corrected)    355.9
           MLE Mean (bias corrected)    5.572                          MLE Sd (bias corrected)    2.288

                     Background Statistics Assuming Gamma Distribution
     95% Wilson Hilferty (WH) Approx. Gamma UPL    9.919                      90% Percentile    8.63
    95% Hawkins Wixley (HW) Approx. Gamma UPL     10.06                      95% Percentile    9.789
  95% WH Approx. Gamma UTL with   95% Coverage    11.61                      99% Percentile    12.22
  95% HW Approx. Gamma UTL with   95% Coverage    11.9
                                  95% WH USL     13.61                          95% HW USL    14.11

                                       Lognormal GOF Test
           Shapiro Wilk Test Statistic    0.928              Shapiro Wilk Lognormal GOF Test
        5% Shapiro Wilk Critical Value    0.927      Data appear Lognormal at 5% Significance Level
             Lilliefors Test Statistic    0.16                Lilliefors Lognormal GOF Test
           5% Lilliefors Critical Value   0.159        Data Not Lognormal at 5% Significance Level
                  Data appear Approximate Lognormal at 5% Significance Level

                   Background Statistics assuming Lognormal Distribution
        95% UTL with   95% Coverage    13.05                           90% Percentile (z)    8.812
                           95% UPL (t) 10.62                           95% Percentile (z)    10.26
                            95% USL    16.26                           99% Percentile (z)    13.65
```

Nonparametric Distribution Free Background Statistics

Data appear Normal at 5% Significance Level

Nonparametric Upper Limits for Background Threshold Values

Order of Statistic, r	30	95% UTL with 95% Coverage	10.4
Approx, f used to compute achieved CC	1.579	Approximate Actual Confidence Coefficient achieved by UTL	0.785
		Approximate Sample Size needed to achieve specified CC	59
95% Percentile Bootstrap UTL with 95% Coverage	10.4	95% BCA Bootstrap UTL with 95% Coverage	10.4
95% UPL	9.366	90% Percentile	7.796
90% Chebyshev UPL	11.95	95% Percentile	8.34
95% Chebyshev UPL	14.84	99% Percentile	9.855
95% USL	10.4		

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Copper

General Statistics

Total Number of Observations	30	Number of Distinct Observations	28
Minimum	2.24	First Quartile	6.615
Second Largest	20.8	Median	13.8
Maximum	23.8	Third Quartile	16.3
Mean	12.2	SD	6.121
Coefficient of Variation	0.502	Skewness	-0.206
Mean of logged Data	2.317	SD of logged Data	0.696

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

Normal GOF Test

Shapiro Wilk Test Statistic	0.94	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.165	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.159	Data Not Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Background Statistics Assuming Normal Distribution

95% UTL with 95% Coverage	25.78	90% Percentile (z)	20.04
95% UPL (t)	22.77	95% Percentile (z)	22.26
95% USL	29	99% Percentile (z)	26.44

Gamma GOF Test

A-D Test Statistic	1.312	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.753	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.23	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.161	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.868	k star (bias corrected MLE)	2.603
Theta hat (MLE)	4.253	Theta star (bias corrected MLE)	4.685
nu hat (MLE)	172.1	nu star (bias corrected)	156.2
MLE Mean (bias corrected)	12.2	MLE Sd (bias corrected)	7.559

Background Statistics Assuming Gamma Distribution

95% Wilson Hilferty (WH) Approx. Gamma UPL	27.31	90% Percentile	22.33
95% Hawkins Wixley (HW) Approx. Gamma UPL	28.44	95% Percentile	26.68
95% WH Approx. Gamma UTL with 95% Coverage	33.95	99% Percentile	36.19
95% HW Approx. Gamma UTL with 95% Coverage	36.14		
95% WH USL	42.12	95% HW USL	45.97

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.853	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.247	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.159	Data Not Lognormal at 5% Significance Level

Data Not Lognormal at 5% Significance Level

Background Statistics assuming Lognormal Distribution

95% UTL with 95% Coverage	47.55	90% Percentile (z)	24.75
95% UPL (t)	33.75	95% Percentile (z)	31.87
95% USL	68.53	99% Percentile (z)	51.2

Nonparametric Distribution Free Background Statistics

Data appear Approximate Normal at 5% Significance Level

Nonparametric Upper Limits for Background Threshold Values

Order of Statistic, r	30	95% UTL with 95% Coverage	23.8
Approx, f used to compute achieved CC	1.579	Approximate Actual Confidence Coefficient achieved by UTL	0.785
		Approximate Sample Size needed to achieve specified CC	59
95% Percentile Bootstrap UTL with 95% Coverage	23.8	95% BCA Bootstrap UTL with 95% Coverage	23.8
95% UPL	22.15	90% Percentile	19.41
90% Chebyshev UPL	30.86	95% Percentile	20.62
95% Chebyshev UPL	39.32	99% Percentile	22.93
95% USL	23.8		

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Fluoride

General Statistics

Total Number of Observations	30	Number of Missing Observations	0
Number of Distinct Observations	29		
Number of Detects	29	Number of Non-Detects	1
Number of Distinct Detects	28	Number of Distinct Non-Detects	1
Minimum Detect	0.855	Minimum Non-Detect	0.827
Maximum Detect	5.4	Maximum Non-Detect	0.827
Variance Detected	2.115	Percent Non-Detects	3.333%
Mean Detected	2.645	SD Detected	1.454
Mean of Detected Logged Data	0.808	SD of Detected Logged Data	0.606

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.909	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.926	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.135	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.161	Detected Data appear Normal at 5% Significance Level

Detected Data appear Approximate Normal at 5% Significance Level

Kaplan Meier (KM) Background Statistics Assuming Normal Distribution

KM Mean	2.584	KM SD	1.442
95% UTL95% Coverage	5.786	95% KM UPL (t)	5.075
90% KM Percentile (z)	4.432	95% KM Percentile (z)	4.956
99% KM Percentile (z)	5.939	95% KM USL	6.543

DL/2 Substitution Background Statistics Assuming Normal Distribution

Mean	2.57	SD	1.486
95% UTL95% Coverage	5.869	95% UPL (t)	5.137
90% Percentile (z)	4.474	95% Percentile (z)	5.014
99% Percentile (z)	6.027	95% USL	6.649

DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.751	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.752	Detected data appear Gamma Distributed at 5% Significance Level

```
                  K-S Test Statistic    0.148                 Kolmogorov-Smirnov GOF
                5% K-S Critical Value   0.164    Detected data appear Gamma Distributed at 5% Significance Level
                     Detected data appear Gamma Distributed at 5% Significance Level

                                  Gamma Statistics on Detected Data Only
                       k hat (MLE)      3.188                          k star (bias corrected MLE)    2.881
                   Theta hat (MLE)      0.83                       Theta star (bias corrected MLE)    0.918
                      nu hat (MLE)    184.9                              nu star (bias corrected)   167.1
            MLE Mean (bias corrected)   2.645
              MLE Sd (bias corrected)   1.558                  95% Percentile of Chisquare (2kstar)    12.24

                             Gamma ROS Statistics using Imputed Non-Detects
              GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
     GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)
                     For such situations, GROS method may yield incorrect values of UCLs and BTVs
                                  This is especially true when the sample size is small.
          For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates
                           Minimum      0.268                                                 Mean    2.565
                           Maximum      5.4                                                 Median    2.315
                                SD      1.493                                                   CV    0.582
                       k hat (MLE)      2.589                          k star (bias corrected MLE)    2.352
                   Theta hat (MLE)      0.991                      Theta star (bias corrected MLE)    1.091
                      nu hat (MLE)    155.3                              nu star (bias corrected)   141.1
            MLE Mean (bias corrected)   2.565                              MLE Sd (bias corrected)    1.673
   95% Percentile of Chisquare (2kstar) 10.61                                       90% Percentile    4.805
                    95% Percentile      5.786                                      99% Percentile     7.941
                The following statistics are computed using Gamma ROS Statistics on Imputed Data
                     Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods
                                    WH        HW                                         WH        HW
  95% Approx. Gamma UTL with 95% Coverage   7.418     7.844             95% Approx. Gamma UPL    5.915     6.12
                        95% Gamma USL   9.279     10.06

                             Estimates of Gamma Parameters using KM Estimates
                         Mean (KM)      2.584                                              SD (KM)    1.442
                     Variance (KM)      2.08                                       SE of Mean (KM)    0.268
                        k hat (KM)      3.21                                            k star (KM)    2.911
                       nu hat (KM)    192.6                                           nu star (KM)  174.7
                     theta hat (KM)     0.805                                        theta star (KM)    0.888
           80% gamma percentile (KM)    3.699                          90% gamma percentile (KM)    4.614
           95% gamma percentile (KM)    5.47                           99% gamma percentile (KM)    7.327

                The following statistics are computed using gamma distribution and KM estimates
                     Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods
                                    WH        HW                                         WH        HW
  95% Approx. Gamma UTL with 95% Coverage   6.941     7.215             95% Approx. Gamma UPL    5.615     5.737
```

95% KM Gamma Percentile	5.412	5.514	95% Gamma USL	8.567	9.086

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.912	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.926	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.171	Lilliefors GOF Test
5% Lilliefors Critical Value	0.161	Data Not Lognormal at 5% Significance Level

Data Not Lognormal at 5% Significance Level

Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects

Mean in Original Scale	2.573	Mean in Log Scale	0.758
SD in Original Scale	1.482	SD in Log Scale	0.656
95% UTL95% Coverage	9.143	95% BCA UTL95% Coverage	5.4
95% Bootstrap (%) UTL95% Coverage	5.4	95% UPL (t)	6.619
90% Percentile (z)	4.942	95% Percentile (z)	6.271
99% Percentile (z)	9.803	95% USL	12.9

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean of Logged Data	0.774	95% KM UTL (Lognormal)95% Coverage	8.447
KM SD of Logged Data	0.612	95% KM UPL (Lognormal)	6.247
95% KM Percentile Lognormal (z)	5.94	95% KM USL (Lognormal)	11.65

Background DL/2 Statistics Assuming Lognormal Distribution

Mean in Original Scale	2.57	Mean in Log Scale	0.751
SD in Original Scale	1.486	SD in Log Scale	0.671
95% UTL95% Coverage	9.399	95% UPL (t)	6.753
90% Percentile (z)	5.008	95% Percentile (z)	6.39
99% Percentile (z)	10.09	95% USL	13.37

DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.

Nonparametric Distribution Free Background Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)

Order of Statistic, r	30	95% UTL with95% Coverage	5.4
Approx, f used to compute achieved CC	1.579	Approximate Actual Confidence Coefficient achieved by UTL	0.785
Approximate Sample Size needed to achieve specified CC	59	95% UPL	5.378
95% USL	5.4	95% KM Chebyshev UPL	8.975

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Lead

General Statistics

Total Number of Observations	30	Number of Distinct Observations	28
Minimum	3.72	First Quartile	7.95
Second Largest	27.7	Median	12.9
Maximum	28.4	Third Quartile	16.58
Mean	13.33	SD	6.605
Coefficient of Variation	0.495	Skewness	0.594
Mean of logged Data	2.453	SD of logged Data	0.564

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

Normal GOF Test

Shapiro Wilk Test Statistic	0.924	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.145	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.159	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Background Statistics Assuming Normal Distribution

95% UTL with 95% Coverage	27.99	90% Percentile (z)	21.8
95% UPL (t)	24.74	95% Percentile (z)	24.19
95% USL	31.46	99% Percentile (z)	28.7

Gamma GOF Test

A-D Test Statistic	0.644	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.75	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.143	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.161	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	3.81	k star (bias corrected MLE)	3.451
Theta hat (MLE)	3.499	Theta star (bias corrected MLE)	3.862
nu hat (MLE)	228.6	nu star (bias corrected)	207.1
MLE Mean (bias corrected)	13.33	MLE Sd (bias corrected)	7.175

Background Statistics Assuming Gamma Distribution

95% Wilson Hilferty (WH) Approx. Gamma UPL	27.37	90% Percentile	22.95
95% Hawkins Wixley (HW) Approx. Gamma UPL	28.02	95% Percentile	26.89
95% WH Approx. Gamma UTL with 95% Coverage	33.28	99% Percentile	35.37
95% HW Approx. Gamma UTL with 95% Coverage	34.6		
95% WH USL	40.45	95% HW USL	42.82

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.921	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.158	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.159	Data appear Lognormal at 5% Significance Level

Data appear Approximate Lognormal at 5% Significance Level

Background Statistics assuming Lognormal Distribution

95% UTL with 95% Coverage	40.68	90% Percentile (z)	23.96
95% UPL (t)	30.81	95% Percentile (z)	29.41
95% USL	54.71	99% Percentile (z)	43.2

Nonparametric Distribution Free Background Statistics

Data appear Approximate Normal at 5% Significance Level

Nonparametric Upper Limits for Background Threshold Values

Order of Statistic, r	30	95% UTL with 95% Coverage	28.4
Approx, f used to compute achieved CC	1.579	Approximate Actual Confidence Coefficient achieved by UTL	0.785
		Approximate Sample Size needed to achieve specified CC	59
95% Percentile Bootstrap UTL with 95% Coverage	28.4	95% BCA Bootstrap UTL with 95% Coverage	28.4
95% UPL	28.02	90% Percentile	18.75
90% Chebyshev UPL	33.47	95% Percentile	27.12
95% Chebyshev UPL	42.6	99% Percentile	28.2
95% USL	28.4		

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Lithium

General Statistics

Total Number of Observations	30	Number of Distinct Observations	29
Minimum	1.88	First Quartile	4.145
Second Largest	14.9	Median	9.335
Maximum	15.6	Third Quartile	10.98
Mean	8.369	SD	3.999
Coefficient of Variation	0.478	Skewness	0.0632
Mean of logged Data	1.987	SD of logged Data	0.568

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

```
                                        Normal GOF Test
              Shapiro Wilk Test Statistic    0.931                Shapiro Wilk GOF Test
           5% Shapiro Wilk Critical Value    0.927      Data appear Normal at 5% Significance Level
                Lilliefors Test Statistic    0.164                 Lilliefors GOF Test
              5% Lilliefors Critical Value   0.159        Data Not Normal at 5% Significance Level
                        Data appear Approximate Normal at 5% Significance Level

                          Background Statistics Assuming Normal Distribution
           95% UTL with   95% Coverage    17.25                       90% Percentile (z)    13.49
                               95% UPL (t)    15.28                       95% Percentile (z)    14.95
                                  95% USL    19.35                       99% Percentile (z)    17.67

                                        Gamma GOF Test
                      A-D Test Statistic    0.996             Anderson-Darling Gamma GOF Test
                     5% A-D Critical Value    0.75      Data Not Gamma Distributed at 5% Significance Level
                      K-S Test Statistic    0.168            Kolmogorov-Smirnov Gamma GOF Test
                     5% K-S Critical Value    0.161      Data Not Gamma Distributed at 5% Significance Level
                          Data Not Gamma Distributed at 5% Significance Level

                                        Gamma Statistics
                              k hat (MLE)    3.802                 k star (bias corrected MLE)    3.444
                          Theta hat (MLE)    2.201             Theta star (bias corrected MLE)    2.43
                             nu hat (MLE)   228.1                   nu star (bias corrected)   206.6
               MLE Mean (bias corrected)    8.369                     MLE Sd (bias corrected)    4.51

                          Background Statistics Assuming Gamma Distribution
     95% Wilson Hilferty (WH) Approx. Gamma UPL    17.22                         90% Percentile    14.42
    95% Hawkins Wixley (HW) Approx. Gamma UPL    17.65                         95% Percentile    16.89
  95% WH Approx. Gamma UTL with   95% Coverage    20.94                         99% Percentile    22.22
  95% HW Approx. Gamma UTL with   95% Coverage    21.81
                               95% WH USL    25.46                             95% HW USL    27.01

                                        Lognormal GOF Test
              Shapiro Wilk Test Statistic    0.905            Shapiro Wilk Lognormal GOF Test
           5% Shapiro Wilk Critical Value    0.927      Data Not Lognormal at 5% Significance Level
                Lilliefors Test Statistic    0.186              Lilliefors Lognormal GOF Test
              5% Lilliefors Critical Value   0.159      Data Not Lognormal at 5% Significance Level
                             Data Not Lognormal at 5% Significance Level

                         Background Statistics assuming Lognormal Distribution
           95% UTL with   95% Coverage    25.74                       90% Percentile (z)    15.1
                               95% UPL (t)    19.45                       95% Percentile (z)    18.57
                                  95% USL    34.68                       99% Percentile (z)    27.34
```

Nonparametric Distribution Free Background Statistics

Data appear Approximate Normal at 5% Significance Level

Nonparametric Upper Limits for Background Threshold Values

Order of Statistic, r	30	95% UTL with 95% Coverage	15.6
Approx, f used to compute achieved CC	1.579	Approximate Actual Confidence Coefficient achieved by UTL	0.785
		Approximate Sample Size needed to achieve specified CC	59
95% Percentile Bootstrap UTL with 95% Coverage	15.6	95% BCA Bootstrap UTL with 95% Coverage	15.6
95% UPL	15.22	90% Percentile	13.81
90% Chebyshev UPL	20.56	95% Percentile	14.45
95% Chebyshev UPL	26.09	99% Percentile	15.4
95% USL	15.6		

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Mercury

General Statistics

Total Number of Observations	30	Number of Missing Observations	0
Number of Distinct Observations	30		
Number of Detects	12	Number of Non-Detects	18
Number of Distinct Detects	12	Number of Distinct Non-Detects	18
Minimum Detect	0.0151	Minimum Non-Detect	0.0128
Maximum Detect	0.193	Maximum Non-Detect	0.0881
Variance Detected	0.00322	Percent Non-Detects	60%
Mean Detected	0.0651	SD Detected	0.0567
Mean of Detected Logged Data	-3.073	SD of Detected Logged Data	0.873

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.83	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.859	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.279	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.243	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Kaplan Meier (KM) Background Statistics Assuming Normal Distribution

KM Mean	0.0357	KM SD	0.0424
95% UTL95% Coverage	0.13	95% KM UPL (t)	0.109

90% KM Percentile (z)	0.09	95% KM Percentile (z)	0.105
99% KM Percentile (z)	0.134	95% KM USL	0.152

DL/2 Substitution Background Statistics Assuming Normal Distribution

Mean	0.0362	SD	0.0433
95% UTL95% Coverage	0.132	95% UPL (t)	0.111
90% Percentile (z)	0.0917	95% Percentile (z)	0.107
99% Percentile (z)	0.137	95% USL	0.155

DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.455	Anderson-Darling GOF Test
5% A-D Critical Value	0.745	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.179	Kolmogorov-Smirnov GOF
5% K-S Critical Value	0.249	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	1.611	k star (bias corrected MLE)	1.264
Theta hat (MLE)	0.0404	Theta star (bias corrected MLE)	0.0515
nu hat (MLE)	38.66	nu star (bias corrected)	30.33
MLE Mean (bias corrected)	0.0651		
MLE Sd (bias corrected)	0.0579	95% Percentile of Chisquare (2kstar)	6.978

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	0.0321
Maximum	0.193	Median	0.01
SD	0.0444	CV	1.386
k hat (MLE)	1.041	k star (bias corrected MLE)	0.959
Theta hat (MLE)	0.0308	Theta star (bias corrected MLE)	0.0334
nu hat (MLE)	62.47	nu star (bias corrected)	57.56
MLE Mean (bias corrected)	0.0321	MLE Sd (bias corrected)	0.0327
95% Percentile of Chisquare (2kstar)	5.833	90% Percentile	0.0746
95% Percentile	0.0974	99% Percentile	0.151

The following statistics are computed using Gamma ROS Statistics on Imputed Data

Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods

	WH	HW		WH	HW
95% Approx. Gamma UTL with 95% Coverage	0.132	0.134	95% Approx. Gamma UPL	0.0962	0.095
95% Gamma USL	0.179	0.188			

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	0.0357	SD (KM)	0.0424
Variance (KM)	0.0018	SE of Mean (KM)	0.00817
k hat (KM)	0.708	k star (KM)	0.659
nu hat (KM)	42.47	nu star (KM)	39.55
theta hat (KM)	0.0504	theta star (KM)	0.0541
80% gamma percentile (KM)	0.0587	90% gamma percentile (KM)	0.0908
95% gamma percentile (KM)	0.124	99% gamma percentile (KM)	0.204

The following statistics are computed using gamma distribution and KM estimates

Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods

	WH	HW		WH	HW
95% Approx. Gamma UTL with 95% Coverage	0.129	0.13	95% Approx. Gamma UPL	0.097	0.0958
95% KM Gamma Percentile	0.0922	0.0908	95% Gamma USL	0.17	0.177

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.925	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.859	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.155	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.243	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects

Mean in Original Scale	0.0316	Mean in Log Scale	-4.069
SD in Original Scale	0.0447	SD in Log Scale	1.02
95% UTL95% Coverage	0.164	95% BCA UTL95% Coverage	0.193
95% Bootstrap (%) UTL95% Coverage	0.193	95% UPL (t)	0.0995
90% Percentile (z)	0.0632	95% Percentile (z)	0.0915
99% Percentile (z)	0.183	95% USL	0.281

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean of Logged Data	-3.745	95% KM UTL (Lognormal)95% Coverage	0.138
KM SD of Logged Data	0.795	95% KM UPL (Lognormal)	0.0932
95% KM Percentile Lognormal (z)	0.0873	95% KM USL (Lognormal)	0.209

Background DL/2 Statistics Assuming Lognormal Distribution

Mean in Original Scale	0.0362	Mean in Log Scale	-3.798
SD in Original Scale	0.0433	SD in Log Scale	0.943
95% UTL95% Coverage	0.182	95% UPL (t)	0.114
90% Percentile (z)	0.0751	95% Percentile (z)	0.106
99% Percentile (z)	0.201	95% USL	0.299

DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.

Nonparametric Distribution Free Background Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

```
                    Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)
                              Order of Statistic, r    30                              95% UTL with95% Coverage    0.193
                  Approx, f used to compute achieved CC    1.579   Approximate Actual Confidence Coefficient achieved by UTL    0.785
      Approximate Sample Size needed to achieve specified CC    59                                               95% UPL    0.166
                                         95% USL    0.193                                     95% KM Chebyshev UPL    0.223

        Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
         Therefore, one may use USL to estimate a BTV only when the data set represents a background data set  free of outliers
                             and consists of observations collected from clean unimpacted locations.
                  The use of USL tends to provide a balance between false positives and false negatives provided the data
                 represents a background data set and when many onsite observations need to be compared with the BTV.

Molybdenum

                                                    General Statistics
                      Total Number of Observations    30                        Number of Missing Observations    0
                   Number of Distinct Observations    30
                               Number of Detects    29                                 Number of Non-Detects    1
                      Number of Distinct Detects    29                        Number of Distinct Non-Detects    1
                                  Minimum Detect    0.273                               Minimum Non-Detect    0.182
                                  Maximum Detect    1.74                                Maximum Non-Detect    0.182
                               Variance Detected    0.0846                              Percent Non-Detects    3.333%
                                   Mean Detected    0.701                                      SD Detected    0.291
                    Mean of Detected Logged Data    -0.432                     SD of Detected Logged Data    0.403

                              Critical Values for Background Threshold Values (BTVs)
                      Tolerance Factor K (For UTL)    2.22                                   d2max (for USL)    2.745

                                           Normal GOF Test on Detects Only
                        Shapiro Wilk Test Statistic    0.888                    Shapiro Wilk GOF Test
                      5% Shapiro Wilk Critical Value    0.926          Data Not Normal at 5% Significance Level
                           Lilliefors Test Statistic    0.136                      Lilliefors GOF Test
                        5% Lilliefors Critical Value    0.161    Detected Data appear Normal at 5% Significance Level
                               Detected Data appear Approximate Normal at 5% Significance Level

                          Kaplan Meier (KM) Background Statistics Assuming Normal Distribution
                                         KM Mean    0.684                                            KM SD    0.296
                            95% UTL95% Coverage    1.341                                   95% KM UPL (t)    1.195
                            90% KM Percentile (z)    1.063                             95% KM Percentile (z)    1.171
                            99% KM Percentile (z)    1.373                                       95% KM USL    1.497

                          DL/2 Substitution Background Statistics Assuming Normal Distribution
                                            Mean    0.681                                               SD    0.307
                            95% UTL95% Coverage    1.362                                      95% UPL (t)    1.211
```

90% Percentile (z)	1.074	95% Percentile (z)	1.185
99% Percentile (z)	1.395	95% USL	1.523

DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.432	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.747	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.1	**Kolmogorov-Smirnov GOF**
5% K-S Critical Value	0.163	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	6.645	k star (bias corrected MLE)	5.981
Theta hat (MLE)	0.106	Theta star (bias corrected MLE)	0.117
nu hat (MLE)	385.4	nu star (bias corrected)	346.9
MLE Mean (bias corrected)	0.701		
MLE Sd (bias corrected)	0.287	95% Percentile of Chisquare (2kstar)	20.97

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.169	Mean	0.683
Maximum	1.74	Median	0.682
SD	0.302	CV	0.442
k hat (MLE)	5.353	k star (bias corrected MLE)	4.84
Theta hat (MLE)	0.128	Theta star (bias corrected MLE)	0.141
nu hat (MLE)	321.2	nu star (bias corrected)	290.4
MLE Mean (bias corrected)	0.683	MLE Sd (bias corrected)	0.311
95% Percentile of Chisquare (2kstar)	17.86	90% Percentile	1.099
95% Percentile	1.261	99% Percentile	1.604

The following statistics are computed using Gamma ROS Statistics on Imputed Data

Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods

	WH	HW		WH	HW
95% Approx. Gamma UTL with 95% Coverage	1.515	1.557	95% Approx. Gamma UPL	1.278	1.298
95% Gamma USL	1.799	1.874			

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	0.684	SD (KM)	0.296
Variance (KM)	0.0877	SE of Mean (KM)	0.055
k hat (KM)	5.333	k star (KM)	4.822
nu hat (KM)	320	nu star (KM)	289.3
theta hat (KM)	0.128	theta star (KM)	0.142

80% gamma percentile (KM)	0.923	90% gamma percentile (KM)	1.101
95% gamma percentile (KM)	1.263	99% gamma percentile (KM)	1.607

The following statistics are computed using gamma distribution and KM estimates

Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods

	WH	HW		WH	HW
95% Approx. Gamma UTL with 95% Coverage	1.489	1.526	95% Approx. Gamma UPL	1.26	1.278
95% KM Gamma Percentile	1.224	1.239	95% Gamma USL	1.762	1.83

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.964	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.926	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.127	Lilliefors GOF Test
5% Lilliefors Critical Value	0.161	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects

Mean in Original Scale	0.686	Mean in Log Scale	-0.465
SD in Original Scale	0.298	SD in Log Scale	0.436
95% UTL95% Coverage	1.652	95% BCA UTL95% Coverage	1.74
95% Bootstrap (%) UTL95% Coverage	1.74	95% UPL (t)	1.333
90% Percentile (z)	1.097	95% Percentile (z)	1.286
99% Percentile (z)	1.73	95% USL	2.076

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean of Logged Data	-0.475	95% KM UTL (Lognormal)95% Coverage	1.694
KM SD of Logged Data	0.451	95% KM UPL (Lognormal)	1.356
95% KM Percentile Lognormal (z)	1.307	95% KM USL (Lognormal)	2.147

Background DL/2 Statistics Assuming Lognormal Distribution

Mean in Original Scale	0.681	Mean in Log Scale	-0.498
SD in Original Scale	0.307	SD in Log Scale	0.534
95% UTL95% Coverage	1.99	95% UPL (t)	1.53
90% Percentile (z)	1.206	95% Percentile (z)	1.464
99% Percentile (z)	2.107	95% USL	2.635

DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.

Nonparametric Distribution Free Background Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)

Order of Statistic, r	30	95% UTL with95% Coverage	1.74
Approx, f used to compute achieved CC	1.579	Approximate Actual Confidence Coefficient achieved by UTL	0.785
Approximate Sample Size needed to achieve specified CC	59	95% UPL	1.421
95% USL	1.74	95% KM Chebyshev UPL	1.996

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Nickel

General Statistics

Total Number of Observations	30	Number of Distinct Observations	30
Minimum	5.94	First Quartile	8.713
Second Largest	21.3	Median	14.45
Maximum	23.3	Third Quartile	17.55
Mean	13.84	SD	5.087
Coefficient of Variation	0.368	Skewness	0.0143
Mean of logged Data	2.553	SD of logged Data	0.405

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

Normal GOF Test

Shapiro Wilk Test Statistic	0.946	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.136	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.159	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Background Statistics Assuming Normal Distribution

95% UTL with 95% Coverage	25.13	90% Percentile (z)	20.36
95% UPL (t)	22.63	95% Percentile (z)	22.21
95% USL	27.8	99% Percentile (z)	25.67

Gamma GOF Test

A-D Test Statistic	0.672	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.746	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.131	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.16	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	6.916	k star (bias corrected MLE)	6.246
Theta hat (MLE)	2.001	Theta star (bias corrected MLE)	2.216
nu hat (MLE)	414.9	nu star (bias corrected)	374.8
MLE Mean (bias corrected)	13.84	MLE Sd (bias corrected)	5.537

```
                                  Background Statistics Assuming Gamma Distribution
      95% Wilson Hilferty (WH) Approx. Gamma UPL    24.33                                    90% Percentile    21.24
     95% Hawkins Wixley (HW) Approx. Gamma UPL    24.66                                    95% Percentile    24.02
    95% WH Approx. Gamma UTL with   95% Coverage    28.39                                    99% Percentile    29.85
    95% HW Approx. Gamma UTL with   95% Coverage    29.04
                                     95% WH USL    33.18                                    95% HW USL    34.32

                                               Lognormal GOF Test
                      Shapiro Wilk Test Statistic     0.926              Shapiro Wilk Lognormal GOF Test
                 5% Shapiro Wilk Critical Value     0.927           Data Not Lognormal at 5% Significance Level
                        Lilliefors Test Statistic     0.143                 Lilliefors Lognormal GOF Test
                      5% Lilliefors Critical Value     0.159         Data appear Lognormal at 5% Significance Level
                              Data appear Approximate Lognormal at 5% Significance Level

                                 Background Statistics assuming Lognormal Distribution
                    95% UTL with   95% Coverage    31.6                                  90% Percentile (z)    21.6
                                      95% UPL (t)    25.88                                 95% Percentile (z)    25.03
                                         95% USL    39.1                                  99% Percentile (z)    32.99

                                  Nonparametric Distribution Free Background Statistics
                                        Data appear Normal at 5% Significance Level

                               Nonparametric Upper Limits for Background Threshold Values
                            Order of Statistic, r    30                         95% UTL with   95% Coverage    23.3
             Approx, f used to compute achieved CC     1.579   Approximate Actual Confidence Coefficient achieved by UTL     0.785
                                                                Approximate Sample Size needed to achieve specified CC    59
    95% Percentile Bootstrap UTL with   95% Coverage    23.3             95% BCA Bootstrap UTL with   95% Coverage    23.3
                                          95% UPL    22.2                                         90% Percentile    20.29
                                90% Chebyshev UPL    29.35                                        95% Percentile    21.21
                                95% Chebyshev UPL    36.38                                        99% Percentile    22.72
                                          95% USL    23.3

          Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
           Therefore, one may use USL to estimate a BTV only when the data set represents a background data set  free of outliers
                                      and consists of observations collected from clean unimpacted locations.
                   The use of USL tends to provide a balance between false positives and false negatives provided the data
                   represents a background data set and when many onsite observations need to be compared with the BTV.

Selenium

General Statistics
                     Total Number of Observations    30                         Number of Distinct Observations    28
                                          Minimum     0.272                                        First Quartile     0.538
                                   Second Largest     1.19                                                Median     0.755
```

Maximum	1.34	Third Quartile	0.942
Mean	0.751	SD	0.277
Coefficient of Variation	0.369	Skewness	0.15
Mean of logged Data	-0.361	SD of logged Data	0.41

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

Normal GOF Test

Shapiro Wilk Test Statistic	0.975	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.081	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.159	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Background Statistics Assuming Normal Distribution

95% UTL with 95% Coverage	1.366	90% Percentile (z)	1.106
95% UPL (t)	1.229	95% Percentile (z)	1.206
95% USL	1.511	99% Percentile (z)	1.395

Gamma GOF Test

A-D Test Statistic	0.283	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.746	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.0947	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.16	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	6.871	k star (bias corrected MLE)	6.206
Theta hat (MLE)	0.109	Theta star (bias corrected MLE)	0.121
nu hat (MLE)	412.2	nu star (bias corrected)	372.3
MLE Mean (bias corrected)	0.751	MLE Sd (bias corrected)	0.301

Background Statistics Assuming Gamma Distribution

95% Wilson Hilferty (WH) Approx. Gamma UPL	1.322	90% Percentile	1.154
95% Hawkins Wixley (HW) Approx. Gamma UPL	1.341	95% Percentile	1.306
95% WH Approx. Gamma UTL with 95% Coverage	1.543	99% Percentile	1.623
95% HW Approx. Gamma UTL with 95% Coverage	1.58		
95% WH USL	1.803	95% HW USL	1.868

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.952	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.106	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.159	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Background Statistics assuming Lognormal Distribution

95% UTL with 95% Coverage	1.73	90% Percentile (z)	1.178
95% UPL (t)	1.414	95% Percentile (z)	1.367
95% USL	2.146	99% Percentile (z)	1.807

Nonparametric Distribution Free Background Statistics

Data appear Normal at 5% Significance Level

Nonparametric Upper Limits for Background Threshold Values

Order of Statistic, r	30	95% UTL with 95% Coverage	1.34
Approx, f used to compute achieved CC	1.579	Approximate Actual Confidence Coefficient achieved by UTL	0.785
		Approximate Sample Size needed to achieve specified CC	59
95% Percentile Bootstrap UTL with 95% Coverage	1.34	95% BCA Bootstrap UTL with 95% Coverage	1.34
95% UPL	1.258	90% Percentile	1.091
90% Chebyshev UPL	1.595	95% Percentile	1.15
95% Chebyshev UPL	1.978	99% Percentile	1.297
95% USL	1.34		

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Silver

General Statistics

Total Number of Observations	30	Number of Missing Observations	0
Number of Distinct Observations	29		
Number of Detects	23	Number of Non-Detects	7
Number of Distinct Detects	23	Number of Distinct Non-Detects	6
Minimum Detect	0.038	Minimum Non-Detect	0.0291
Maximum Detect	1.25	Maximum Non-Detect	0.0338
Variance Detected	0.0785	Percent Non-Detects	23.33%
Mean Detected	0.196	SD Detected	0.28
Mean of Detected Logged Data	-2.189	SD of Detected Logged Data	0.958

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.588	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.914	Data Not Normal at 5% Significance Level

Lilliefors Test Statistic	0.351	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.18	Data Not Normal at 5% Significance Level	

Data Not Normal at 5% Significance Level

Kaplan Meier (KM) Background Statistics Assuming Normal Distribution

KM Mean	0.157	KM SD	0.25
95% UTL95% Coverage	0.712	95% KM UPL (t)	0.589
90% KM Percentile (z)	0.478	95% KM Percentile (z)	0.569
99% KM Percentile (z)	0.739	95% KM USL	0.844

DL/2 Substitution Background Statistics Assuming Normal Distribution

Mean	0.154	SD	0.256
95% UTL95% Coverage	0.723	95% UPL (t)	0.596
90% Percentile (z)	0.482	95% Percentile (z)	0.575
99% Percentile (z)	0.75	95% USL	0.857

DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	2.113	**Anderson-Darling GOF Test**	
5% A-D Critical Value	0.769	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.294	**Kolmogorov-Smirnov GOF**	
5% K-S Critical Value	0.187	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	1.026	k star (bias corrected MLE)	0.921
Theta hat (MLE)	0.191	Theta star (bias corrected MLE)	0.213
nu hat (MLE)	47.21	nu star (bias corrected)	42.39
MLE Mean (bias corrected)	0.196		
MLE Sd (bias corrected)	0.204	95% Percentile of Chisquare (2kstar)	5.683

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	0.153
Maximum	1.25	Median	0.0664
SD	0.257	CV	1.681
k hat (MLE)	0.692	k star (bias corrected MLE)	0.645
Theta hat (MLE)	0.221	Theta star (bias corrected MLE)	0.237
nu hat (MLE)	41.54	nu star (bias corrected)	38.72
MLE Mean (bias corrected)	0.153	MLE Sd (bias corrected)	0.19
95% Percentile of Chisquare (2kstar)	4.524	90% Percentile	0.391

```
                                     95% Percentile     0.536                                    99% Percentile     0.883
                            The following statistics are computed using Gamma ROS Statistics on Imputed Data
                               Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods
                                               WH        HW                                               WH        HW
 95% Approx. Gamma UTL with 95% Coverage      0.744     0.79                  95% Approx. Gamma UPL      0.517     0.525
                         95% Gamma USL      1.049     1.17

                                        Estimates of Gamma Parameters using KM Estimates
                                          Mean (KM)     0.157                                         SD (KM)     0.25
                                      Variance (KM)     0.0625                                SE of Mean (KM)     0.0467
                                         k hat (KM)     0.395                                      k star (KM)     0.378
                                        nu hat (KM)     23.73                                     nu star (KM)     22.69
                                     theta hat (KM)     0.398                                   theta star (KM)     0.416
                            80% gamma percentile (KM)     0.252                       90% gamma percentile (KM)     0.449
                            95% gamma percentile (KM)     0.666                       99% gamma percentile (KM)     1.217

                             The following statistics are computed using gamma distribution and KM estimates
                               Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods
                                               WH        HW                                               WH        HW
 95% Approx. Gamma UTL with 95% Coverage      0.666     0.674                 95% Approx. Gamma UPL      0.478     0.47
               95% KM Gamma Percentile      0.451     0.441                         95% Gamma USL      0.915     0.959

                                        Lognormal GOF Test on Detected Observations Only
                        Shapiro Wilk Test Statistic     0.863                       Shapiro Wilk GOF Test
                      5% Shapiro Wilk Critical Value     0.914          Data Not Lognormal at 5% Significance Level
                           Lilliefors Test Statistic     0.221                        Lilliefors GOF Test
                        5% Lilliefors Critical Value     0.18           Data Not Lognormal at 5% Significance Level
                                           Data Not Lognormal at 5% Significance Level

                     Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects
                               Mean in Original Scale     0.154                               Mean in Log Scale    -2.687
                                 SD in Original Scale     0.256                                 SD in Log Scale     1.243
                                 95% UTL95% Coverage     1.075                          95% BCA UTL95% Coverage     1.25
                     95% Bootstrap (%) UTL95% Coverage     1.25                                     95% UPL (t)     0.583
                                   90% Percentile (z)     0.335                              95% Percentile (z)     0.526
                                   99% Percentile (z)     1.227                                         95% USL     2.066

                            Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution
                              KM Mean of Logged Data    -2.503              95% KM UTL (Lognormal)95% Coverage     0.752
                                KM SD of Logged Data     0.999                           95% KM UPL (Lognormal)     0.459
                     95% KM Percentile Lognormal (z)     0.423                           95% KM USL (Lognormal)     1.27

                                       Background DL/2 Statistics Assuming Lognormal Distribution
                               Mean in Original Scale     0.154                               Mean in Log Scale    -2.65
                                 SD in Original Scale     0.256                                 SD in Log Scale     1.192
```

95% UTL95% Coverage	0.996	95% UPL (t)	0.554
90% Percentile (z)	0.325	95% Percentile (z)	0.502
99% Percentile (z)	1.131	95% USL	1.863

DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.

Nonparametric Distribution Free Background Statistics

Data do not follow a Discernible Distribution (0.05)

Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)

Order of Statistic, r	30	95% UTL with95% Coverage	1.25
Approx, f used to compute achieved CC	1.579	Approximate Actual Confidence Coefficient achieved by UTL	0.785
Approximate Sample Size needed to achieve specified CC	59	95% UPL	0.888
95% USL	1.25	95% KM Chebyshev UPL	1.265

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Sulfate

General Statistics

Total Number of Observations	30	Number of Missing Observations	0
Number of Distinct Observations	29		
Number of Detects	23	Number of Non-Detects	7
Number of Distinct Detects	22	Number of Distinct Non-Detects	7
Minimum Detect	9.28	Minimum Non-Detect	7.18
Maximum Detect	215	Maximum Non-Detect	8.26
Variance Detected	2053	Percent Non-Detects	23.33%
Mean Detected	37.8	SD Detected	45.31
Mean of Detected Logged Data	3.241	SD of Detected Logged Data	0.82

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.616	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.914	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.292	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.18	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Kaplan Meier (KM) Background Statistics Assuming Normal Distribution

KM Mean	30.66	KM SD	40.91

95% UTL95% Coverage	121.5	95% KM UPL (t)	101.3
90% KM Percentile (z)	83.08	95% KM Percentile (z)	97.95
99% KM Percentile (z)	125.8	95% KM USL	143

DL/2 Substitution Background Statistics Assuming Normal Distribution

Mean	29.87	SD	42.09
95% UTL95% Coverage	123.3	95% UPL (t)	102.6
90% Percentile (z)	83.81	95% Percentile (z)	99.1
99% Percentile (z)	127.8	95% USL	145.4

DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	1.144	Anderson-Darling GOF Test
5% A-D Critical Value	0.762	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.185	Kolmogorov-Smirnov GOF
5% K-S Critical Value	0.185	Detected data appear Gamma Distributed at 5% Significance Level

Detected data follow Appr. Gamma Distribution at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	1.422	k star (bias corrected MLE)	1.265
Theta hat (MLE)	26.59	Theta star (bias corrected MLE)	29.88
nu hat (MLE)	65.39	nu star (bias corrected)	58.2
MLE Mean (bias corrected)	37.8		
MLE Sd (bias corrected)	33.61	95% Percentile of Chisquare (2kstar)	6.983

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	28.98
Maximum	215	Median	15.1
SD	42.69	CV	1.473
k hat (MLE)	0.345	k star (bias corrected MLE)	0.332
Theta hat (MLE)	84.11	Theta star (bias corrected MLE)	87.21
nu hat (MLE)	20.67	nu star (bias corrected)	19.94
MLE Mean (bias corrected)	28.98	MLE Sd (bias corrected)	50.28
95% Percentile of Chisquare (2kstar)	2.941	90% Percentile	84.34
95% Percentile	128.2	99% Percentile	240.9

The following statistics are computed using Gamma ROS Statistics on Imputed Data

Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods

	WH	HW		WH	HW
95% Approx. Gamma UTL with 95% Coverage	182.9	249.3	95% Approx. Gamma UPL	121.2	149.9
95% Gamma USL	268.5	402.7			

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	30.66	SD (KM)	40.91
Variance (KM)	1674	SE of Mean (KM)	7.637
k hat (KM)	0.562	k star (KM)	0.528
nu hat (KM)	33.69	nu star (KM)	31.66
theta hat (KM)	54.59	theta star (KM)	58.1
80% gamma percentile (KM)	50.45	90% gamma percentile (KM)	82.01
95% gamma percentile (KM)	115.5	99% gamma percentile (KM)	197.5

The following statistics are computed using gamma distribution and KM estimates

Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods

	WH	HW		WH	HW
95% Approx. Gamma UTL with 95% Coverage	116.9	119.2	95% Approx. Gamma UPL	86.68	86.11
95% KM Gamma Percentile	82.2	81.34	95% Gamma USL	156.2	164

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.925	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.914	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.138	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.18	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects

Mean in Original Scale	29.91	Mean in Log Scale	2.806
SD in Original Scale	42.07	SD in Log Scale	1.074
95% UTL95% Coverage	179.4	95% BCA UTL95% Coverage	215
95% Bootstrap (%) UTL95% Coverage	215	95% UPL (t)	105.7
90% Percentile (z)	65.5	95% Percentile (z)	96.75
99% Percentile (z)	201.1	95% USL	315.3

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean of Logged Data	2.945	95% KM UTL (Lognormal)95% Coverage	135.2
KM SD of Logged Data	0.884	95% KM UPL (Lognormal)	87.47
95% KM Percentile Lognormal (z)	81.33	95% KM USL (Lognormal)	215

Background DL/2 Statistics Assuming Lognormal Distribution

Mean in Original Scale	29.87	Mean in Log Scale	2.797
SD in Original Scale	42.09	SD in Log Scale	1.086
95% UTL95% Coverage	182.8	95% UPL (t)	107.1
90% Percentile (z)	65.98	95% Percentile (z)	97.89
99% Percentile (z)	205.2	95% USL	323.4

DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.

Nonparametric Distribution Free Background Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)

Order of Statistic, r	30	95% UTL with95% Coverage	215
Approx, f used to compute achieved CC	1.579	Approximate Actual Confidence Coefficient achieved by UTL	0.785
Approximate Sample Size needed to achieve specified CC	59	95% UPL	154
95% USL	215	95% KM Chebyshev UPL	211.9

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Thallium

General Statistics

Total Number of Observations	30	Number of Missing Observations	0
Number of Distinct Observations	30		
Number of Detects	28	Number of Non-Detects	2
Number of Distinct Detects	28	Number of Distinct Non-Detects	2
Minimum Detect	0.0555	Minimum Non-Detect	0.114
Maximum Detect	0.558	Maximum Non-Detect	0.238
Variance Detected	0.0206	Percent Non-Detects	6.667%
Mean Detected	0.268	SD Detected	0.144
Mean of Detected Logged Data	-1.475	SD of Detected Logged Data	0.608

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.938	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.924	Detected Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.109	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.164	Detected Data appear Normal at 5% Significance Level

Detected Data appear Normal at 5% Significance Level

Kaplan Meier (KM) Background Statistics Assuming Normal Distribution

KM Mean	0.258	KM SD	0.143
95% UTL95% Coverage	0.574	95% KM UPL (t)	0.504
90% KM Percentile (z)	0.44	95% KM Percentile (z)	0.492
99% KM Percentile (z)	0.589	95% KM USL	0.649

DL/2 Substitution Background Statistics Assuming Normal Distribution

Mean	0.256	SD	0.146

95% UTL95% Coverage	0.581	95% UPL (t)	0.509
90% Percentile (z)	0.444	95% Percentile (z)	0.497
99% Percentile (z)	0.596	95% USL	0.658

DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.249	Anderson-Darling GOF Test
5% A-D Critical Value	0.752	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.0814	Kolmogorov-Smirnov GOF
5% K-S Critical Value	0.166	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	3.305	k star (bias corrected MLE)	2.975
Theta hat (MLE)	0.0812	Theta star (bias corrected MLE)	0.0902
nu hat (MLE)	185.1	nu star (bias corrected)	166.6
MLE Mean (bias corrected)	0.268		
MLE Sd (bias corrected)	0.156	95% Percentile of Chisquare (2kstar)	12.52

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.0555	Mean	0.258
Maximum	0.558	Median	0.238
SD	0.145	CV	0.561
k hat (MLE)	3.076	k star (bias corrected MLE)	2.791
Theta hat (MLE)	0.0838	Theta star (bias corrected MLE)	0.0923
nu hat (MLE)	184.6	nu star (bias corrected)	167.5
MLE Mean (bias corrected)	0.258	MLE Sd (bias corrected)	0.154
95% Percentile of Chisquare (2kstar)	11.96	90% Percentile	0.465
95% Percentile	0.552	99% Percentile	0.743

The following statistics are computed using Gamma ROS Statistics on Imputed Data

Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods

	WH	HW		WH	HW
95% Approx. Gamma UTL with 95% Coverage	0.697	0.727	95% Approx. Gamma UPL	0.563	0.577
95% Gamma USL	0.86	0.917			

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	0.258	SD (KM)	0.143
Variance (KM)	0.0203	SE of Mean (KM)	0.0266
k hat (KM)	3.267	k star (KM)	2.962
nu hat (KM)	196	nu star (KM)	177.7

theta hat (KM)	0.0789	theta star (KM)	0.087
80% gamma percentile (KM)	0.368	90% gamma percentile (KM)	0.458
95% gamma percentile (KM)	0.543	99% gamma percentile (KM)	0.726

The following statistics are computed using gamma distribution and KM estimates

Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods

	WH	HW		WH	HW
95% Approx. Gamma UTL with 95% Coverage	0.692	0.722	95% Approx. Gamma UPL	0.56	0.574
95% KM Gamma Percentile	0.539	0.552	95% Gamma USL	0.853	0.91

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.953	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.924	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.116	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.164	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects

Mean in Original Scale	0.258	Mean in Log Scale	-1.525
SD in Original Scale	0.144	SD in Log Scale	0.621
95% UTL95% Coverage	0.864	95% BCA UTL95% Coverage	0.558
95% Bootstrap (%) UTL95% Coverage	0.558	95% UPL (t)	0.636
90% Percentile (z)	0.482	95% Percentile (z)	0.605
99% Percentile (z)	0.923	95% USL	1.197

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean of Logged Data	-1.531	95% KM UTL (Lognormal)95% Coverage	0.869
KM SD of Logged Data	0.626	95% KM UPL (Lognormal)	0.638
95% KM Percentile Lognormal (z)	0.606	95% KM USL (Lognormal)	1.208

Background DL/2 Statistics Assuming Lognormal Distribution

Mean in Original Scale	0.256	Mean in Log Scale	-1.543
SD in Original Scale	0.146	SD in Log Scale	0.649
95% UTL95% Coverage	0.903	95% UPL (t)	0.656
90% Percentile (z)	0.491	95% Percentile (z)	0.622
99% Percentile (z)	0.968	95% USL	1.27

DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.

Nonparametric Distribution Free Background Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)

Order of Statistic, r	30	95% UTL with95% Coverage	0.558
Approx, f used to compute achieved CC	1.579	Approximate Actual Confidence Coefficient achieved by UTL	0.785
Approximate Sample Size needed to achieve specified CC	59	95% UPL	0.551

95% USL	0.558	95% KM Chebyshev UPL	0.89

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Vanadium

General Statistics

Total Number of Observations	30	Number of Distinct Observations	28
Minimum	5.75	First Quartile	9.53
Second Largest	26.2	Median	17.65
Maximum	26.3	Third Quartile	20.38
Mean	16.12	SD	6.458
Coefficient of Variation	0.401	Skewness	-0.0982
Mean of logged Data	2.687	SD of logged Data	0.46

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

Normal GOF Test

Shapiro Wilk Test Statistic	0.917	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.167	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.159	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Background Statistics Assuming Normal Distribution

95% UTL with 95% Coverage	30.45	90% Percentile (z)	24.39
95% UPL (t)	27.27	95% Percentile (z)	26.74
95% USL	33.85	99% Percentile (z)	31.14

Gamma GOF Test

A-D Test Statistic	1.172	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.746	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.216	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.16	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	5.547	k star (bias corrected MLE)	5.014
Theta hat (MLE)	2.906	Theta star (bias corrected MLE)	3.215
nu hat (MLE)	332.8	nu star (bias corrected)	300.8

MLE Mean (bias corrected)	16.12	MLE Sd (bias corrected)	7.198

Background Statistics Assuming Gamma Distribution

95% Wilson Hilferty (WH) Approx. Gamma UPL	29.94	90% Percentile	25.75
95% Hawkins Wixley (HW) Approx. Gamma UPL	30.46	95% Percentile	29.49
95% WH Approx. Gamma UTL with 95% Coverage	35.43	99% Percentile	37.37
95% HW Approx. Gamma UTL with 95% Coverage	36.47		
95% WH USL	41.98	95% HW USL	43.82

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.893	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.234	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.159	Data Not Lognormal at 5% Significance Level

Data Not Lognormal at 5% Significance Level

Background Statistics assuming Lognormal Distribution

95% UTL with 95% Coverage	40.78	90% Percentile (z)	26.48
95% UPL (t)	32.51	95% Percentile (z)	31.3
95% USL	51.92	99% Percentile (z)	42.82

Nonparametric Distribution Free Background Statistics

Data do not follow a Discernible Distribution (0.05)

Nonparametric Upper Limits for Background Threshold Values

Order of Statistic, r	30	95% UTL with 95% Coverage	26.3
Approx, f used to compute achieved CC	1.579	Approximate Actual Confidence Coefficient achieved by UTL	0.785
		Approximate Sample Size needed to achieve specified CC	59
95% Percentile Bootstrap UTL with 95% Coverage	26.3	95% BCA Bootstrap UTL with 95% Coverage	26.3
95% UPL	26.25	90% Percentile	24.64
90% Chebyshev UPL	35.81	95% Percentile	26.07
95% Chebyshev UPL	44.73	99% Percentile	26.27
95% USL	26.3		

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Zinc

General Statistics

Total Number of Observations	30	Number of Distinct Observations	27
Minimum	11.3	First Quartile	30.45

```
                          Second Largest   70.9                                       Median   49.65
                                 Maximum   91.1                               Third Quartile   56.13
                                    Mean   45.09                                          SD   19.58
                Coefficient of Variation    0.434                                   Skewness   0.00876
                     Mean of logged Data    3.691                           SD of logged Data   0.533

                     Critical Values for Background Threshold Values (BTVs)
               Tolerance Factor K (For UTL)  2.22                            d2max (for USL)   2.745

                                           Normal GOF Test
              Shapiro Wilk Test Statistic   0.961                    Shapiro Wilk GOF Test
           5% Shapiro Wilk Critical Value   0.927          Data appear Normal at 5% Significance Level
                 Lilliefors Test Statistic   0.12                       Lilliefors GOF Test
            5% Lilliefors Critical Value   0.159          Data appear Normal at 5% Significance Level
                          Data appear Normal at 5% Significance Level

                        Background Statistics Assuming Normal Distribution
         95% UTL with   95% Coverage   88.56                             90% Percentile (z)   70.18
                          95% UPL (t)   78.91                             95% Percentile (z)   77.3
                             95% USL   98.85                             99% Percentile (z)   90.64

                                           Gamma GOF Test
                        A-D Test Statistic   0.874            Anderson-Darling Gamma GOF Test
                       5% A-D Critical Value   0.748     Data Not Gamma Distributed at 5% Significance Level
                        K-S Test Statistic   0.176           Kolmogorov-Smirnov Gamma GOF Test
                       5% K-S Critical Value   0.161     Data Not Gamma Distributed at 5% Significance Level
                      Data Not Gamma Distributed at 5% Significance Level

                                           Gamma Statistics
                              k hat (MLE)   4.416                  k star (bias corrected MLE)   3.997
                          Theta hat (MLE)   10.21             Theta star (bias corrected MLE)   11.28
                             nu hat (MLE)   265                      nu star (bias corrected)   239.8
                  MLE Mean (bias corrected)   45.09                     MLE Sd (bias corrected)   22.55

                        Background Statistics Assuming Gamma Distribution
    95% Wilson Hilferty (WH) Approx. Gamma UPL   88.93                          90% Percentile   75.31
     95% Hawkins Wixley (HW) Approx. Gamma UPL   91.17                          95% Percentile   87.41
  95% WH Approx. Gamma UTL with   95% Coverage   106.9                          99% Percentile   113.3
  95% HW Approx. Gamma UTL with   95% Coverage   111.3
                                   95% WH USL   128.6                              95% HW USL   136.1

                                         Lognormal GOF Test
              Shapiro Wilk Test Statistic   0.907               Shapiro Wilk Lognormal GOF Test
           5% Shapiro Wilk Critical Value   0.927          Data Not Lognormal at 5% Significance Level
                 Lilliefors Test Statistic   0.195                 Lilliefors Lognormal GOF Test
```

```
                5% Lilliefors Critical Value    0.159              Data Not Lognormal at 5% Significance Level
                                Data Not Lognormal at 5% Significance Level

                            Background Statistics assuming Lognormal Distribution
             95% UTL with  95% Coverage   130.8                                  90% Percentile (z)   79.36
                              95% UPL (t)   100.6                                  95% Percentile (z)   96.3
                                 95% USL   173.1                                  99% Percentile (z)   138.5

                            Nonparametric Distribution Free Background Statistics
                                Data appear Normal at 5% Significance Level

                          Nonparametric Upper Limits for Background Threshold Values
                       Order of Statistic, r    30                          95% UTL with   95% Coverage    91.1
         Approx, f used to compute achieved CC    1.579   Approximate Actual Confidence Coefficient achieved by UTL    0.785
                                                            Approximate Sample Size needed to achieve specified CC    59
  95% Percentile Bootstrap UTL with  95% Coverage    91.1                  95% BCA Bootstrap UTL with   95% Coverage    91.1
                                  95% UPL    79.99                                       90% Percentile    66.29
                         90% Chebyshev UPL   104.8                                       95% Percentile    69.6
                         95% Chebyshev UPL   131.9                                       99% Percentile    85.24
                                  95% USL    91.1

       Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
        Therefore, one may use USL to estimate a BTV only when the data set represents a background data set  free of outliers
                          and consists of observations collected from clean unimpacted locations.
           The use of USL tends to provide a balance between false positives and false negatives provided the data
          represents a background data set and when many onsite observations need to be compared with the BTV.

                      Background Statistics for Data Sets with Non-Detects
      User Selected Options
     Date/Time of Computation    ProUCL 5.112/16/2019 4:10:17 PM
                    From File    ProUCL_Input_RAD.xls
               Full Precision    OFF
       Confidence Coefficient    95%
                     Coverage    95%
Different or Future K Observations    1
  Number of Bootstrap Operations    2000

Radium-226

General Statistics
                Total Number of Observations    30                  Number of Distinct Observations    27
                                     Minimum    0.566                                First Quartile    0.838
                              Second Largest    1.88                                         Median    1.145
                                     Maximum    3.27                                 Third Quartile    1.413
                                        Mean    1.201                                            SD    0.519
```

Coefficient of Variation	0.432	Skewness	2.144
Mean of logged Data	0.109	SD of logged Data	0.386

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

Normal GOF Test

Shapiro Wilk Test Statistic	0.821	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.163	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.159	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Background Statistics Assuming Normal Distribution

95% UTL with 95% Coverage	2.355	90% Percentile (z)	1.867
95% UPL (t)	2.099	95% Percentile (z)	2.056
95% USL	2.627	99% Percentile (z)	2.41

Gamma GOF Test

A-D Test Statistic	0.481	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.746	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.116	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.16	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	6.838	k star (bias corrected MLE)	6.176
Theta hat (MLE)	0.176	Theta star (bias corrected MLE)	0.195
nu hat (MLE)	410.3	nu star (bias corrected)	370.6
MLE Mean (bias corrected)	1.201	MLE Sd (bias corrected)	0.483

Background Statistics Assuming Gamma Distribution

95% Wilson Hilferty (WH) Approx. Gamma UPL	2.112	90% Percentile	1.847
95% Hawkins Wixley (HW) Approx. Gamma UPL	2.122	95% Percentile	2.091
95% WH Approx. Gamma UTL with 95% Coverage	2.464	99% Percentile	2.6
95% HW Approx. Gamma UTL with 95% Coverage	2.496		
95% WH USL	2.882	95% HW USL	2.945

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.953	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.11	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.159	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Background Statistics assuming Lognormal Distribution

95% UTL with 95% Coverage	2.628	90% Percentile (z)	1.829
95% UPL (t)	2.172	95% Percentile (z)	2.104
95% USL	3.219	99% Percentile (z)	2.738

Nonparametric Distribution Free Background Statistics

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Upper Limits for Background Threshold Values

Order of Statistic, r	30	95% UTL with 95% Coverage	3.27
Approx, f used to compute achieved CC	1.579	Approximate Actual Confidence Coefficient achieved by UTL	0.785
		Approximate Sample Size needed to achieve specified CC	59
95% Percentile Bootstrap UTL with 95% Coverage	3.27	95% BCA Bootstrap UTL with 95% Coverage	3.27
95% UPL	2.506	90% Percentile	1.541
90% Chebyshev UPL	2.786	95% Percentile	1.772
95% Chebyshev UPL	3.503	99% Percentile	2.867
95% USL	3.27		

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

Radium-228

General Statistics

Total Number of Observations	30	Number of Distinct Observations	27
Minimum	0.565	First Quartile	0.808
Second Largest	1.7	Median	1.15
Maximum	1.74	Third Quartile	1.343
Mean	1.119	SD	0.347
Coefficient of Variation	0.31	Skewness	0.0159
Mean of logged Data	0.0605	SD of logged Data	0.337

Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL)	2.22	d2max (for USL)	2.745

Normal GOF Test

Shapiro Wilk Test Statistic	0.954	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.105	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.159	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

```
                              Background Statistics Assuming Normal Distribution
                     95% UTL with   95% Coverage      1.889                              90% Percentile (z)      1.564
                                     95% UPL (t)      1.718                              95% Percentile (z)      1.69
                                       95% USL        2.072                              99% Percentile (z)      1.926

                                                  Gamma GOF Test
                               A-D Test Statistic     0.505                Anderson-Darling Gamma GOF Test
                            5% A-D Critical Value     0.746      Detected data appear Gamma Distributed at 5% Significance Level
                               K-S Test Statistic     0.122               Kolmogorov-Smirnov Gamma GOF Test
                            5% K-S Critical Value     0.16       Detected data appear Gamma Distributed at 5% Significance Level
                        Detected data appear Gamma Distributed at 5% Significance Level

                                                  Gamma Statistics
                                      k hat (MLE)     9.866                      k star (bias corrected MLE)     8.902
                                  Theta hat (MLE)     0.113                  Theta star (bias corrected MLE)     0.126
                                     nu hat (MLE)   592                             nu star (bias corrected)   534.1
                           MLE Mean (bias corrected)  1.119                              MLE Sd (bias corrected)     0.375

                              Background Statistics Assuming Gamma Distribution
              95% Wilson Hilferty (WH) Approx. Gamma UPL  1.816                                90% Percentile      1.618
             95% Hawkins Wixley (HW) Approx. Gamma UPL    1.834                                95% Percentile      1.798
           95% WH Approx. Gamma UTL with   95% Coverage   2.074                                99% Percentile      2.17
           95% HW Approx. Gamma UTL with   95% Coverage   2.11
                                       95% WH USL     2.375                                        95% HW USL      2.436

                                                 Lognormal GOF Test
                          Shapiro Wilk Test Statistic     0.931                 Shapiro Wilk Lognormal GOF Test
                       5% Shapiro Wilk Critical Value     0.927          Data appear Lognormal at 5% Significance Level
                            Lilliefors Test Statistic     0.141                   Lilliefors Lognormal GOF Test
                         5% Lilliefors Critical Value     0.159          Data appear Lognormal at 5% Significance Level
                              Data appear Lognormal at 5% Significance Level

                             Background Statistics assuming Lognormal Distribution
                     95% UTL with   95% Coverage      2.243                              90% Percentile (z)      1.635
                                     95% UPL (t)      1.9                                95% Percentile (z)      1.848
                                         95% USL      2.676                              99% Percentile (z)      2.324

                             Nonparametric Distribution Free Background Statistics
                                   Data appear Normal at 5% Significance Level

                           Nonparametric Upper Limits for Background Threshold Values
                              Order of Statistic, r    30                         95% UTL with   95% Coverage      1.74
                  Approx, f used to compute achieved CC  1.579   Approximate Actual Confidence Coefficient achieved by UTL   0.785
                                                              Approximate Sample Size needed to achieve specified CC    59
           95% Percentile Bootstrap UTL with   95% Coverage   1.74              95% BCA Bootstrap UTL with   95% Coverage    1.74
```

```
                   95% UPL    1.718                          90% Percentile    1.617
          90% Chebyshev UPL    2.177                          95% Percentile    1.691
          95% Chebyshev UPL    2.657                          99% Percentile    1.728
                   95% USL    1.74

     Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
      Therefore, one may use USL to estimate a BTV only when the data set represents a background data set  free of outliers
                    and consists of observations collected from clean unimpacted locations.
          The use of USL tends to provide a balance between false positives and false negatives provided the data
         represents a background data set and when many onsite observations need to be compared with the BTV.

                       Background Statistics for Uncensored Full Data Sets
        User Selected Options
     Date/Time of Computation    ProUCL 5.112/20/2019 12:49:21 PM
                    From File    C:\Data\TVA\1_ALF\2_InitialDraft\2_Bkgd Data\export20191220_Ra226+228_bkgd.xlsx
               Full Precision    OFF
       Confidence Coefficient    95%
                     Coverage    95%
  New or Future K Observations    1
 Number of Bootstrap Operations    2000

Ra226228

General Statistics
          Total Number of Observations    30                Number of Distinct Observations    28
                               Minimum    1.13                                First Quartile    1.715
                        Second Largest    3.56                                        Median    2.38
                               Maximum    5.01                                Third Quartile    2.77
                                  Mean    2.32                                            SD    0.816
                 Coefficient of Variation    0.352                                      Skewness    1.049
                     Mean of logged Data    0.783                            SD of logged Data    0.35

                     Critical Values for Background Threshold Values (BTVs)
           Tolerance Factor K (For UTL)    2.22                             d2max (for USL)    2.745

                                         Normal GOF Test
             Shapiro Wilk Test Statistic    0.924               Shapiro Wilk GOF Test
         5% Shapiro Wilk Critical Value    0.927        Data Not Normal at 5% Significance Level
                Lilliefors Test Statistic    0.106                 Lilliefors GOF Test
            5% Lilliefors Critical Value    0.159       Data appear Normal at 5% Significance Level
                         Data appear Approximate Normal at 5% Significance Level

                          Background Statistics Assuming Normal Distribution
          95% UTL with  95% Coverage    4.132                          90% Percentile (z)    3.366
                           95% UPL (t)    3.73                           95% Percentile (z)    3.663
```

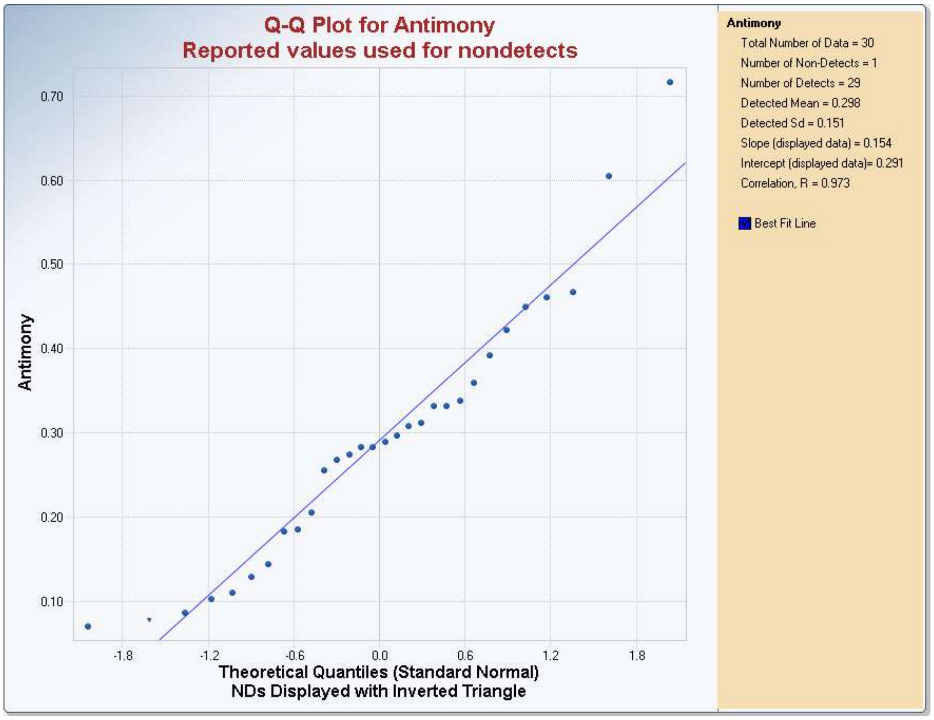
```
                                             95% USL     4.561                                      99% Percentile (z)    4.219

                                                              Gamma GOF Test
                                  A-D Test Statistic     0.406                  Anderson-Darling Gamma GOF Test
                               5% A-D Critical Value     0.746     Detected data appear Gamma Distributed at 5% Significance Level
                                  K-S Test Statistic     0.103                Kolmogorov-Smirnov Gamma GOF Test
                               5% K-S Critical Value     0.16      Detected data appear Gamma Distributed at 5% Significance Level
                               Detected data appear Gamma Distributed at 5% Significance Level

                                                              Gamma Statistics
                                        k hat (MLE)     8.735                               k star (bias corrected MLE)     7.884
                                    Theta hat (MLE)     0.266                           Theta star (bias corrected MLE)     0.294
                                       nu hat (MLE)   524.1                                     nu star (bias corrected)   473
                           MLE Mean (bias corrected)     2.32                                    MLE Sd (bias corrected)     0.826

                                              Background Statistics Assuming Gamma Distribution
                95% Wilson Hilferty (WH) Approx. Gamma UPL     3.863                                      90% Percentile     3.421
               95% Hawkins Wixley (HW) Approx. Gamma UPL     3.893                                      95% Percentile     3.824
             95% WH Approx. Gamma UTL with   95% Coverage     4.442                                      99% Percentile     4.659
             95% HW Approx. Gamma UTL with   95% Coverage     4.507
                                               95% WH USL     5.12                                        95% HW USL     5.24

                                                              Lognormal GOF Test
                               Shapiro Wilk Test Statistic     0.96                  Shapiro Wilk Lognormal GOF Test
                            5% Shapiro Wilk Critical Value     0.927          Data appear Lognormal at 5% Significance Level
                                 Lilliefors Test Statistic     0.123                  Lilliefors Lognormal GOF Test
                              5% Lilliefors Critical Value     0.159          Data appear Lognormal at 5% Significance Level
                                          Data appear Lognormal at 5% Significance Level

                                              Background Statistics assuming Lognormal Distribution
                             95% UTL with   95% Coverage     4.763                                  90% Percentile (z)     3.429
                                              95% UPL (t)     4.008                                  95% Percentile (z)     3.894
                                                  95% USL     5.726                                  99% Percentile (z)     4.944

                                              Nonparametric Distribution Free Background Statistics
                                              Data appear Approximate Normal at 5% Significance Level

                                              Nonparametric Upper Limits for Background Threshold Values
                                     Order of Statistic, r    30                                 95% UTL with   95% Coverage     5.01
                        Approx, f used to compute achieved CC     1.579    Approximate Actual Confidence Coefficient achieved by UTL     0.785
                                                                             Approximate Sample Size needed to achieve specified CC    59
           95% Percentile Bootstrap UTL with   95% Coverage     5.01                       95% BCA Bootstrap UTL with   95% Coverage     5.01
                                                  95% UPL     4.213                                          90% Percentile     3.081
                                        90% Chebyshev UPL     4.81                                           95% Percentile     3.349
                                        95% Chebyshev UPL     5.937                                          99% Percentile     4.59
```

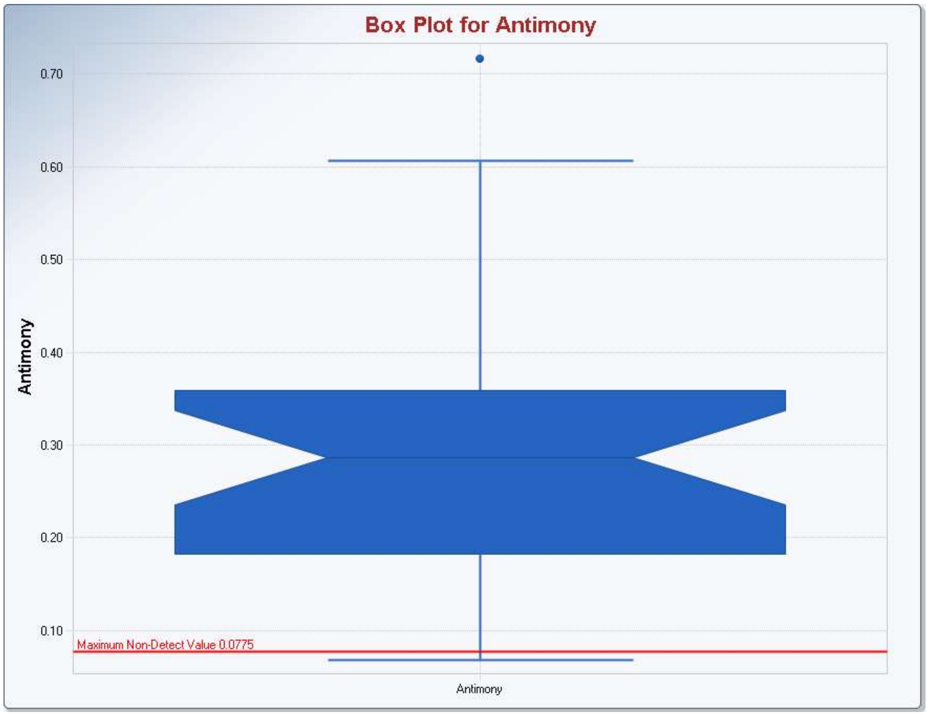
95% USL	5.01

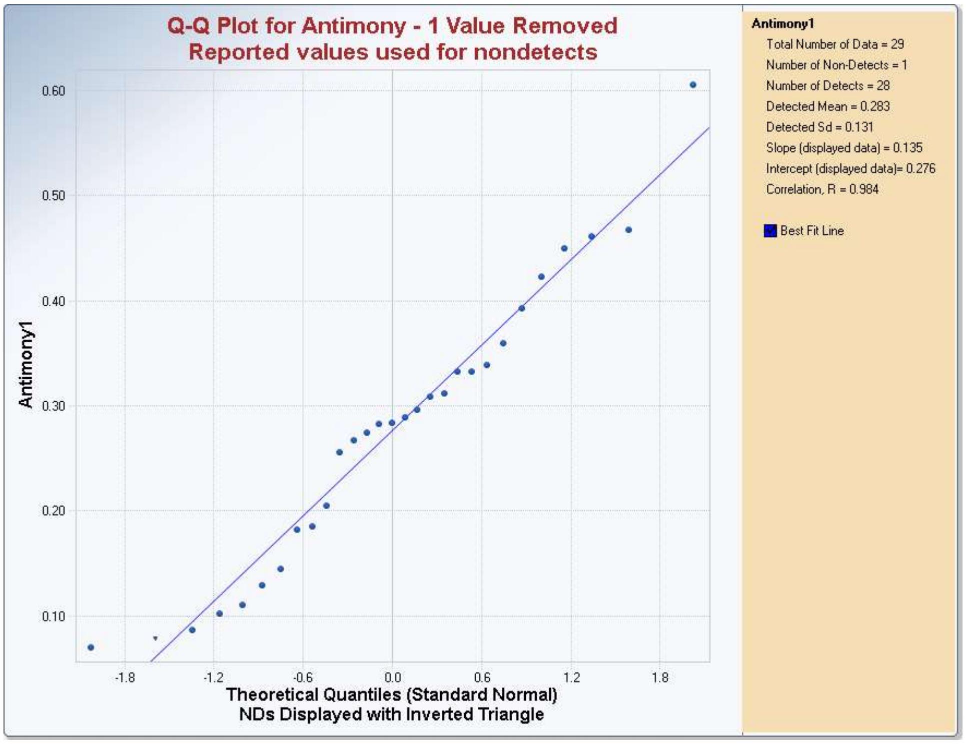
Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers
and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data
represents a background data set and when many onsite observations need to be compared with the BTV.

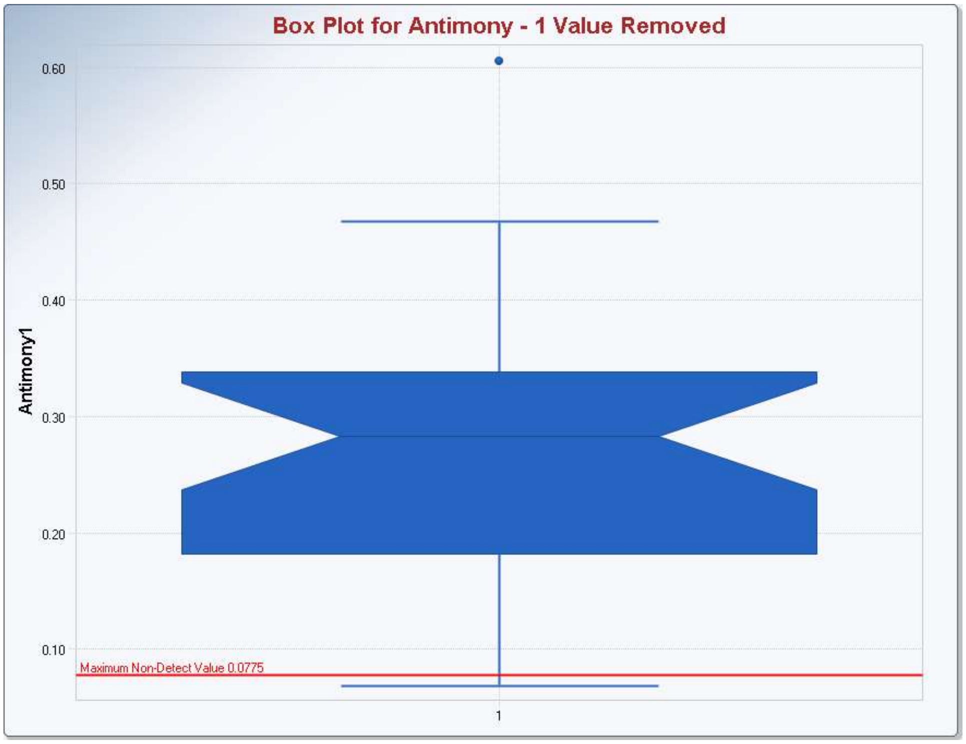
Antimony

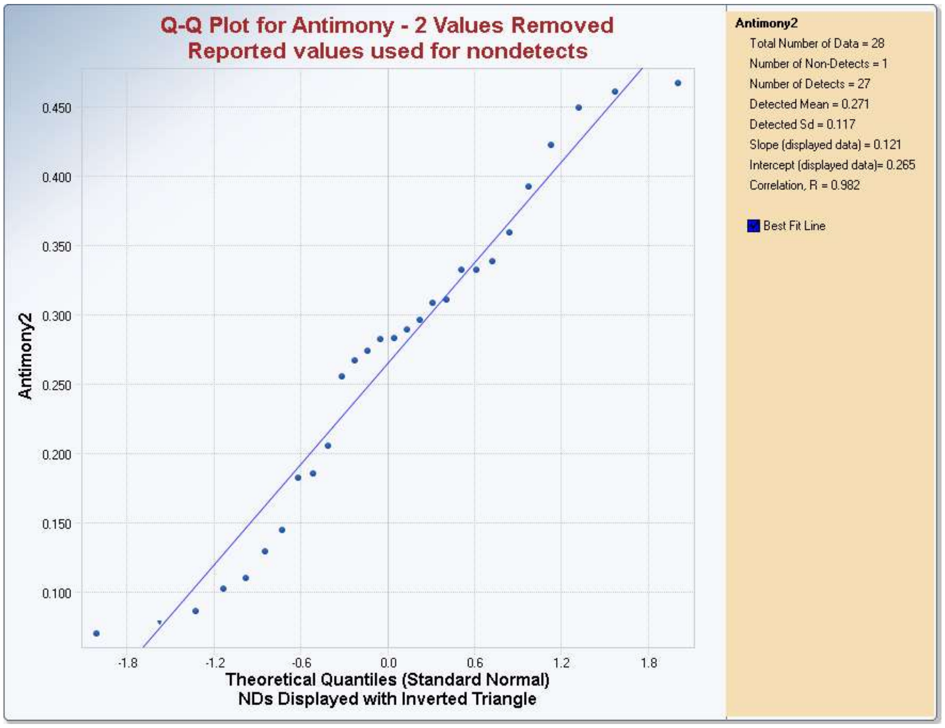
Two potential high outliers are present in the QQ plot and one potential high outlier is present in the box plot. Non-detects were evaluated at one-half the reported value. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Rosner's outlier test indicates no statistical outliers. *Background dataset is not censored because no statistical outliers were identified.*



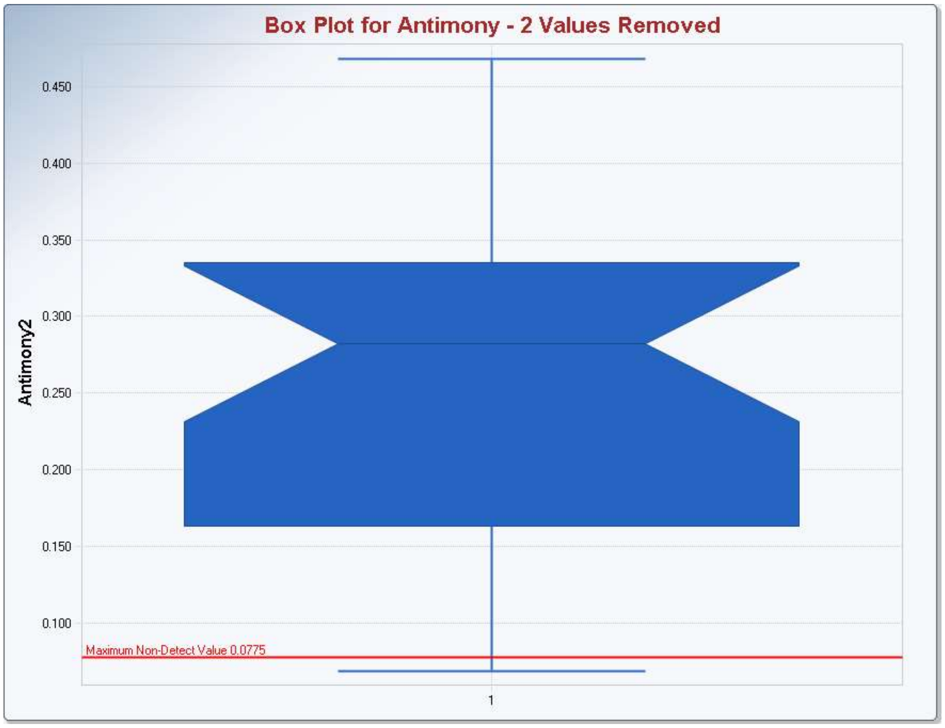



Q-Q Plot for Antimony - 1 Value Removed
Reported values used for nondetects
0.60
0.50
0.40
0.30
0.20
0.10
Antimony1
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)
NDs Displayed with Inverted Triangle
Antimony1
Total Number of Data = 29
Number of Non-Detects = 1
Number of Detects = 28
Detected Mean = 0.283
Detected Sd = 0.131
Slope (displayed data) = 0.135
Intercept (displayed data)= 0.276
Correlation, R = 0.984
Best Fit Line


Box Plot for Antimony - 1 Value Removed
0.60
0.50
0.40
0.30
0.20
0.10
Antimony1
Maximum Non-Detect Value 0.0775
1

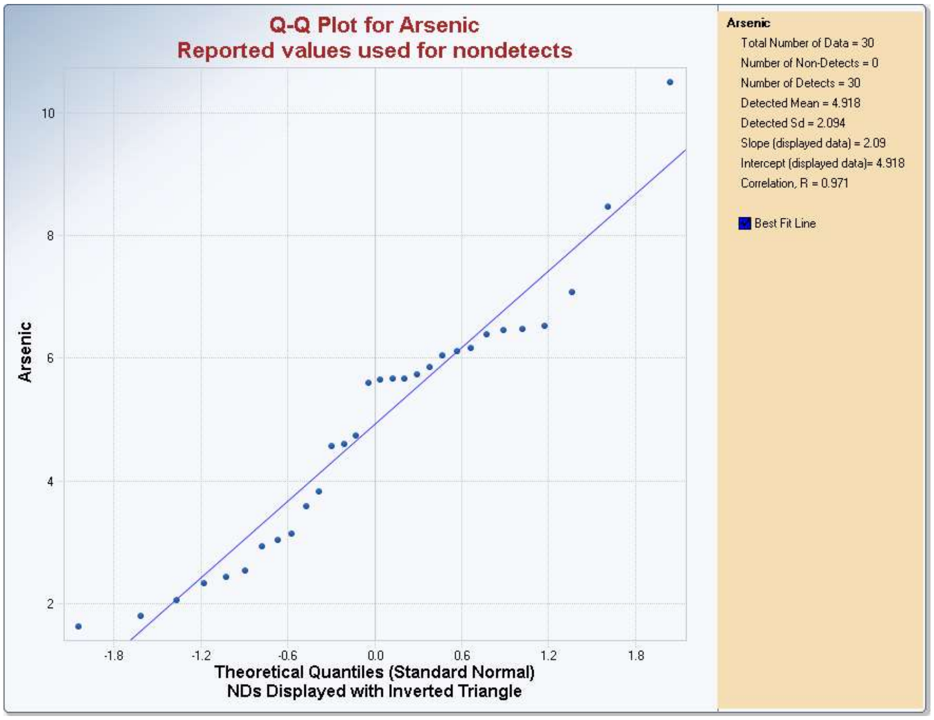


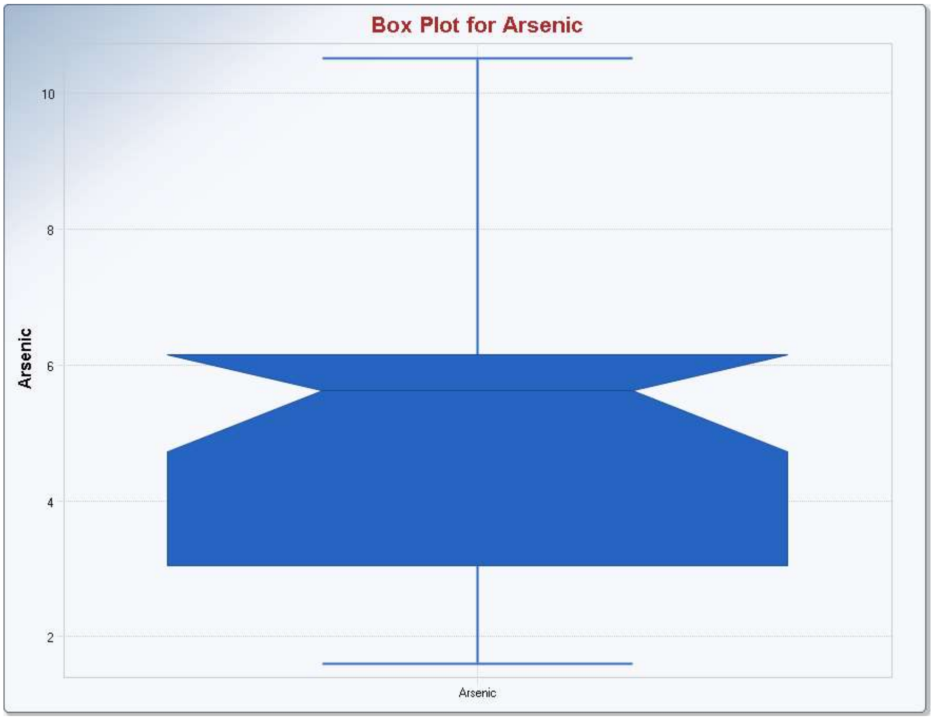
Antimony2
Total Number of Data = 28
Number of Non-Detects = 1
Number of Detects = 27
Detected Mean = 0.271
Detected Sd = 0.117
Slope (displayed data) = 0.121
Intercept (displayed data)= 0.265
Correlation, R = 0.982

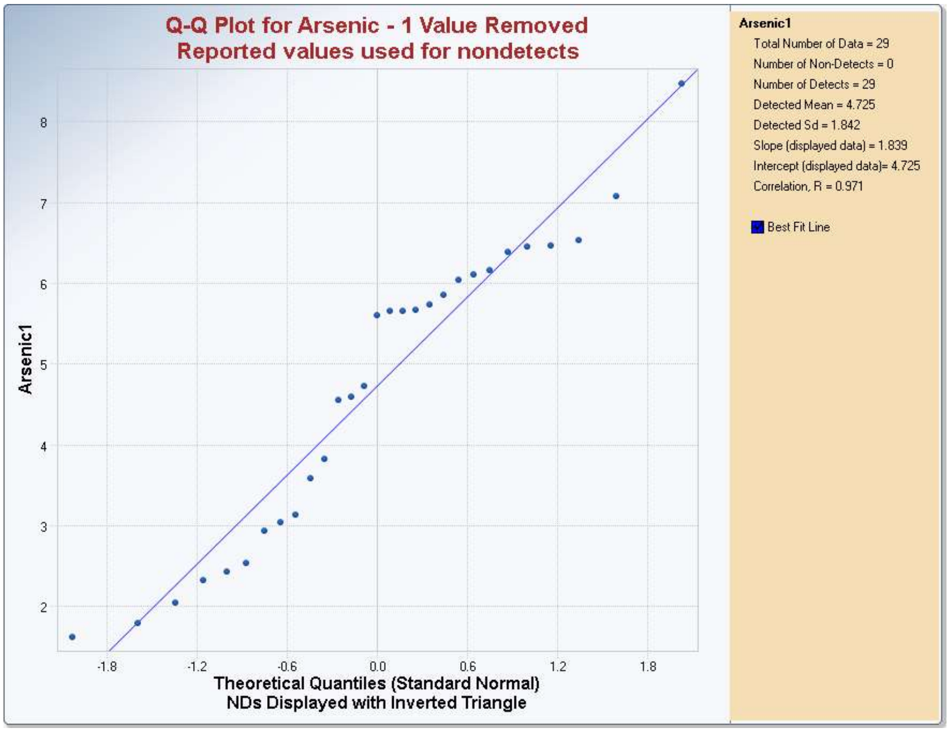


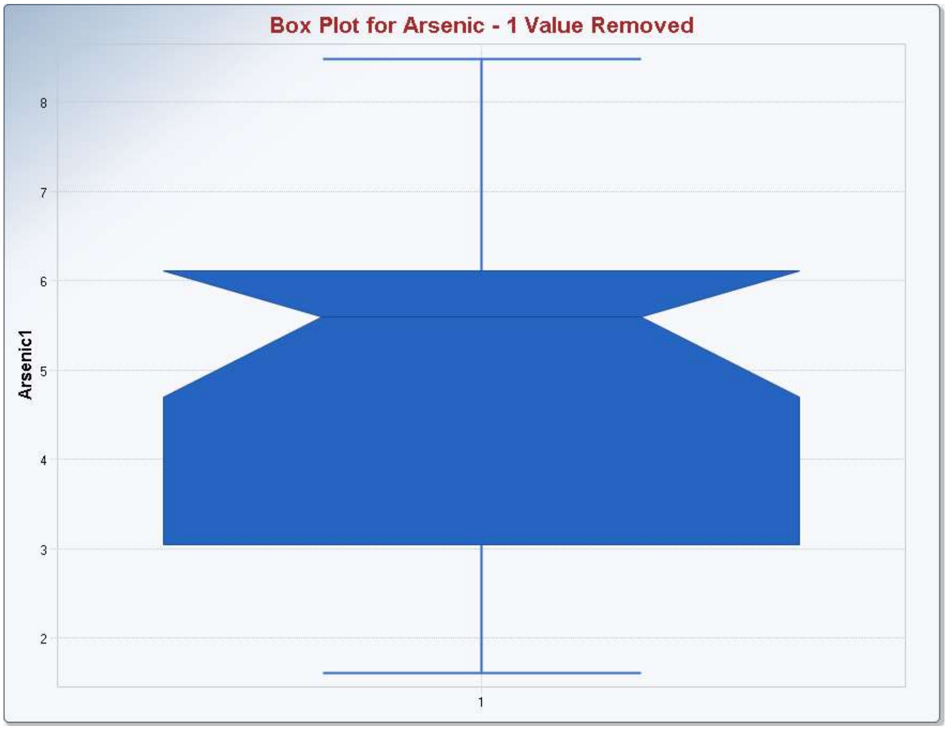
Arsenic

One potential high outlier is present in the QQ plot but none are present in the box plot. Rosner’s outlier test was run in USEPA’s ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Rosner’s outlier test indicates no statistical outliers. *Background dataset is not censored because no statistical outliers were identified.*



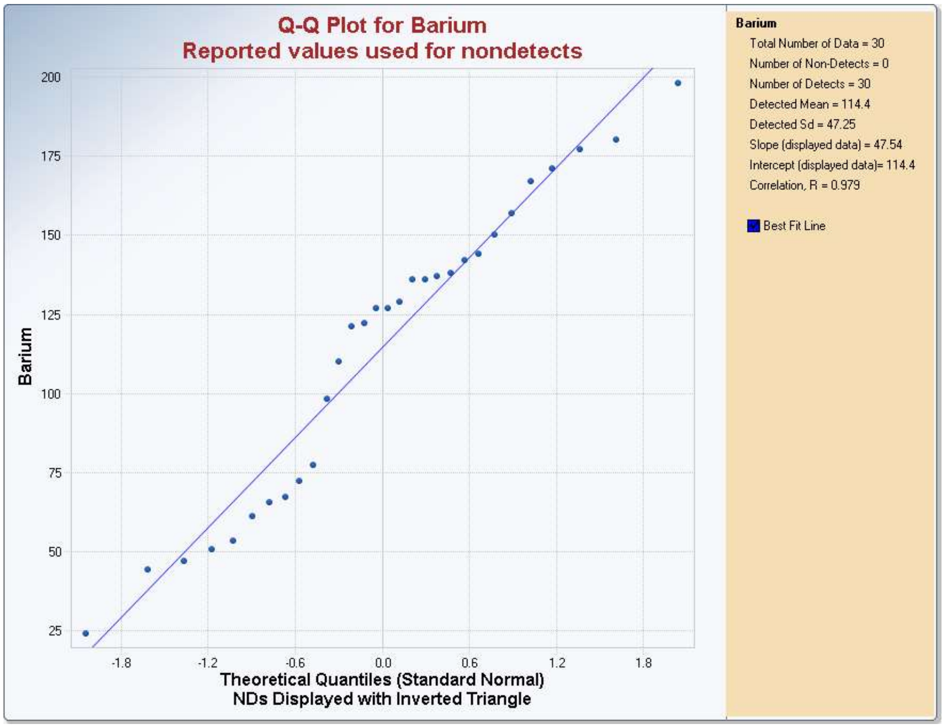


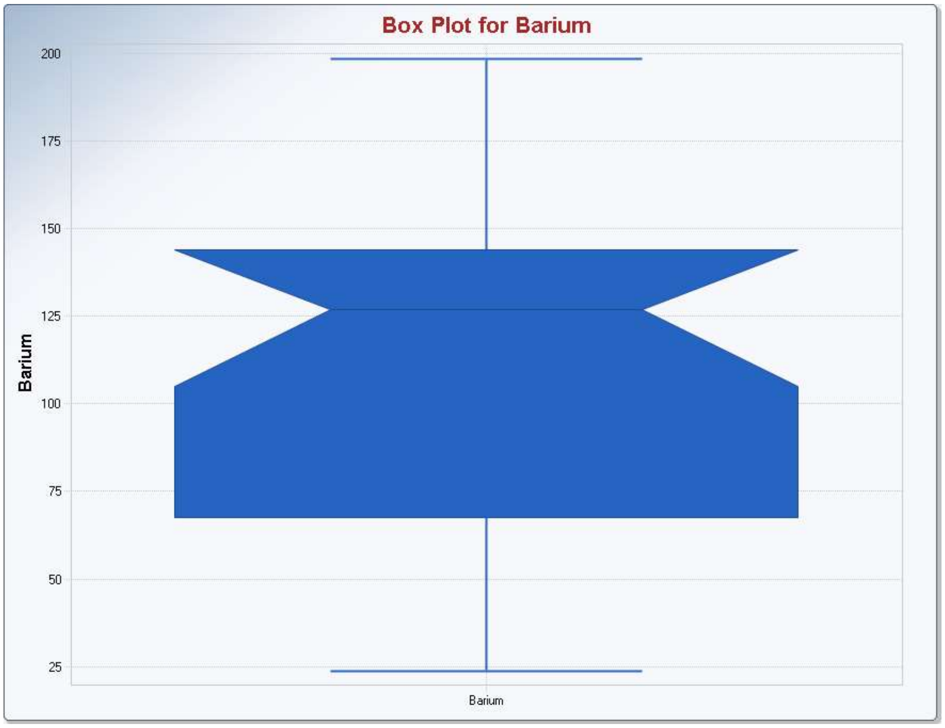

Q-Q Plot for Arsenic - 1 Value Removed
Reported values used for nondetects
Arsenic1
8
7
6
5
4
3
2
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)
NDs Displayed with Inverted Triangle
Arsenic1
Total Number of Data = 29
Number of Non-Detects = 0
Number of Detects = 29
Detected Mean = 4.725
Detected Sd = 1.842
Slope (displayed data) = 1.839
Intercept (displayed data)= 4.725
Correlation, R = 0.971
Best Fit Line


Box Plot for Arsenic - 1 Value Removed
Arsenic1
8
7
6
5
4
3
2
1

Barium

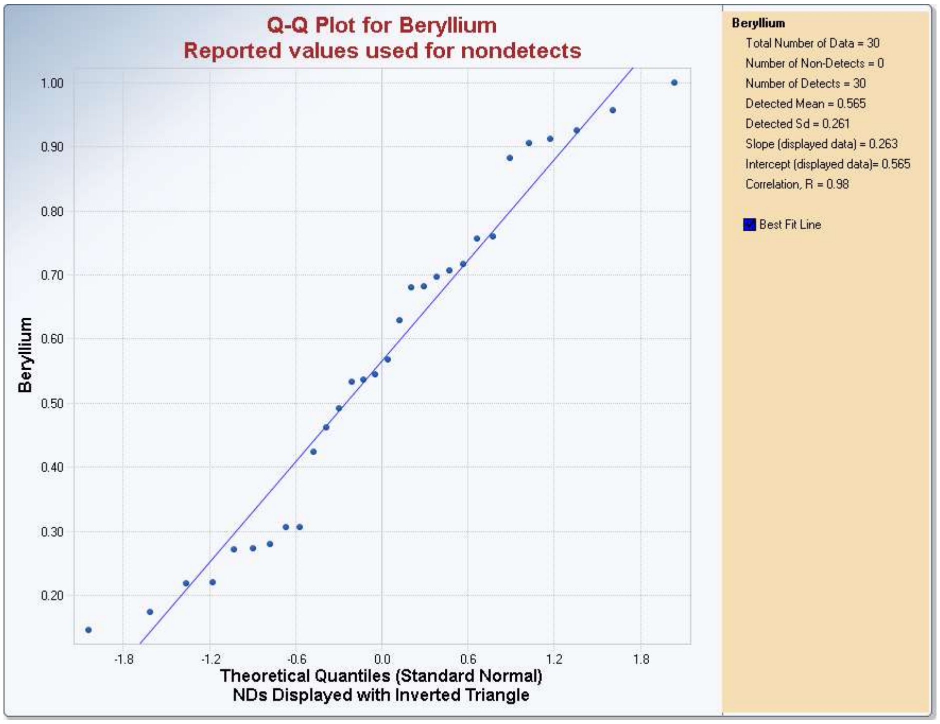
No high outliers are present in the QQ plot or box plot. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Rosner's test indicates no statistical outliers. *Background dataset is not censored because no statistical outliers were identified.*

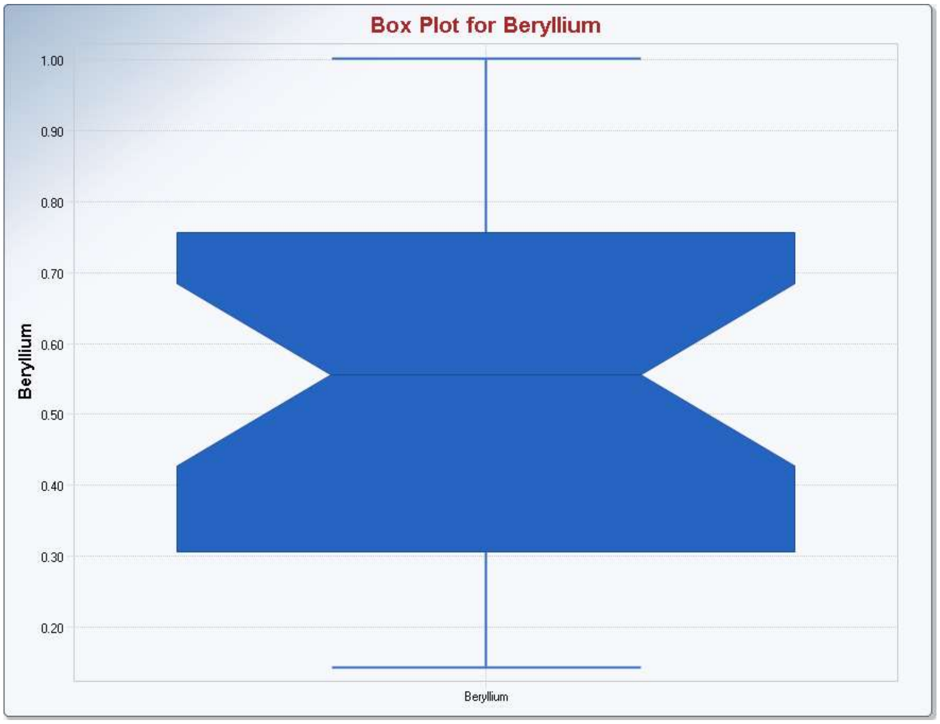




Beryllium

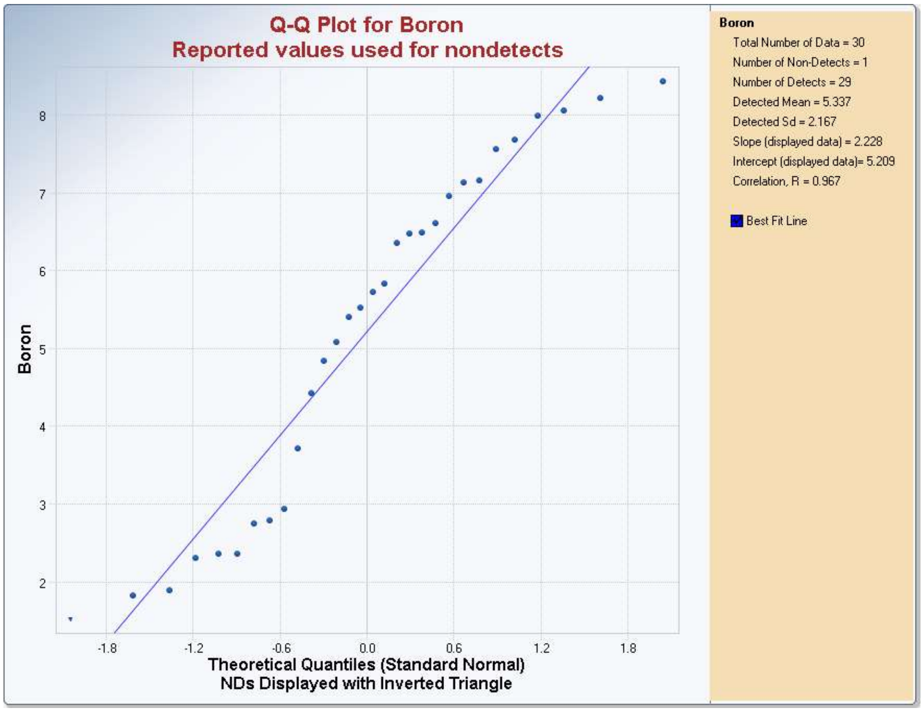
No high outliers are present in the QQ plot or box plot. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Rosner's test indicates no statistical outliers. *Background dataset is not censored because no statistical outliers were identified.*

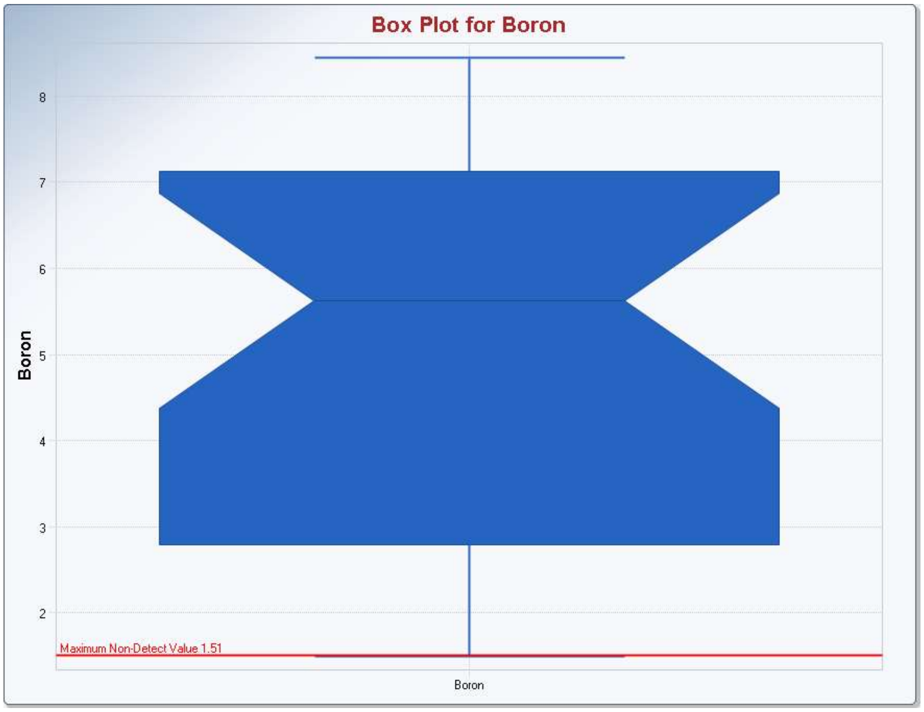




Boron

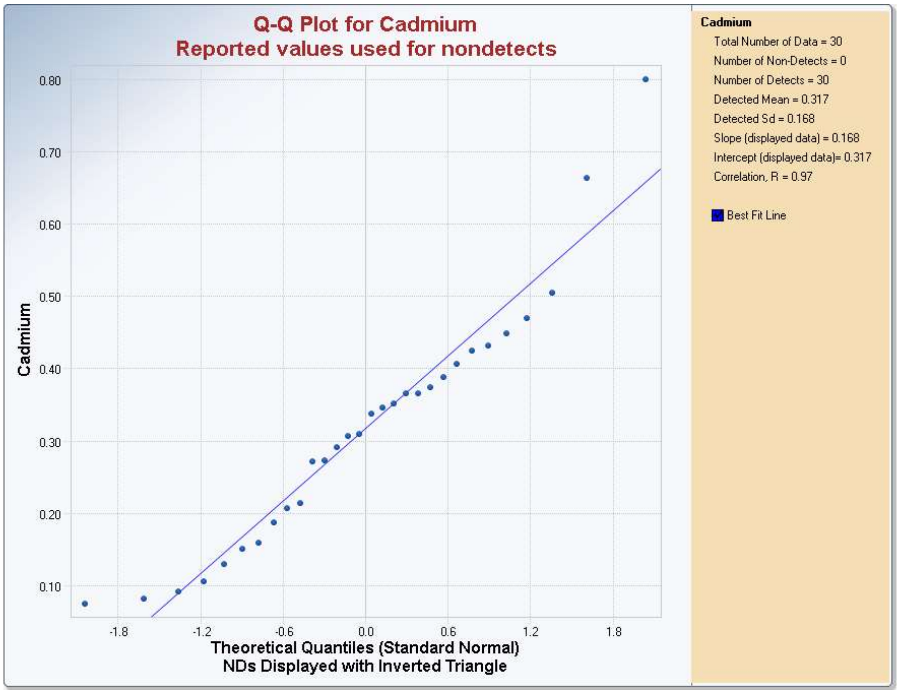
No high outliers are present in the QQ plot or box plot. Non-detects were evaluated at one-half the reported value. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Rosner's test indicates no statistical outliers. *Background dataset is not censored because no statistical outliers were identified.*

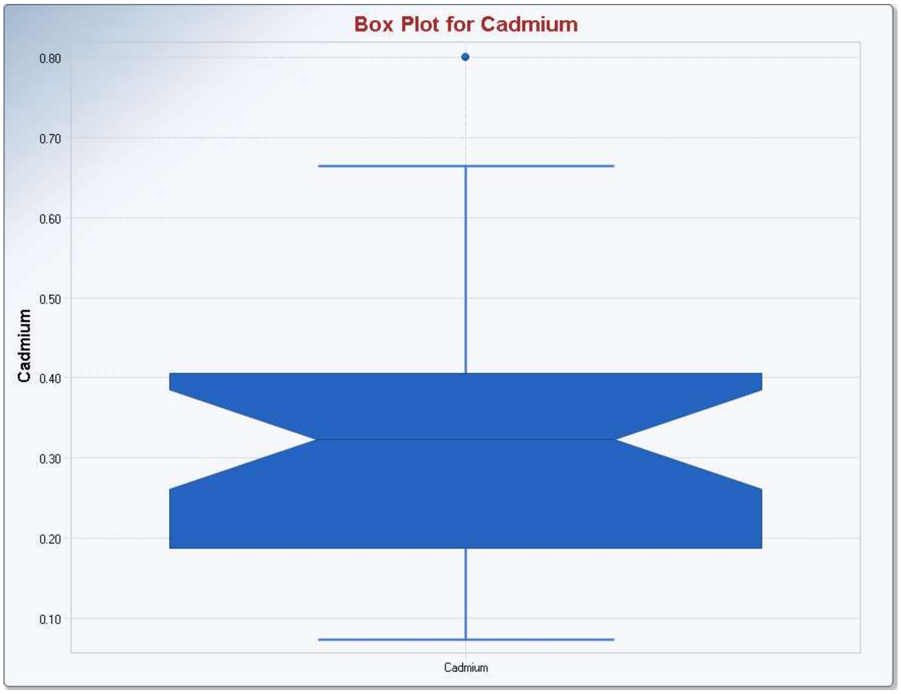




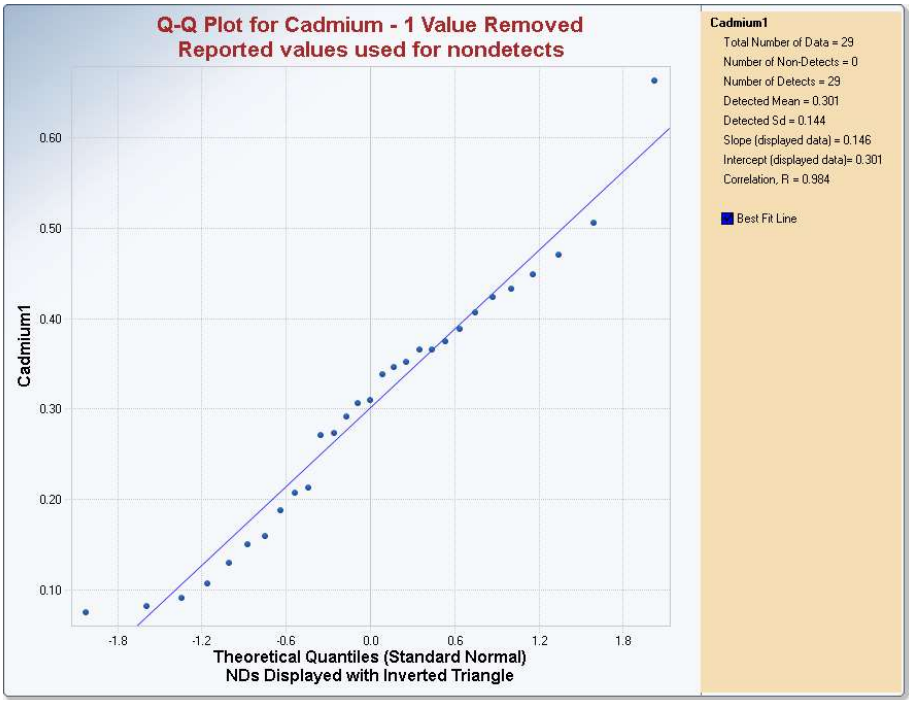
Cadmium

Two potential high outliers are present in the QQ plot and one potential high outlier is present in the box plot. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Rosner's outlier test indicates one statistical outlier. *The variability in the background dataset, and the associated outlier, likely represent natural variability within an industrialized site. Based on existing knowledge that these data are from background sample locations, no outliers were removed from the background dataset.*

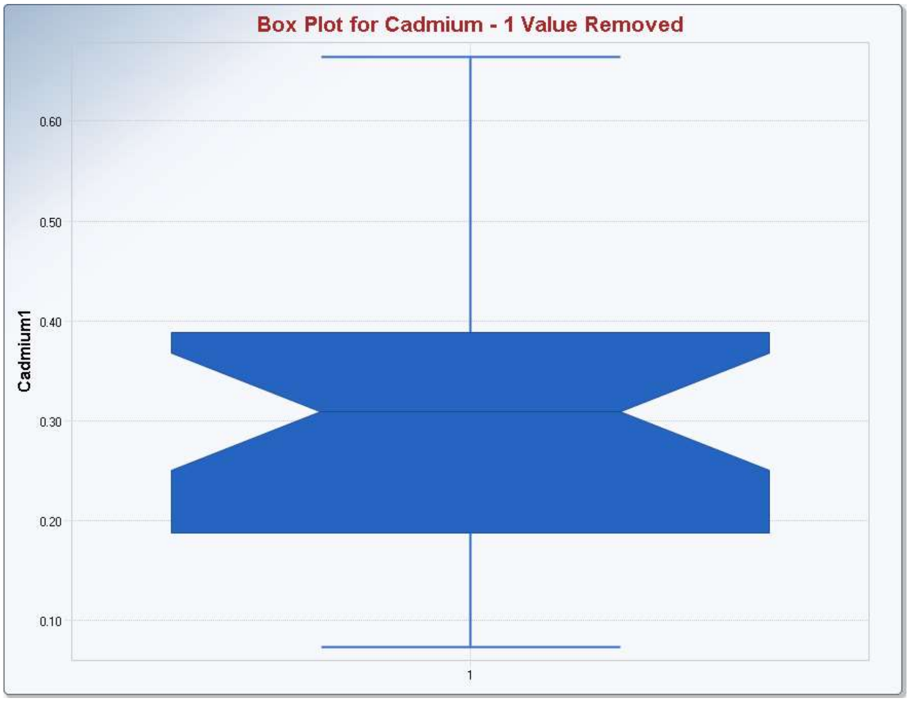


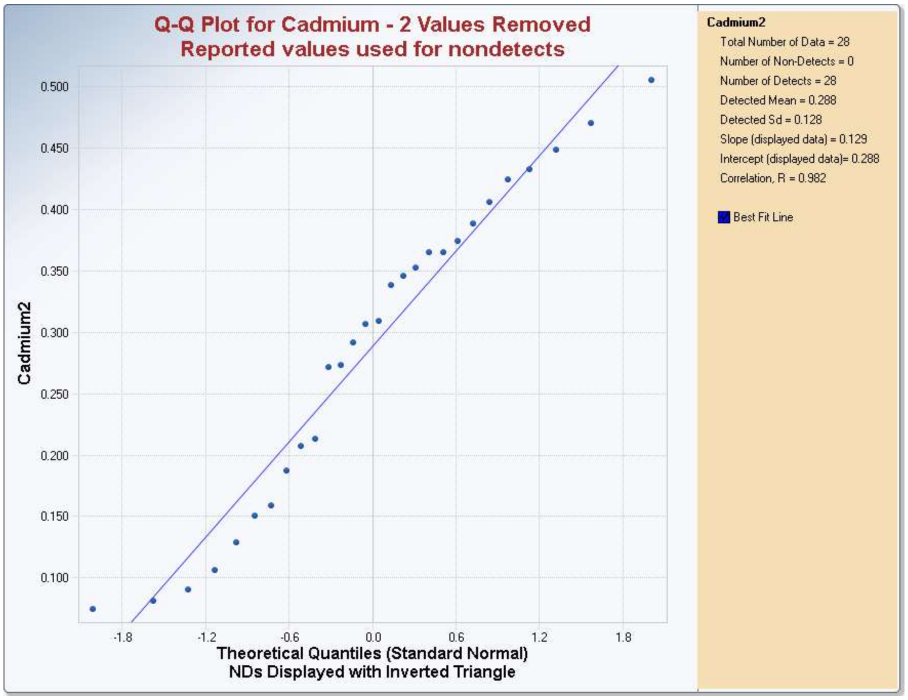


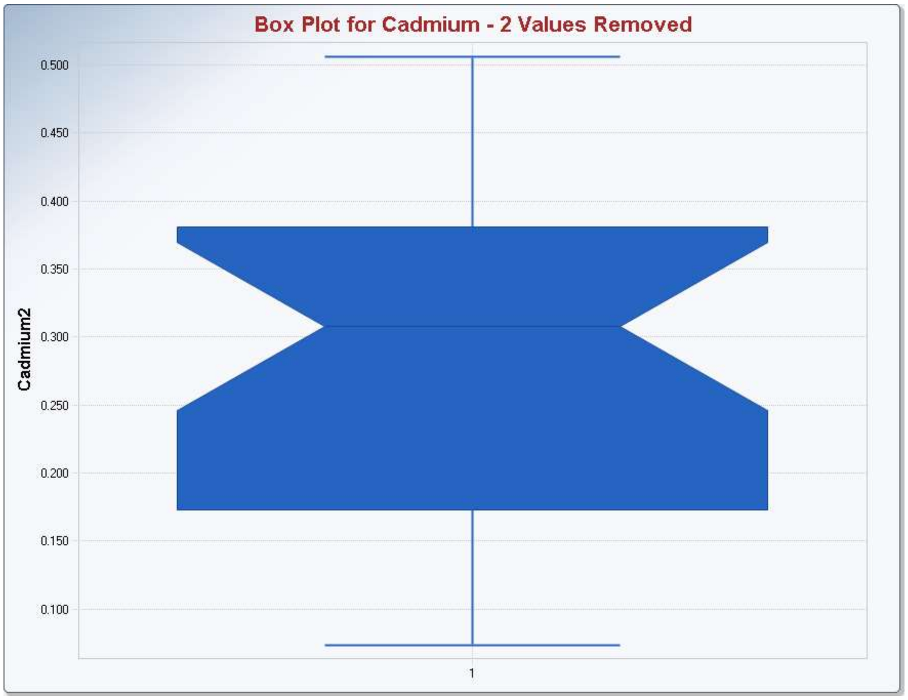
Attachment A – Background Threshold Value Derivation



Cadmium1
Total Number of Data = 29
Number of Non-Detects = 0
Number of Detects = 29
Detected Mean = 0.301
Detected Sd = 0.144
Slope (displayed data) = 0.146
Intercept (displayed data)= 0.301
Correlation, R = 0.984

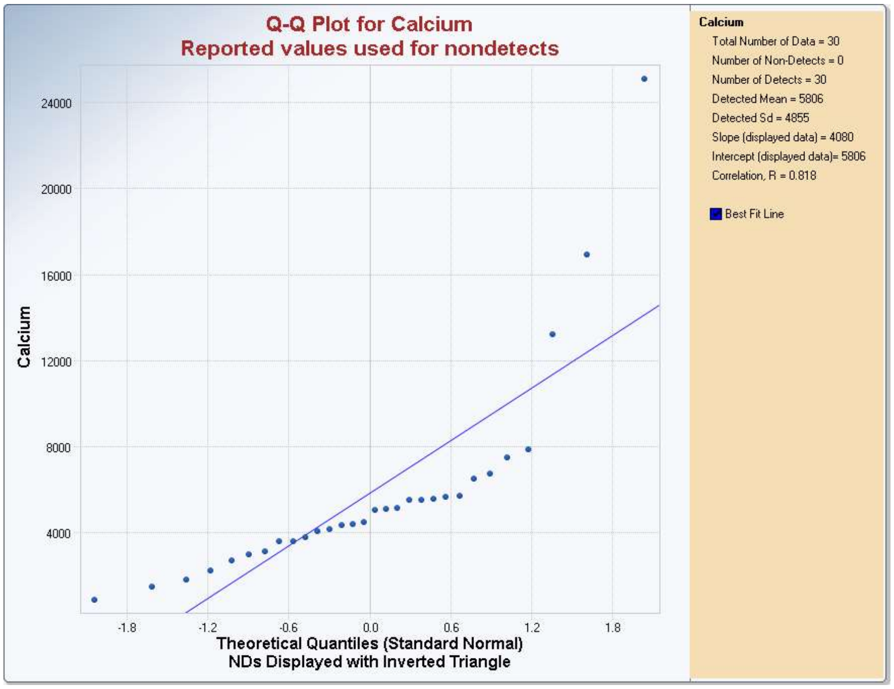


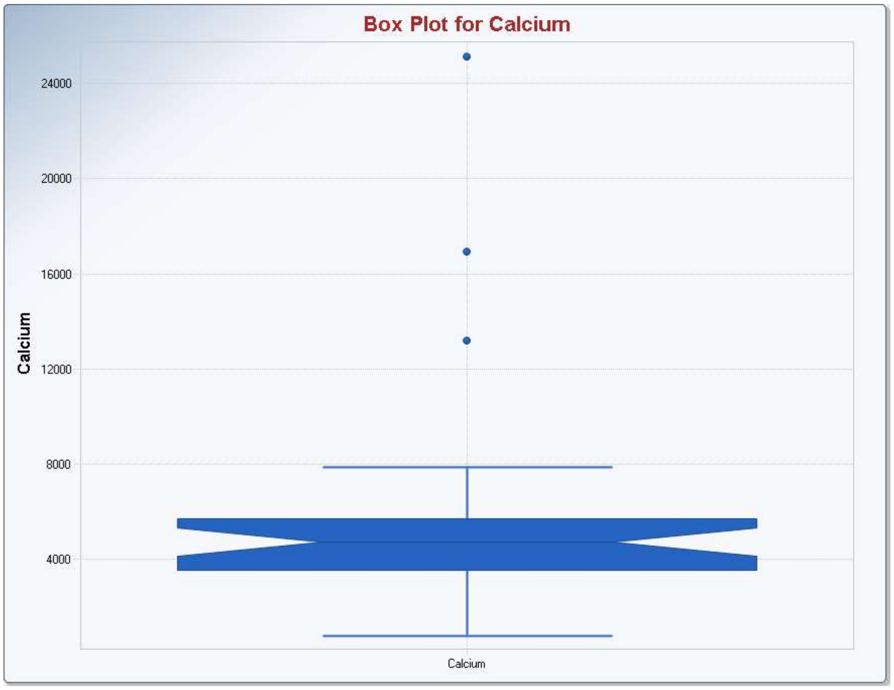

Q-Q Plot for Cadmium - 2 Values Removed
Reported values used for nondetects
Cadmium2
0.500
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)
NDs Displayed with Inverted Triangle
Cadmium2
Total Number of Data = 28
Number of Non-Detects = 0
Number of Detects = 28
Detected Mean = 0.288
Detected Sd = 0.128
Slope (displayed data) = 0.129
Intercept (displayed data)= 0.288
Correlation, R = 0.982
Best Fit Line

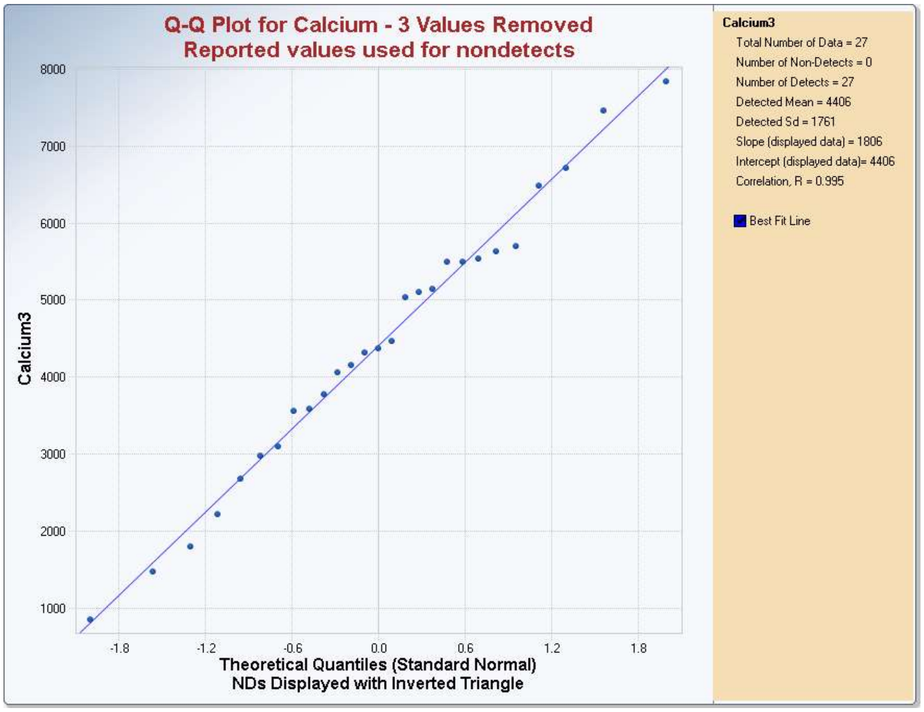

Box Plot for Cadmium - 2 Values Removed
Cadmium2
0.500
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
1

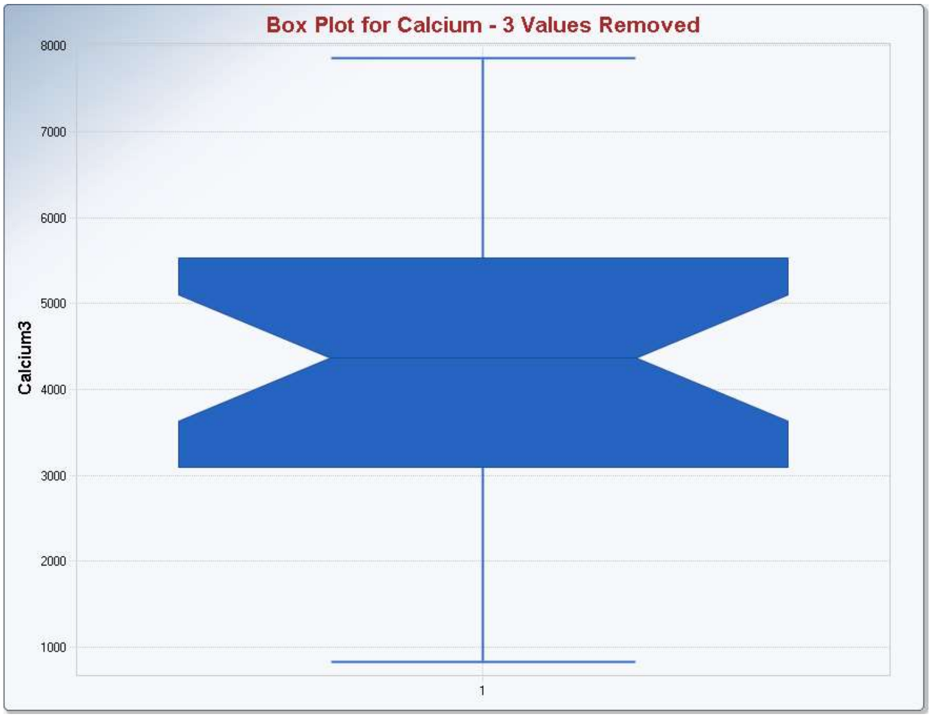
Calcium

Three potential high outliers are present in the QQ plot and box plot. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Rosner's outlier test indicates three statistical outliers. *The variability in the background dataset, and the associated outliers, likely represent natural variability within an industrialized site. Based on existing knowledge that these data are from background sample locations, no outliers were removed from the background dataset.*



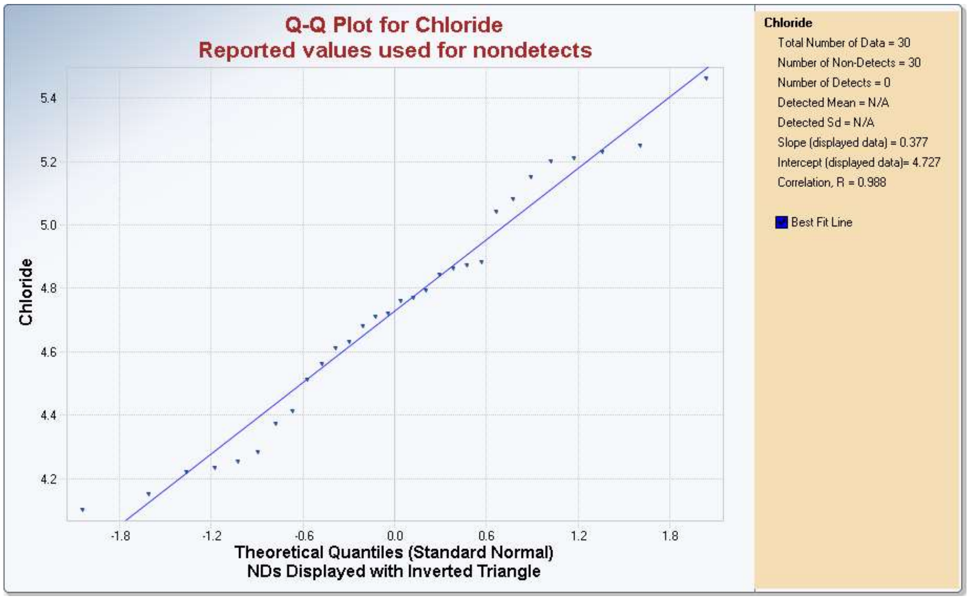



Q-Q Plot for Calcium - 3 Values Removed
Reported values used for nondetects
Calcium3
8000
7000
6000
5000
4000
3000
2000
1000
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)
NDs Displayed with Inverted Triangle
Calcium3
Total Number of Data = 27
Number of Non-Detects = 0
Number of Detects = 27
Detected Mean = 4406
Detected Sd = 1761
Slope (displayed data) = 1806
Intercept (displayed data)= 4406
Correlation, R = 0.995
Best Fit Line


Box Plot for Calcium - 3 Values Removed
Calcium3
8000
7000
6000
5000
4000
3000
2000
1000
1

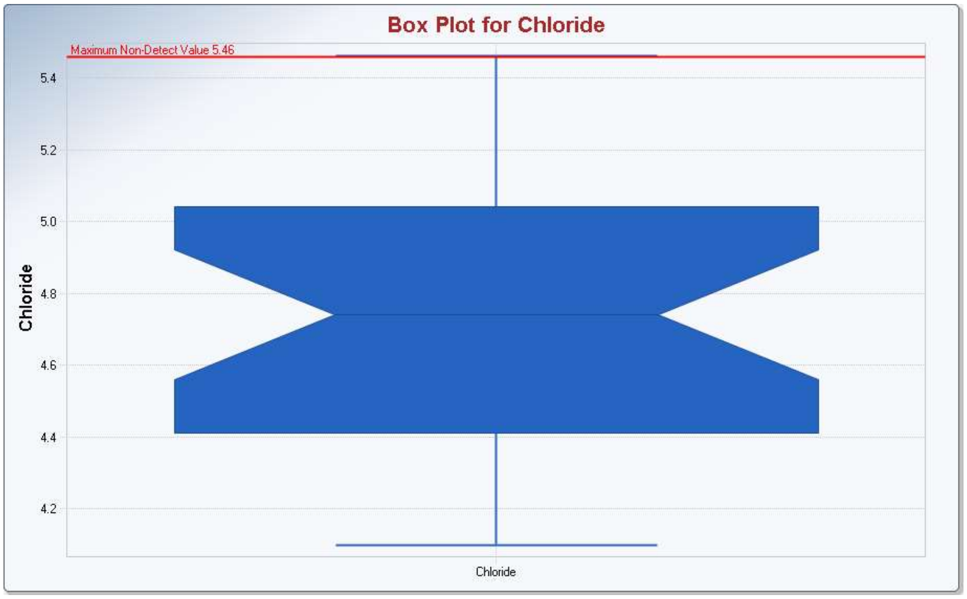
Chloride

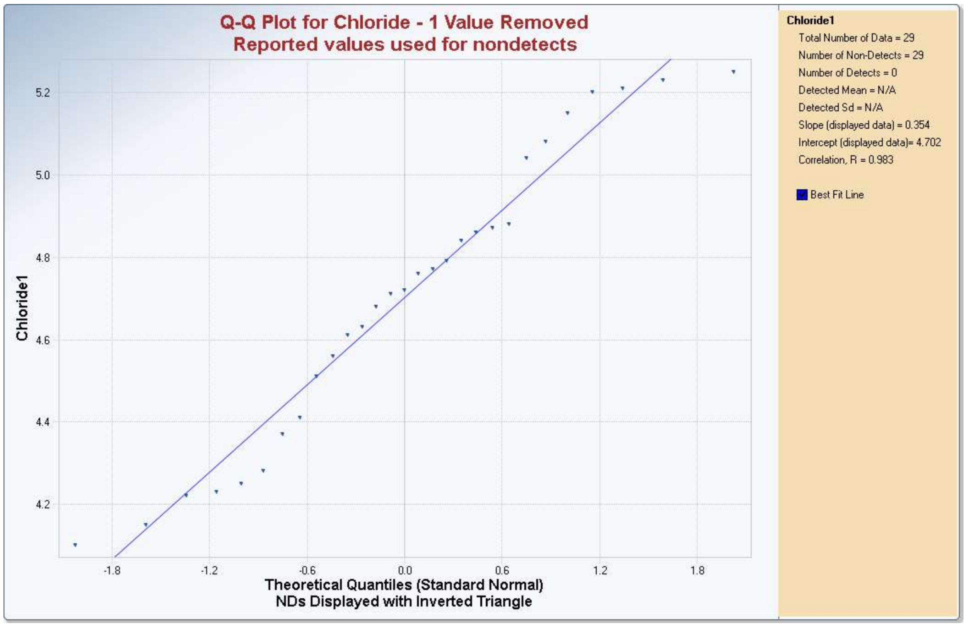
One potential non-detect high outlier is present in the QQ plot and box plot. Non-detects were evaluated at one-half the reported value. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Results of Rosner's test indicates no statistical outliers. *Background dataset is not censored because no statistical outliers were identified.*

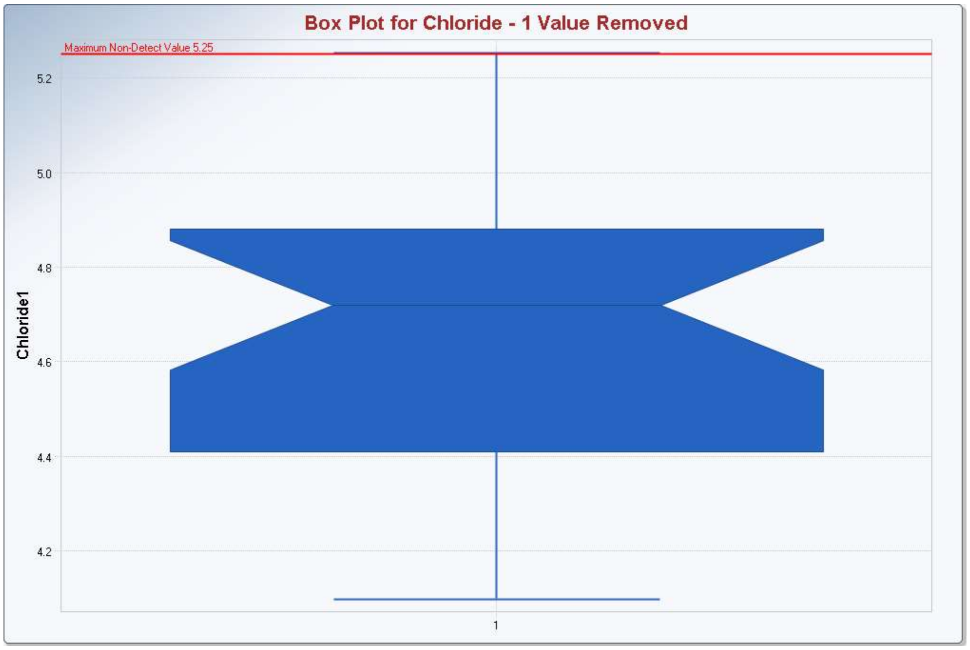


Chloride

Total Number of Data = 30
Number of Non-Detects = 30
Number of Detects = 0
Detected Mean = N/A
Detected Sd = N/A
Slope (displayed data) = 0.377
Intercept (displayed data)= 4.727
Correlation, R = 0.988

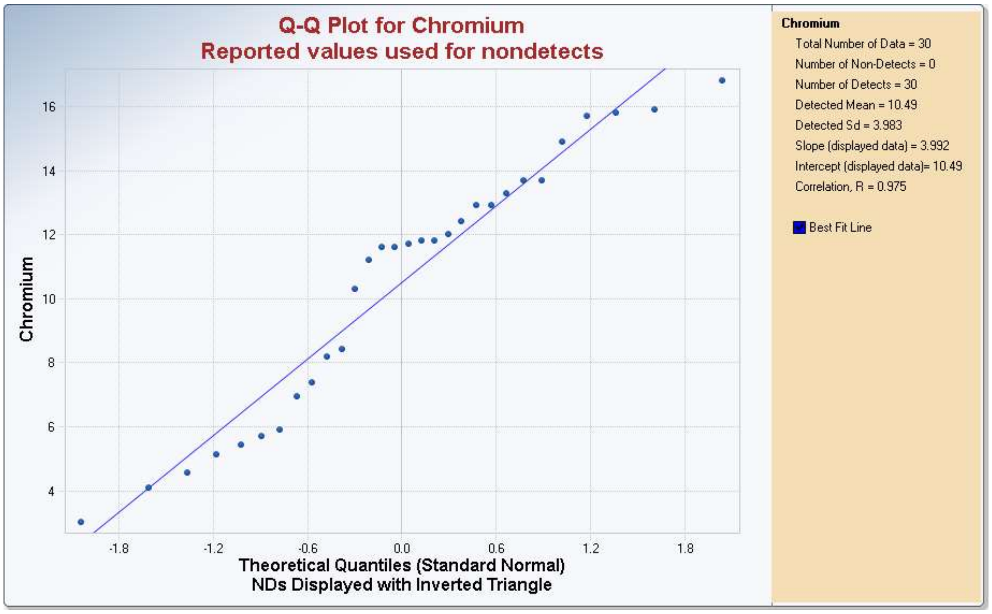


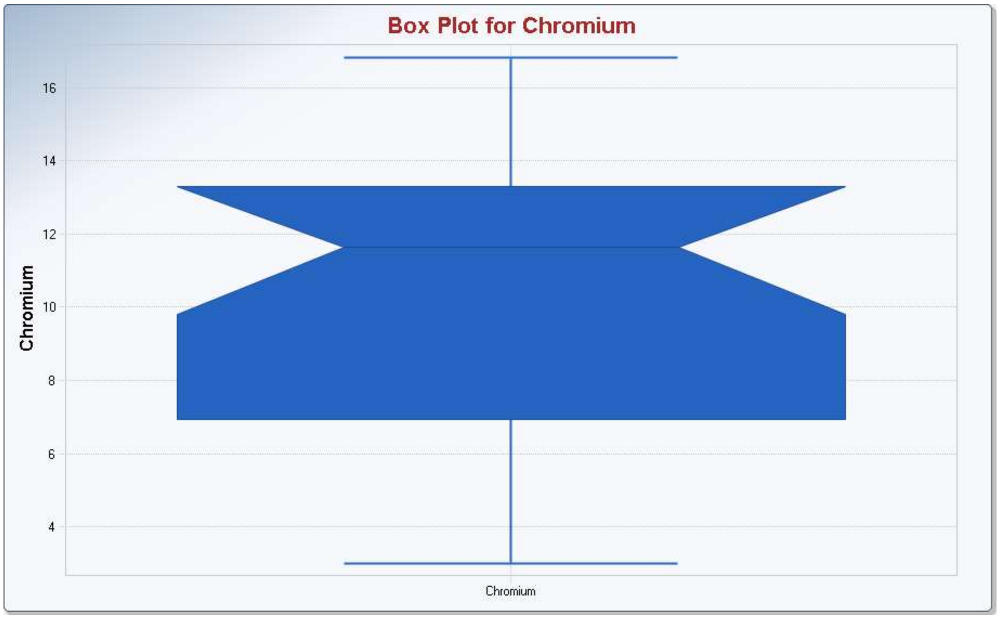

Q-Q Plot for Chloride - 1 Value Removed
Reported values used for nondetects
Chloride1
5.2
5.0
4.8
4.6
4.4
4.2
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)
NDs Displayed with Inverted Triangle
Chloride1
Total Number of Data = 29
Number of Non-Detects = 29
Number of Detects = 0
Detected Mean = N/A
Detected Sd = N/A
Slope (displayed data) = 0.354
Intercept (displayed data)= 4.702
Correlation, R = 0.983
Best Fit Line


Box Plot for Chloride - 1 Value Removed
Maximum Non-Detect Value 5.25
Chloride1
5.2
5.0
4.8
4.6
4.4
4.2
1

Chromium

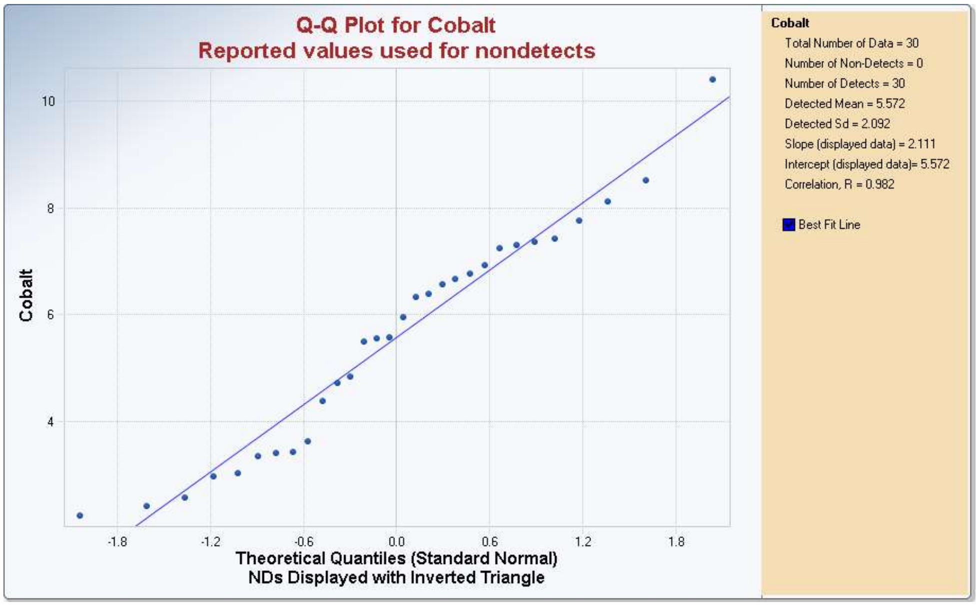
No potential high outliers are present in the QQ plot or box plot. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Results of Rosner's test indicates no statistical outliers. *Background dataset is not censored because no statistical outliers were identified.*

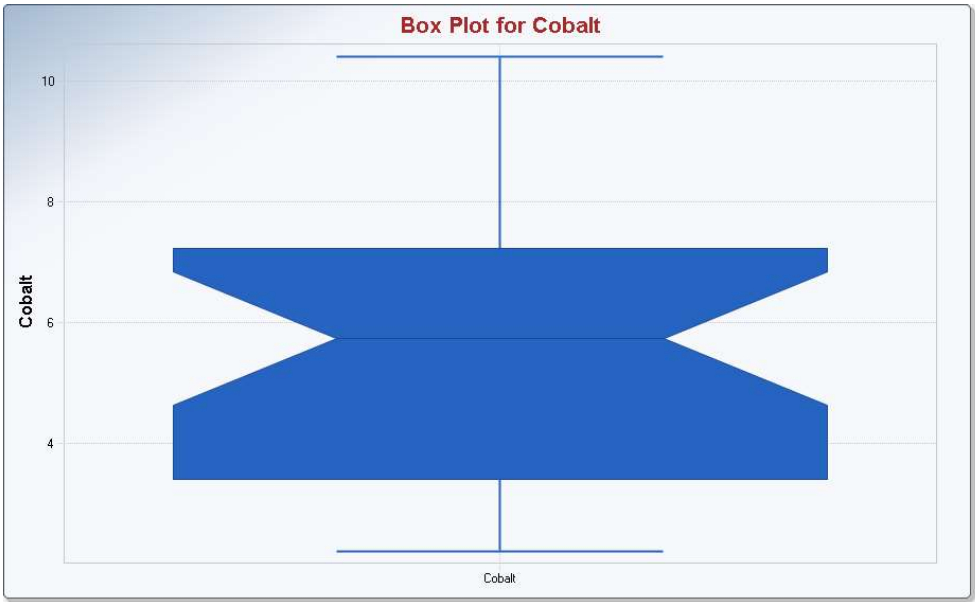


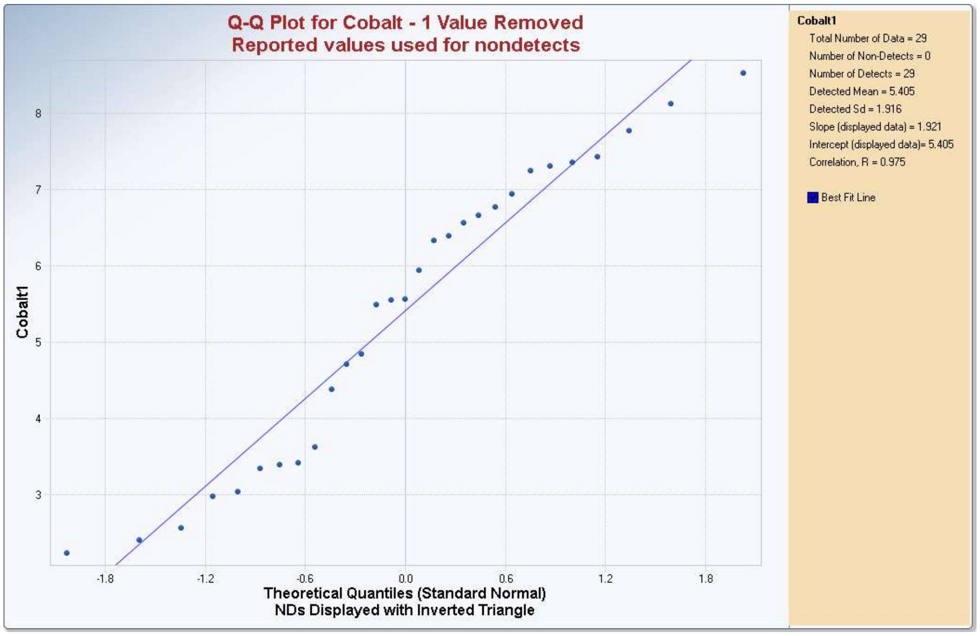


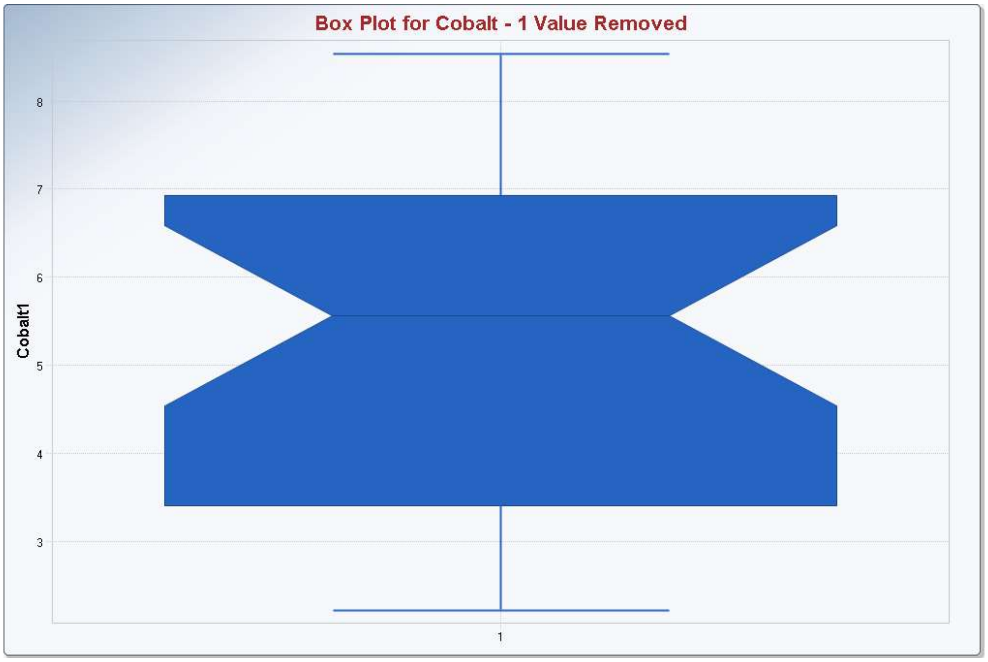
Cobalt

One potential high outlier is present in the QQ plot but none are present in the box plot. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Results of Rosner's test indicates no statistical outliers. *Background dataset is not censored because no statistical outliers were identified.*



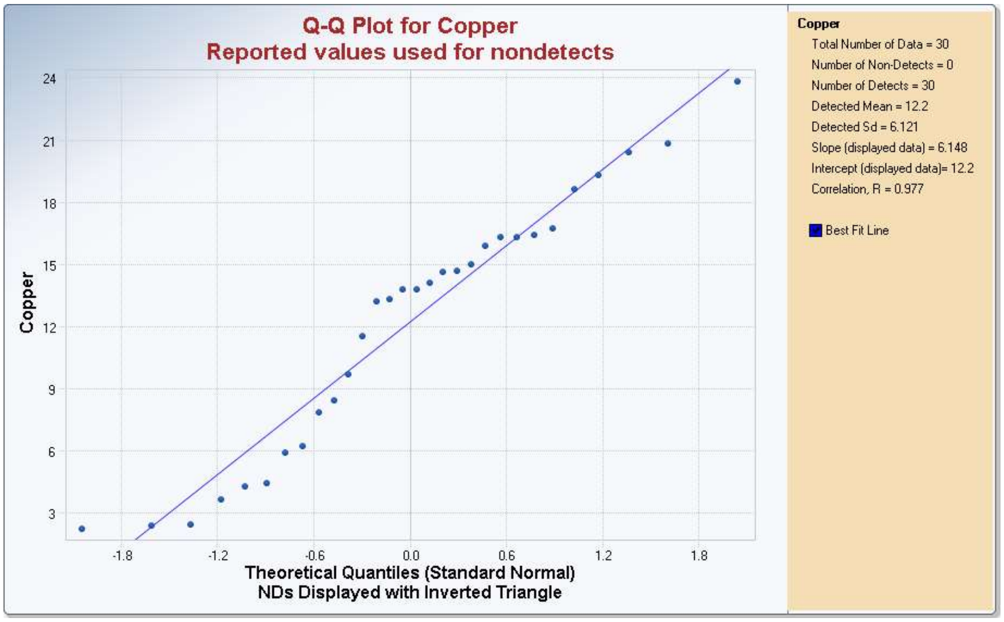


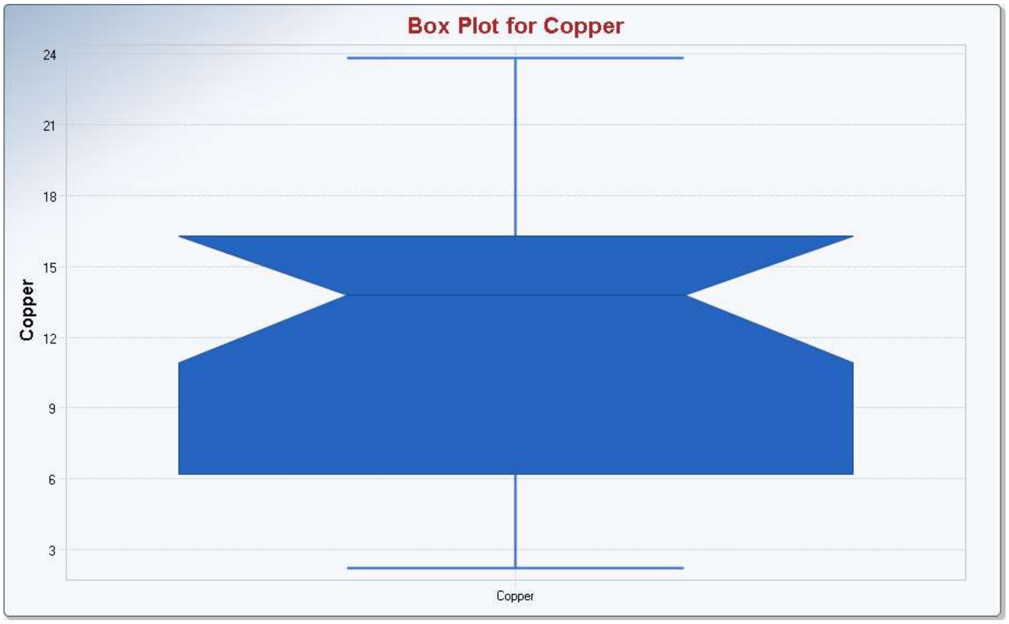

Q-Q Plot for Cobalt - 1 Value Removed
Reported values used for nondetects
Cobalt1
8
7
6
5
4
3
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)
NDs Displayed with Inverted Triangle
Cobalt1
Total Number of Data = 29
Number of Non-Detects = 0
Number of Detects = 29
Detected Mean = 5.405
Detected Sd = 1.916
Slope (displayed data) = 1.921
Intercept (displayed data)= 5.405
Correlation, R = 0.975
Best Fit Line

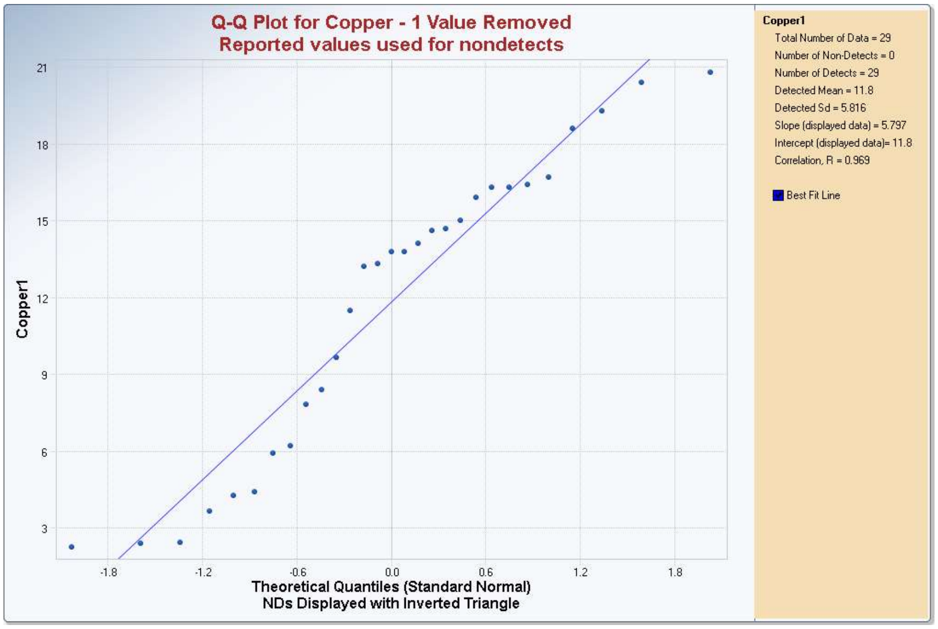

Box Plot for Cobalt - 1 Value Removed
Cobalt1
8
7
6
5
4
3
1

Copper

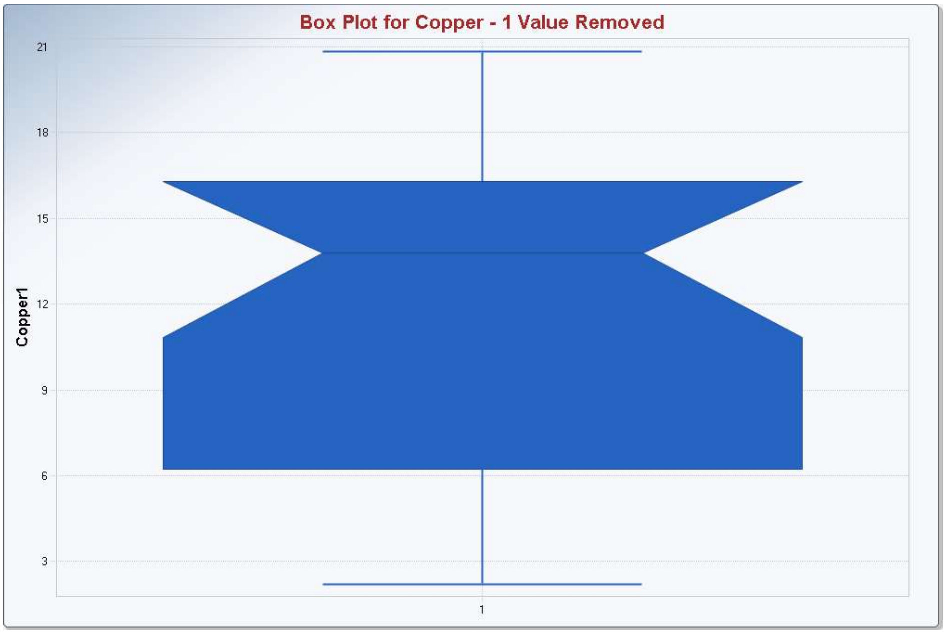
One potential high outlier is present in the QQ plot but none are present in the box plot. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Results of Rosner's test indicates no statistical outliers. *Background dataset is not censored because no statistical outliers were identified.*





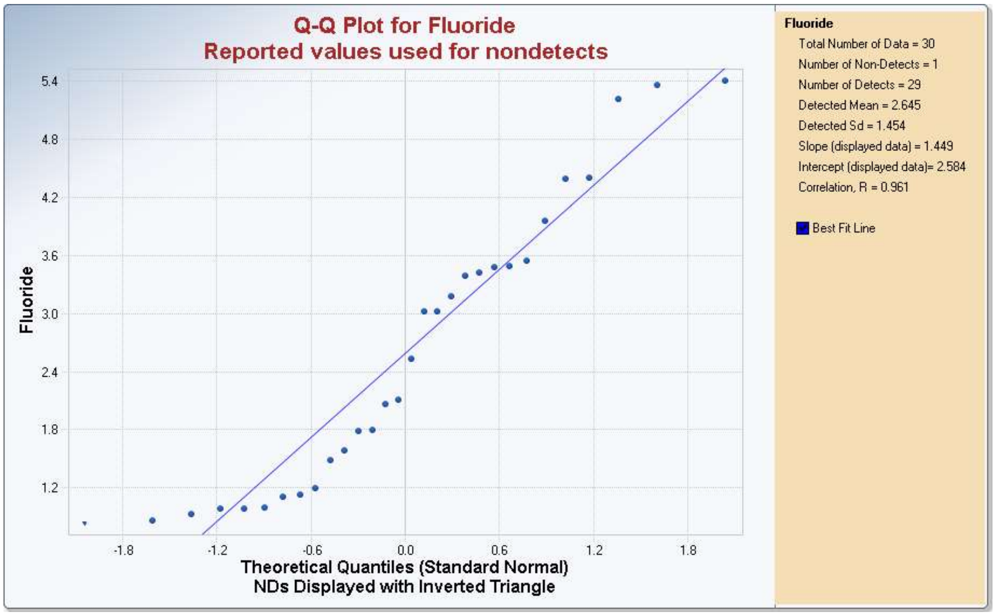


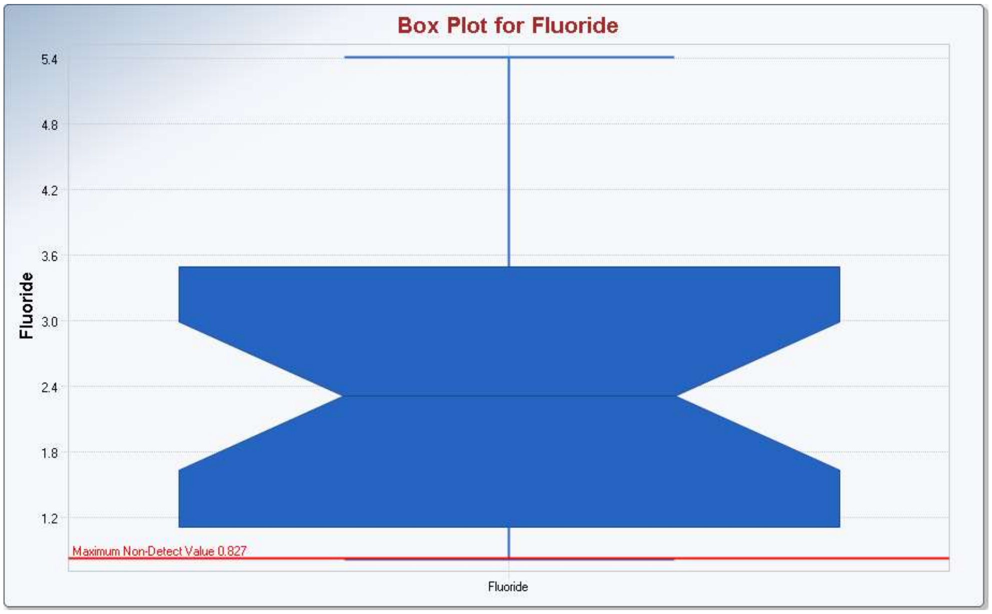
Copper1
Total Number of Data = 29
Number of Non-Detects = 0
Number of Detects = 29
Detected Mean = 11.8
Detected Sd = 5.816
Slope (displayed data) = 5.797
Intercept (displayed data)= 11.8
Correlation, R = 0.969



Fluoride

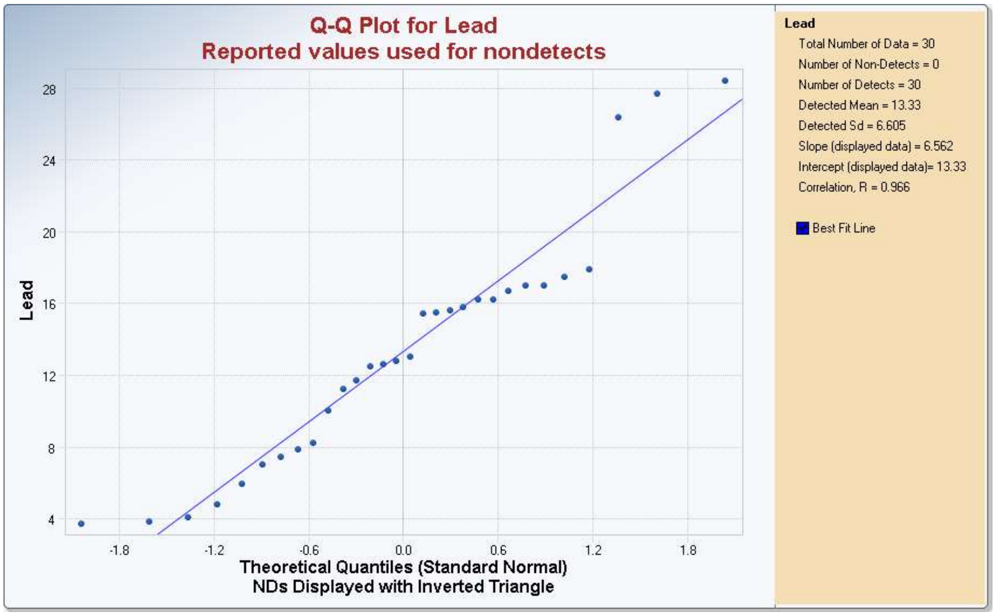
No potential high outliers are present in QQ plot or box plot. Non-detects were evaluated at one-half the reported value. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Results of Rosner's test indicates no statistical outliers. *Background dataset is not censored because no statistical outliers were identified.*

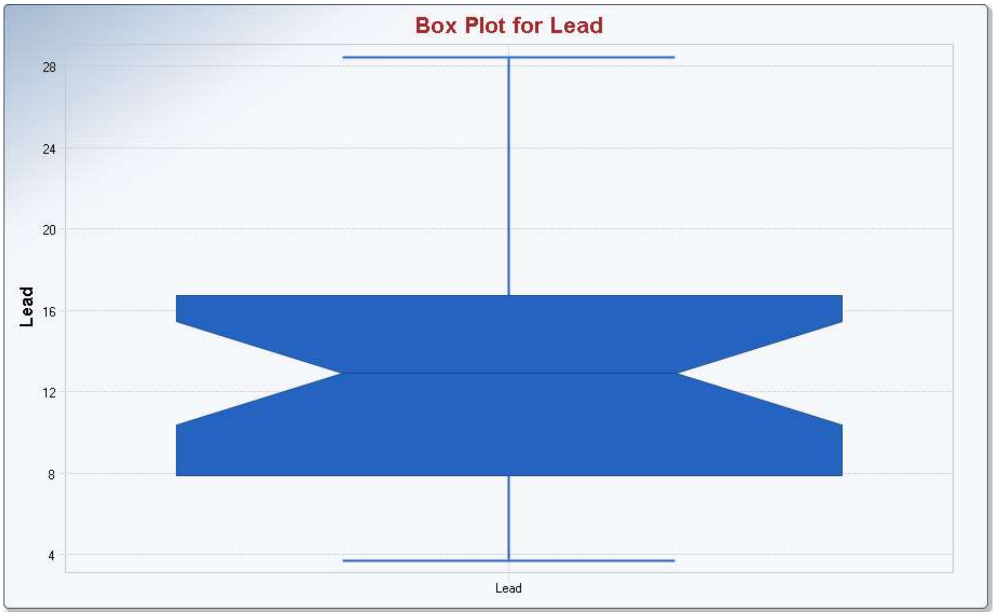


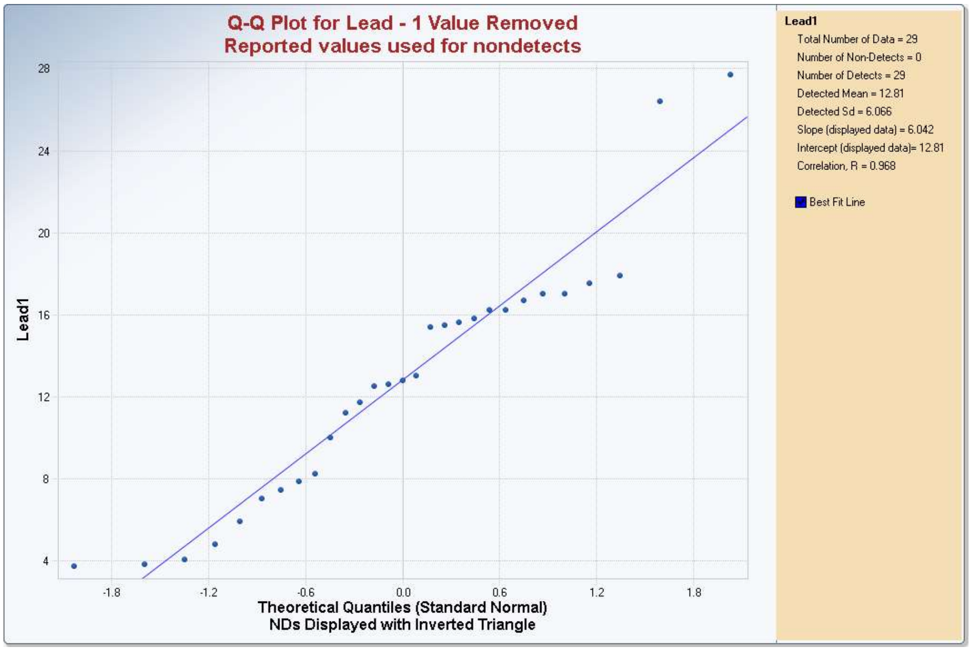


Lead

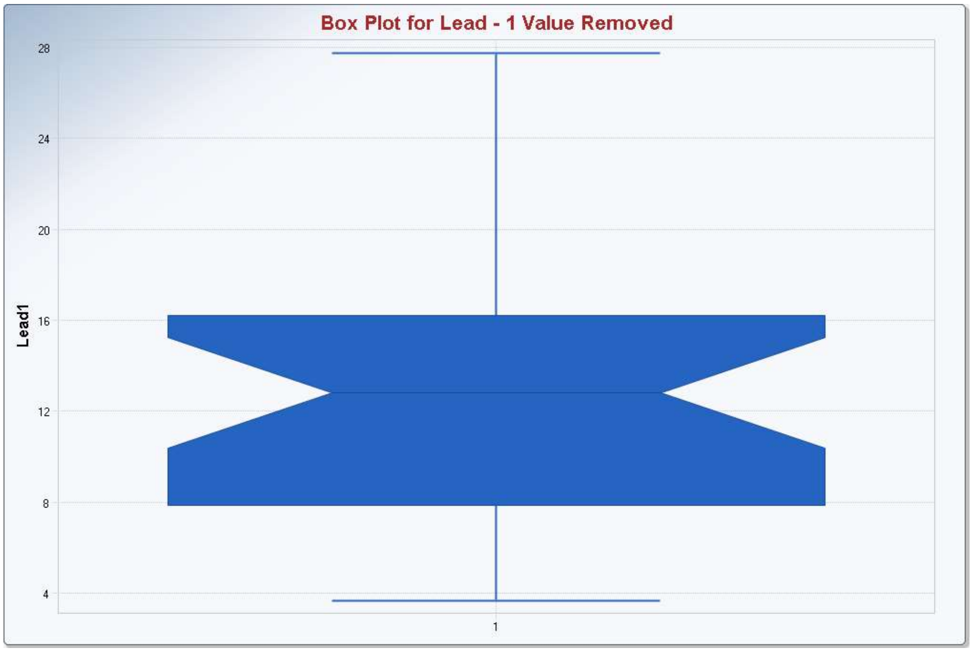
Three potential high outliers are present in the QQ plot but none are present in the box plot. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Results of Rosner's test indicates no statistical outliers. *Background dataset is not censored because no statistical outliers were identified.*

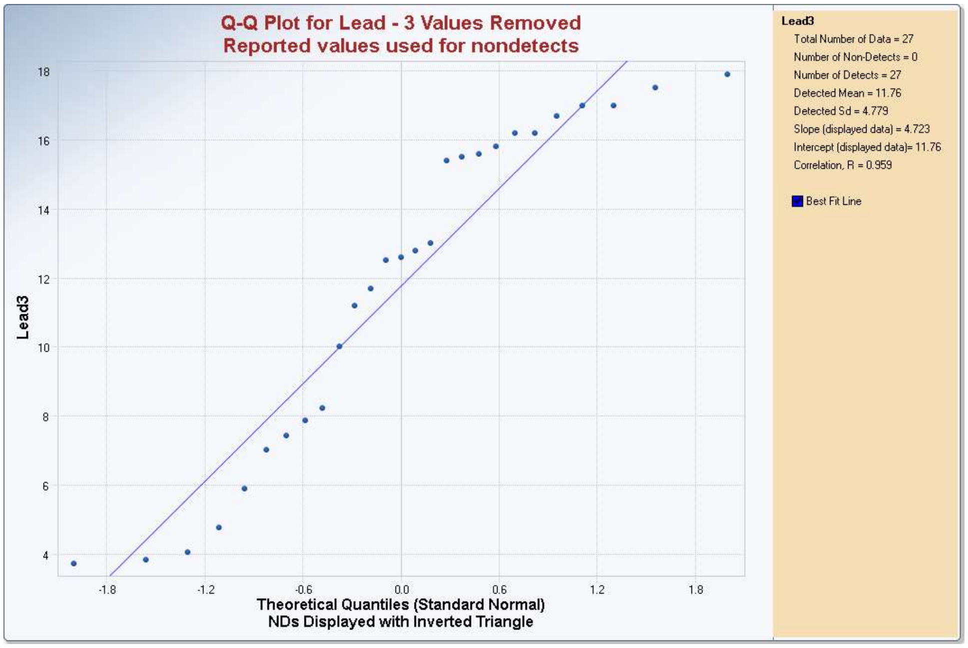


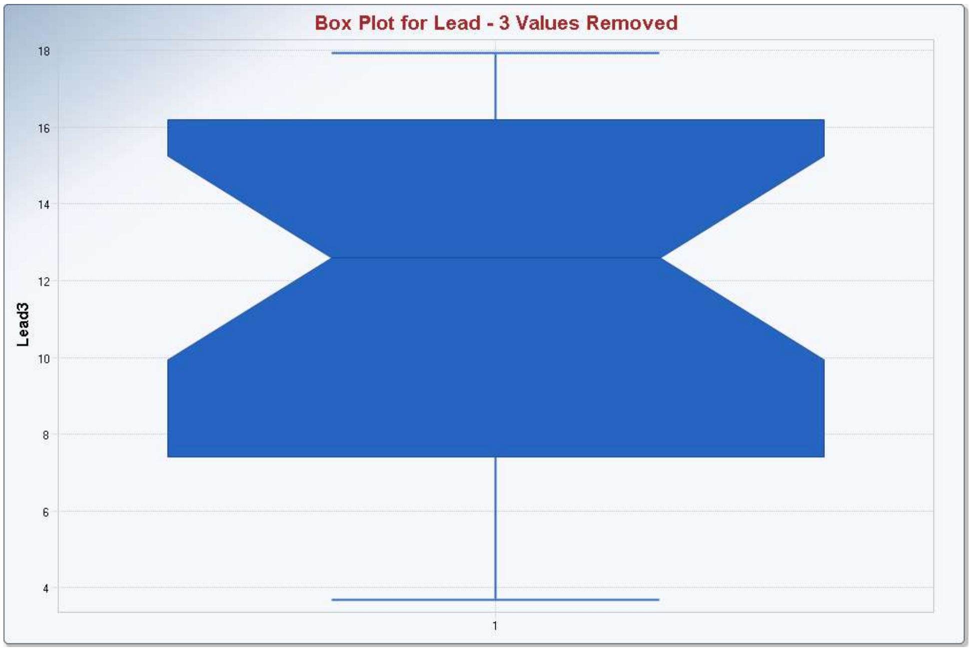




Lead1
Total Number of Data = 29
Number of Non-Detects = 0
Number of Detects = 29
Detected Mean = 12.81
Detected Sd = 6.066
Slope (displayed data) = 6.042
Intercept (displayed data)= 12.81
Correlation, R = 0.968

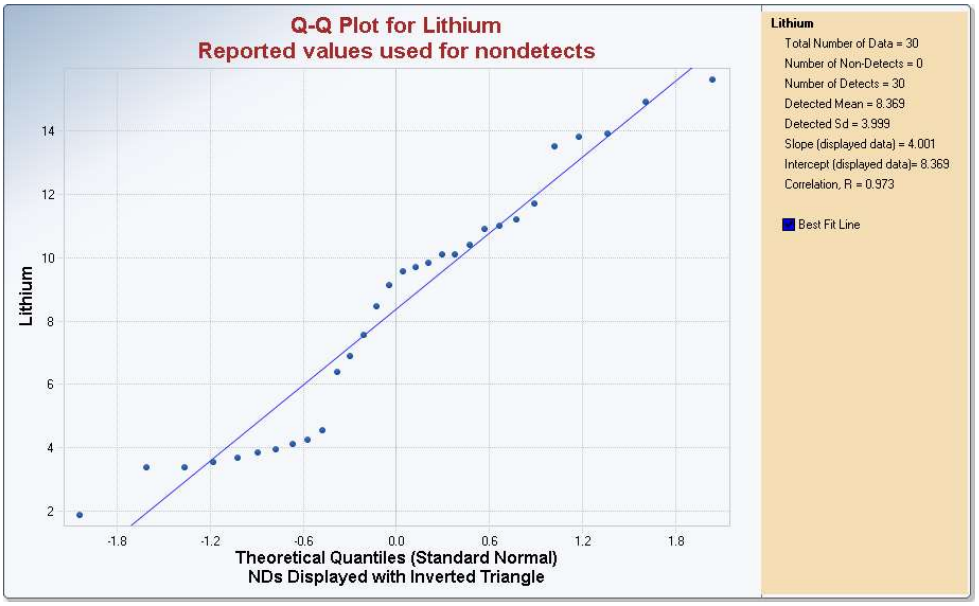



Q-Q Plot for Lead - 3 Values Removed
Reported values used for nondetects
18
16
14
12
10
8
6
4
Lead3
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)
NDs Displayed with Inverted Triangle
Lead3
Total Number of Data = 27
Number of Non-Detects = 0
Number of Detects = 27
Detected Mean = 11.76
Detected Sd = 4.779
Slope (displayed data) = 4.723
Intercept (displayed data)= 11.76
Correlation, R = 0.959
Best Fit Line

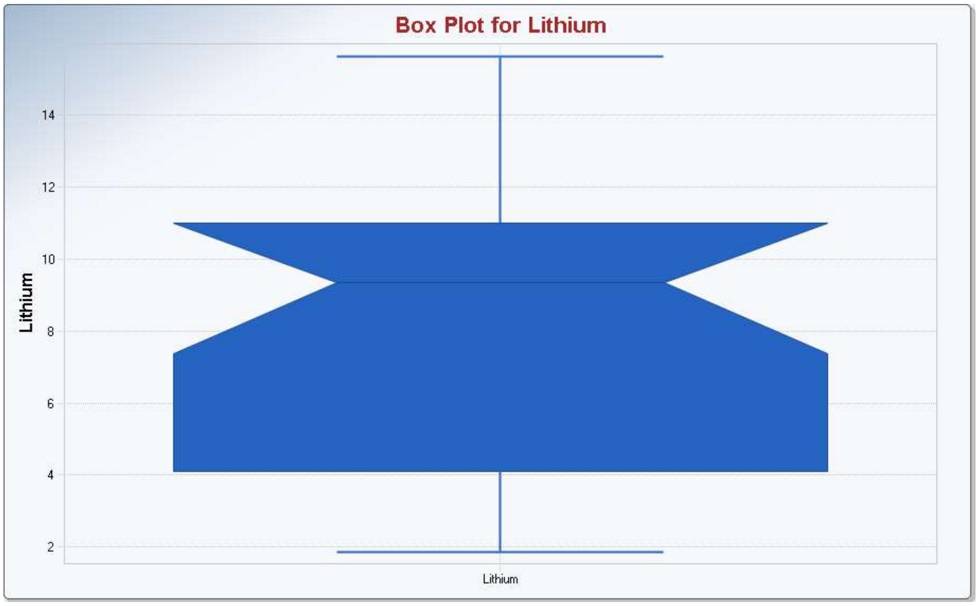

Box Plot for Lead - 3 Values Removed
18
16
14
12
10
8
6
4
Lead3
1

Lithium

No potential high outliers are present in the QQ plot or box plot. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Results of Rosner's test indicates no statistical outliers. *Background dataset is not censored because no statistical outliers were identified.*

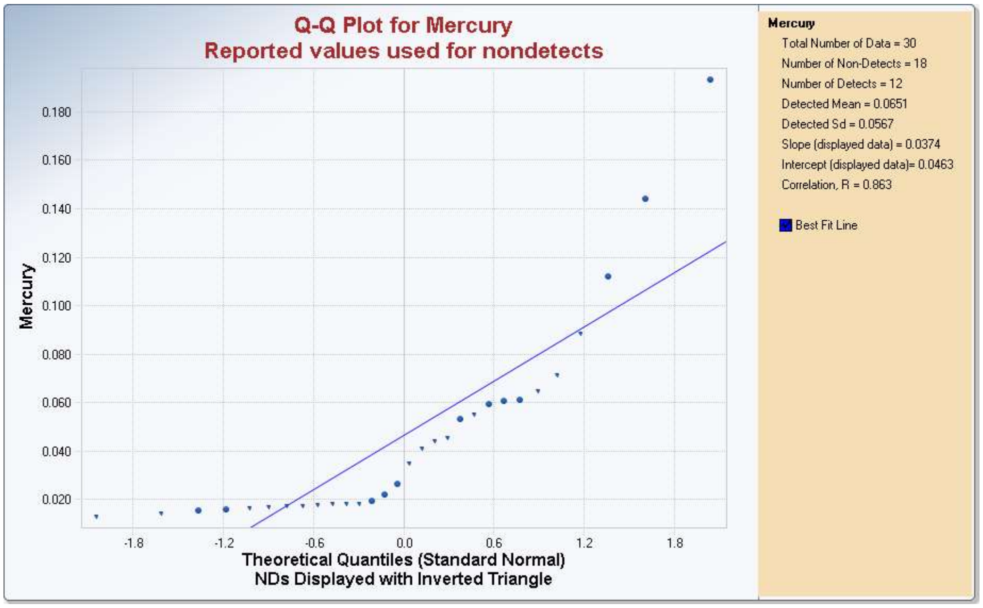


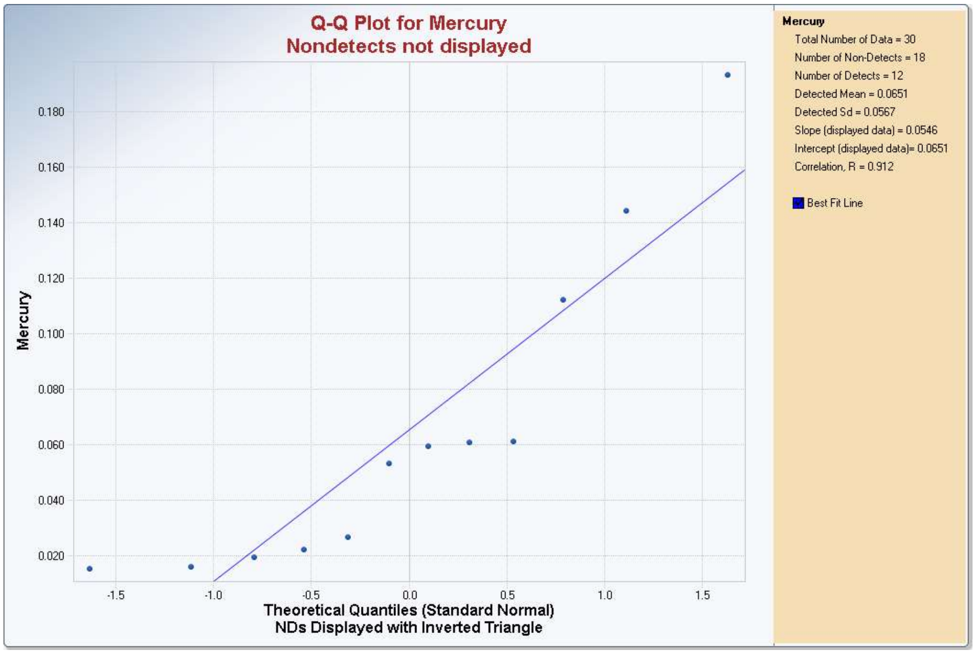
Lithium
Total Number of Data = 30
Number of Non-Detects = 0
Number of Detects = 30
Detected Mean = 8.369
Detected Sd = 3.999
Slope (displayed data) = 4.001
Intercept (displayed data)= 8.369
Correlation, R = 0.973



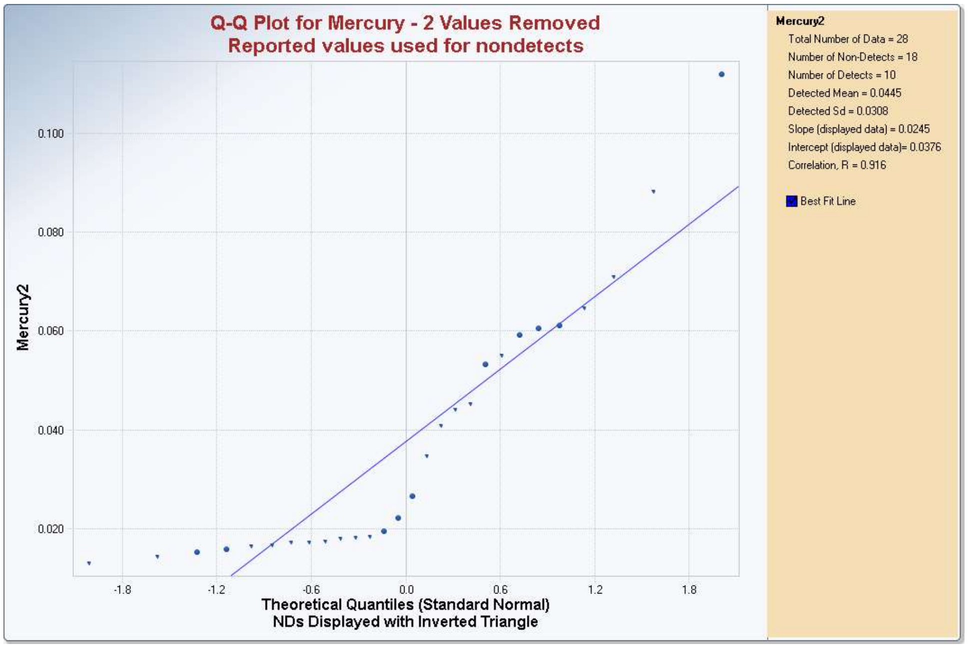
Mercury

Two potential high outliers are present in the QQ plot and box plot when non-detects are presented. When non-detects were evaluated at one-half the reported value using Rosner's outlier test in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016), two statistical outliers are present. No high outliers are present in the QQ plot when non-detects are excluded. When non-detects were excluded from the outlier test, no statistical outliers are present. *Background dataset is not censored because no statistical outliers were identified when non-detects were excluded.*

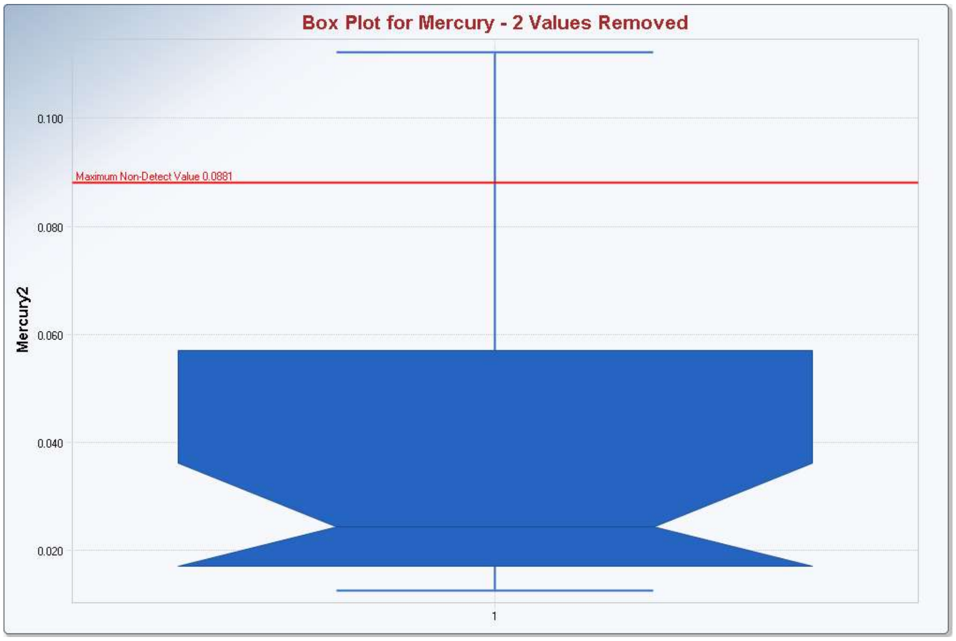





Box Plot for Mercury
Mercury
0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
Maximum Non-Detect Value 0.0881
Mercury

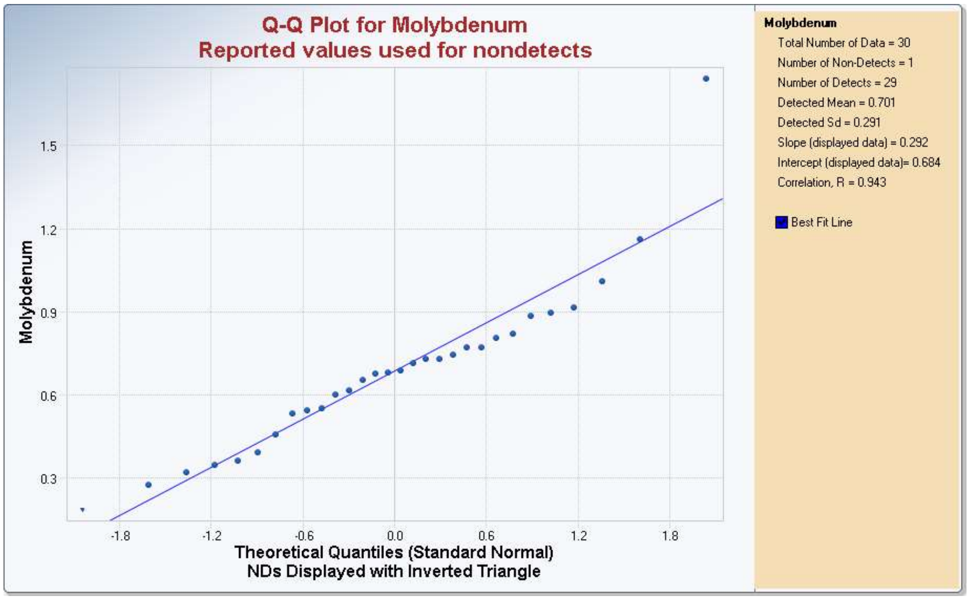

Q-Q Plot for Mercury - 2 Values Removed
Reported values used for nondetects
Mercury2
0.100
0.080
0.060
0.040
0.020
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)
NDs Displayed with Inverted Triangle
Mercury2
Total Number of Data = 28
Number of Non-Detects = 18
Number of Detects = 10
Detected Mean = 0.0445
Detected Sd = 0.0308
Slope (displayed data) = 0.0245
Intercept (displayed data)= 0.0376
Correlation, R = 0.916
Best Fit Line

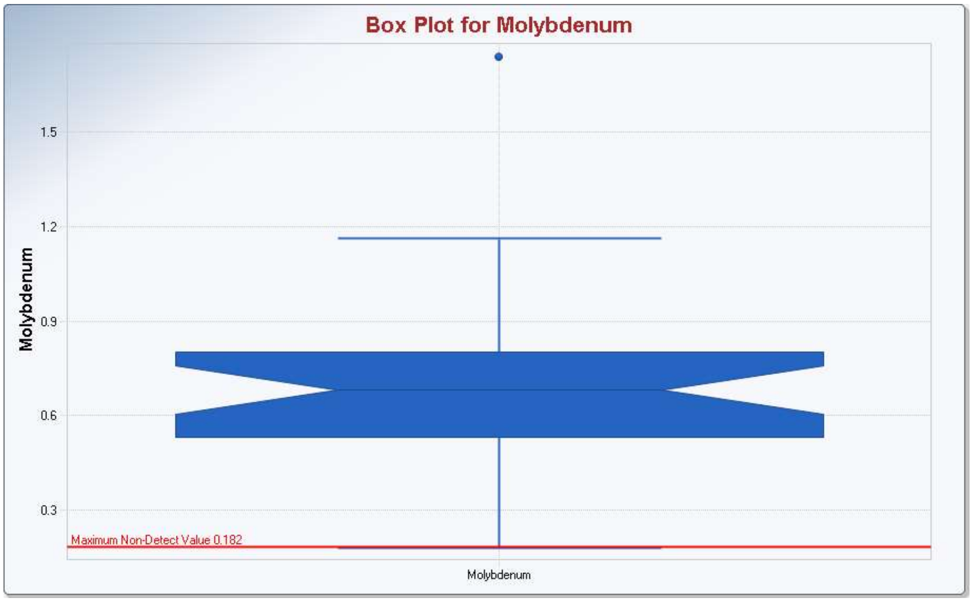
Attachment A – Background Threshold Value Derivation

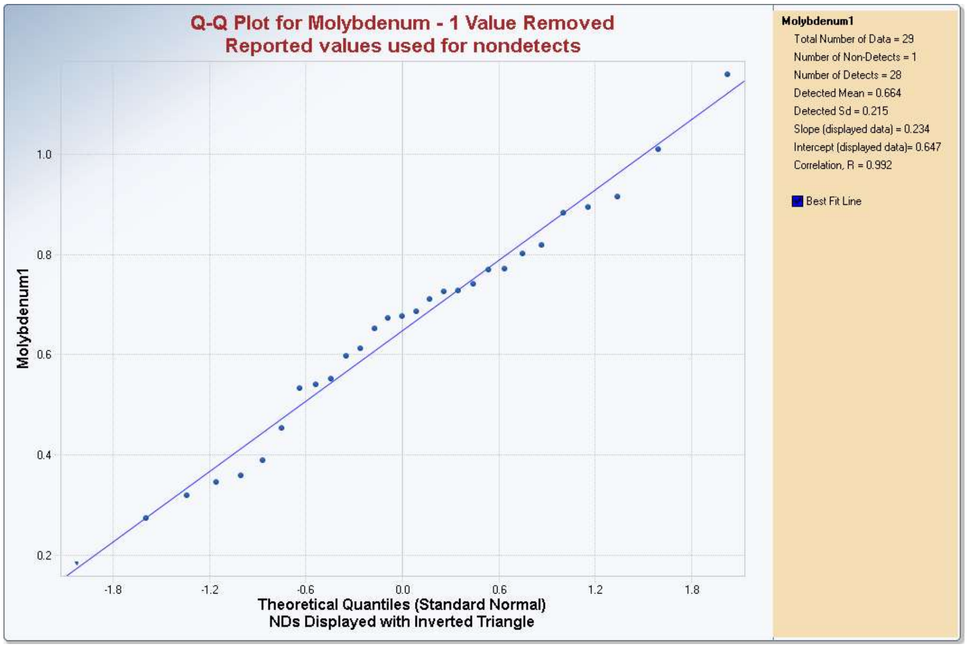


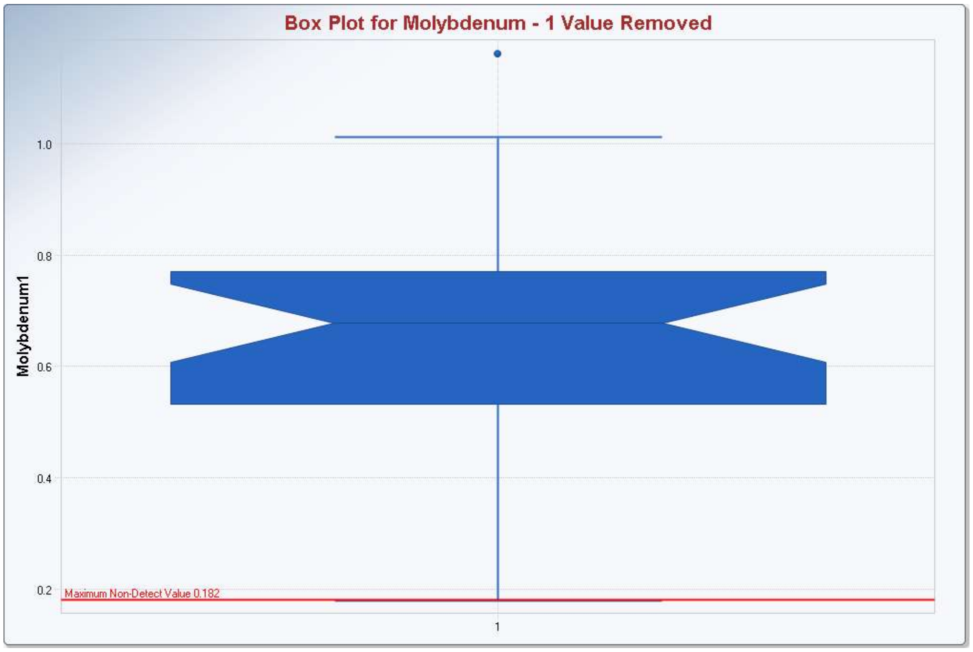
Molybdenum

One potential high outlier is present in the QQ plot and box plot. Non-detects were evaluated at one-half the reported value. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Results of Rosner's test indicates one statistical outlier. *The variability in the background dataset, and the associated outlier, likely represent natural variability within an industrialized site. Based on existing knowledge that these data are from background sample locations, no outliers were removed from the background dataset.*



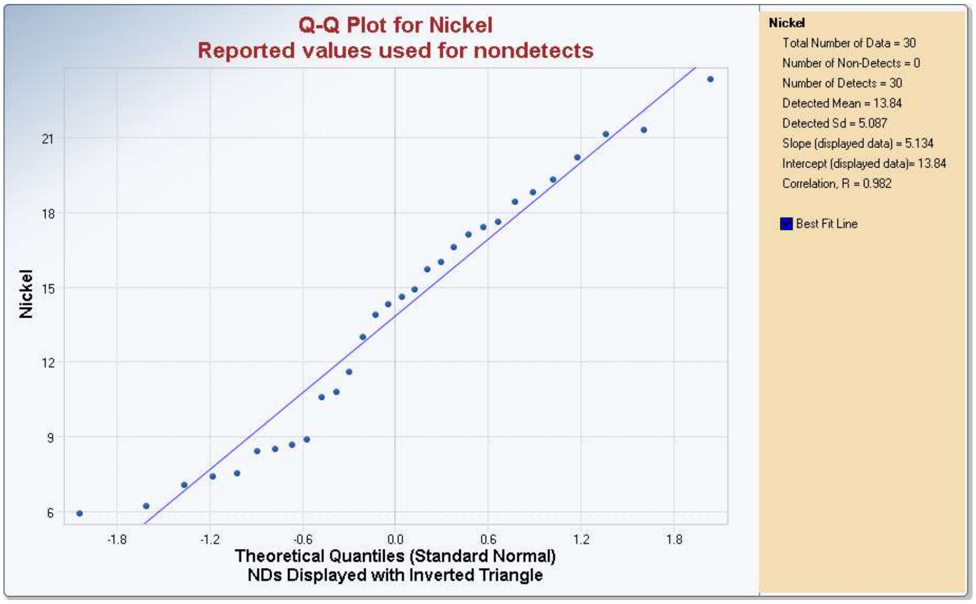


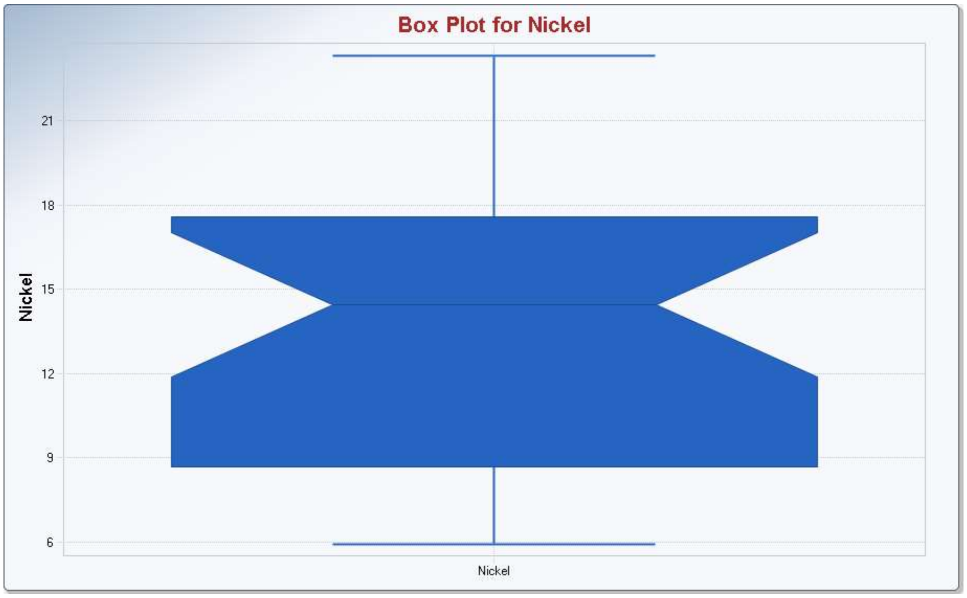

Q-Q Plot for Molybdenum - 1 Value Removed
Reported values used for nondetects
Molybdenum1
1.0
0.8
0.6
0.4
0.2
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)
NDs Displayed with Inverted Triangle
Molybdenum1
Total Number of Data = 29
Number of Non-Detects = 1
Number of Detects = 28
Detected Mean = 0.664
Detected Sd = 0.215
Slope (displayed data) = 0.234
Intercept (displayed data)= 0.647
Correlation, R = 0.992
Best Fit Line

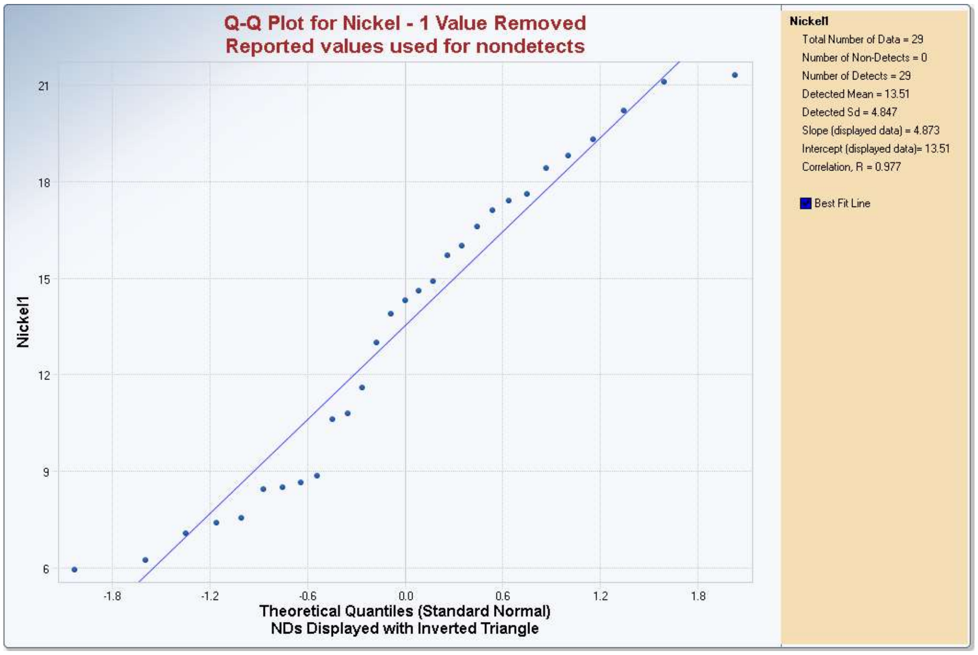

Box Plot for Molybdenum - 1 Value Removed
Molybdenum1
1.0
0.8
0.6
0.4
0.2
Maximum Non-Detect Value 0.182
1

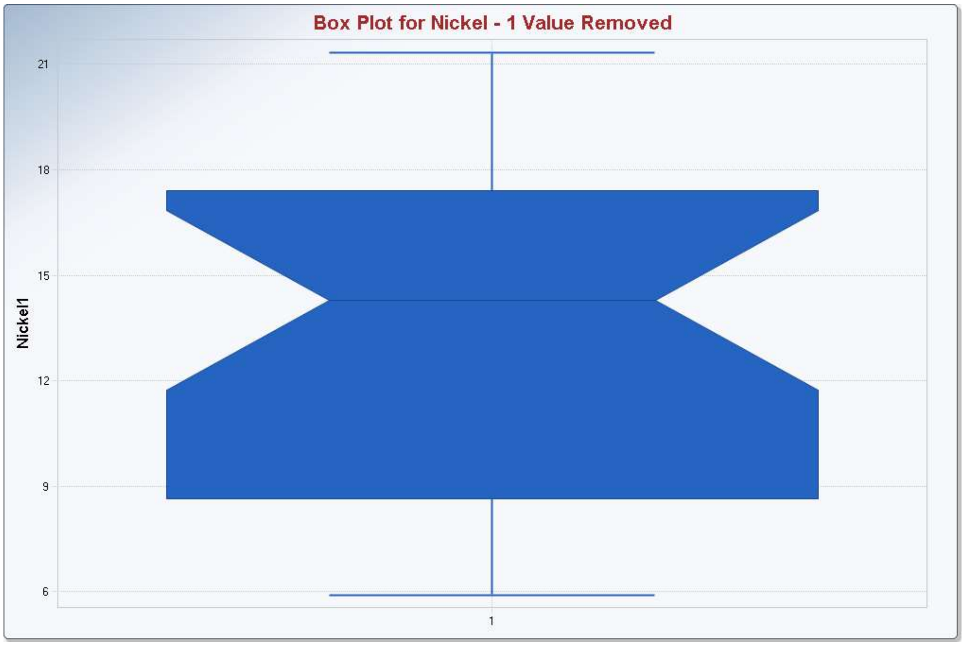
Nickel

One potential high outlier is present in the QQ plot but none are present in the box plot. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Results of Rosner's test indicates no statistical outliers. *Background dataset is not censored because no statistical outliers were identified.*



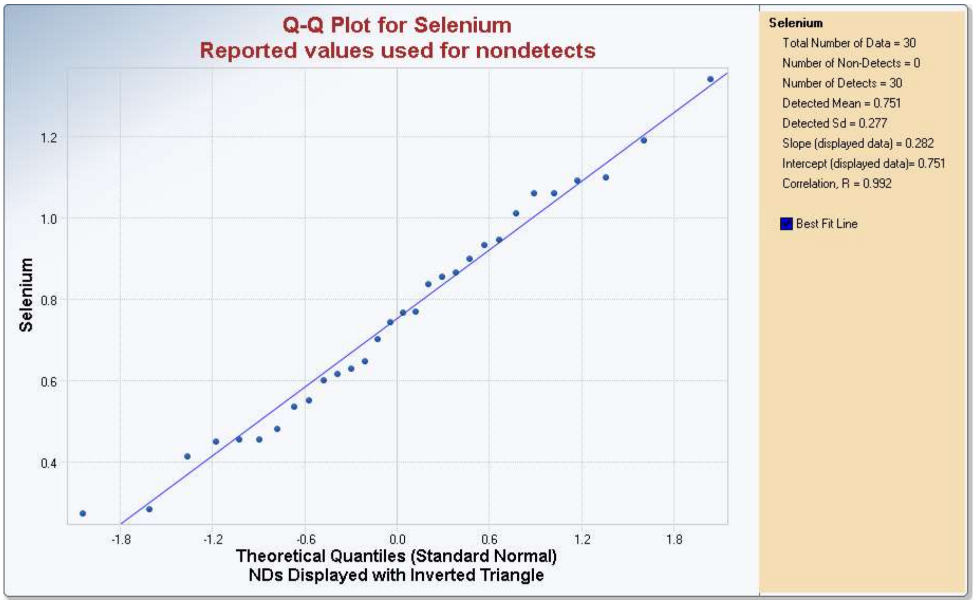


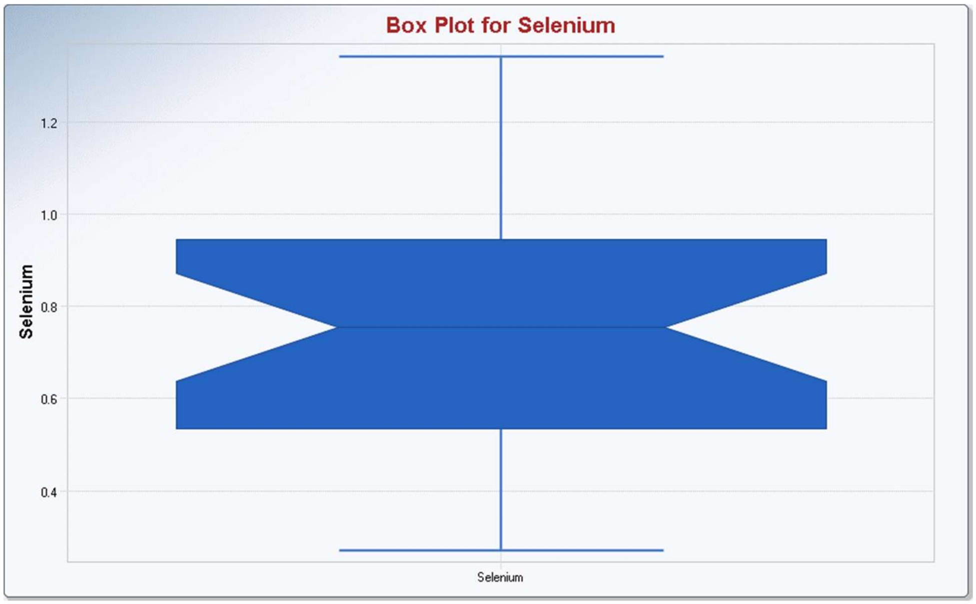

Q-Q Plot for Nickel - 1 Value Removed
Reported values used for nondetects
Nickel1
21
18
15
12
9
6
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)
NDs Displayed with Inverted Triangle
Nickel1
Total Number of Data = 29
Number of Non-Detects = 0
Number of Detects = 29
Detected Mean = 13.51
Detected Sd = 4.847
Slope (displayed data) = 4.873
Intercept (displayed data)= 13.51
Correlation, R = 0.977
Best Fit Line

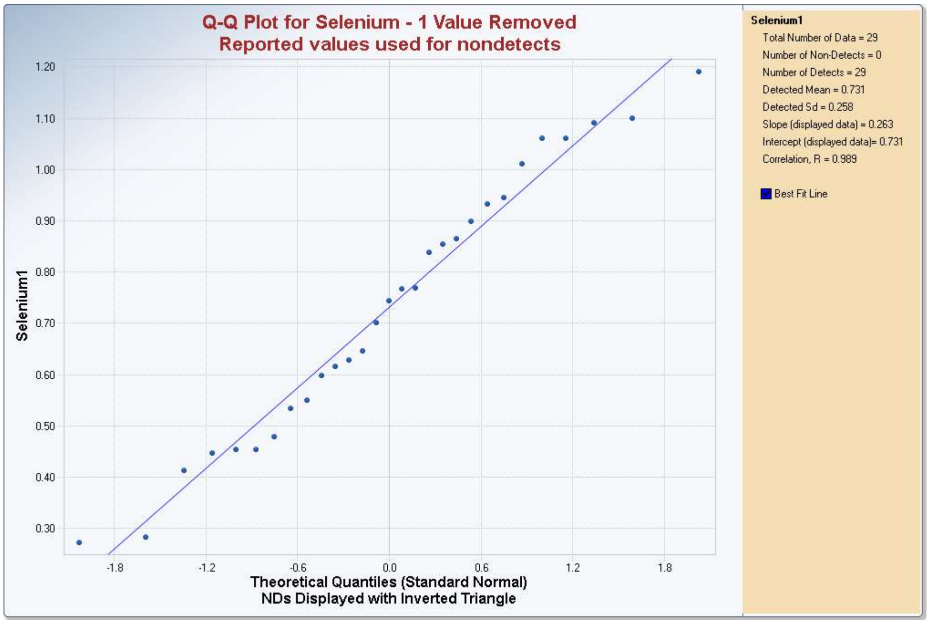

Box Plot for Nickel - 1 Value Removed
Nickel1
21
18
15
12
9
6
1

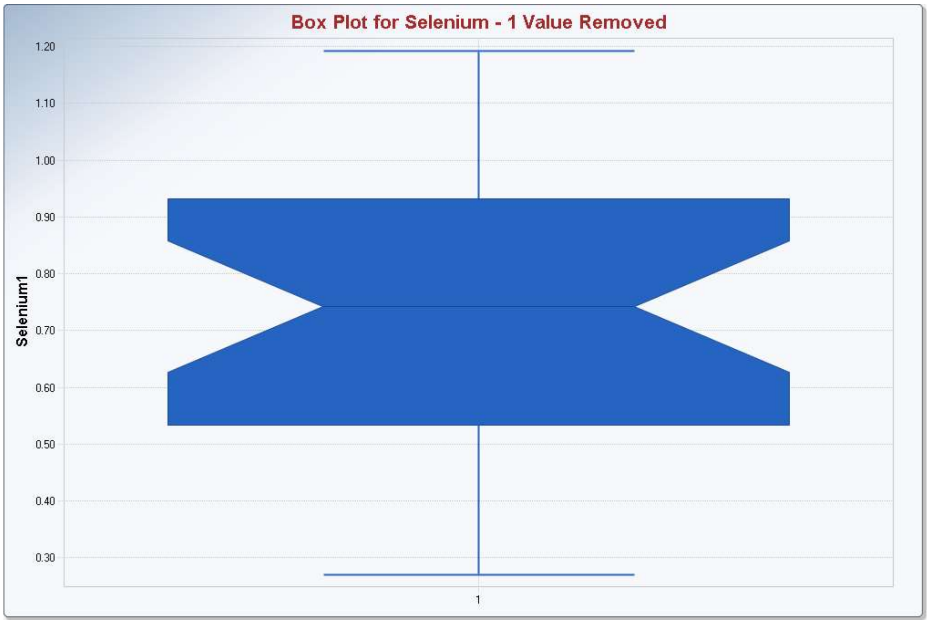
Selenium

One potential high outlier is present in the QQ plot but none are present in the box plot. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Results of Rosner's test indicates no statistical outliers. *Background dataset is not censored because no statistical outliers were identified.*



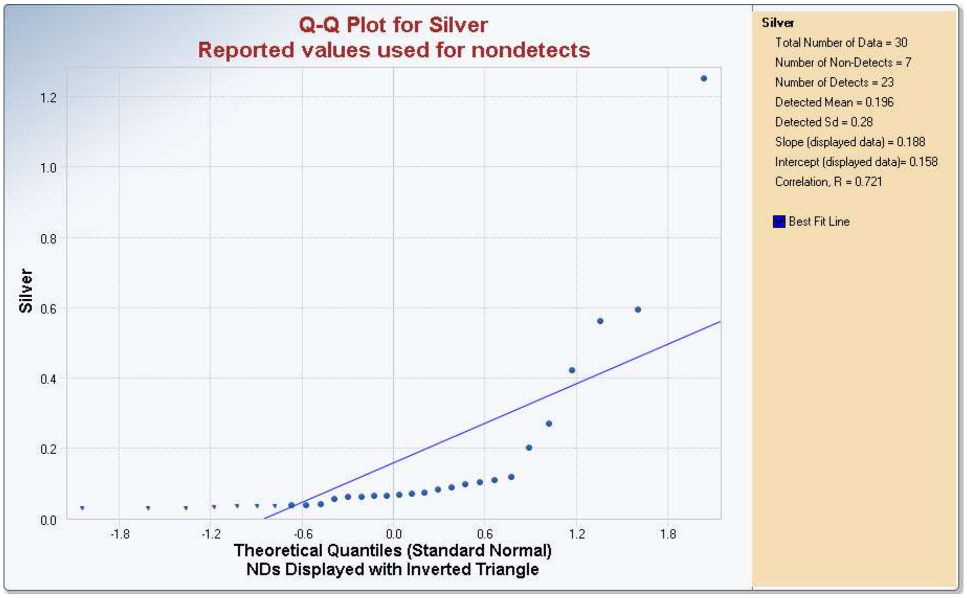


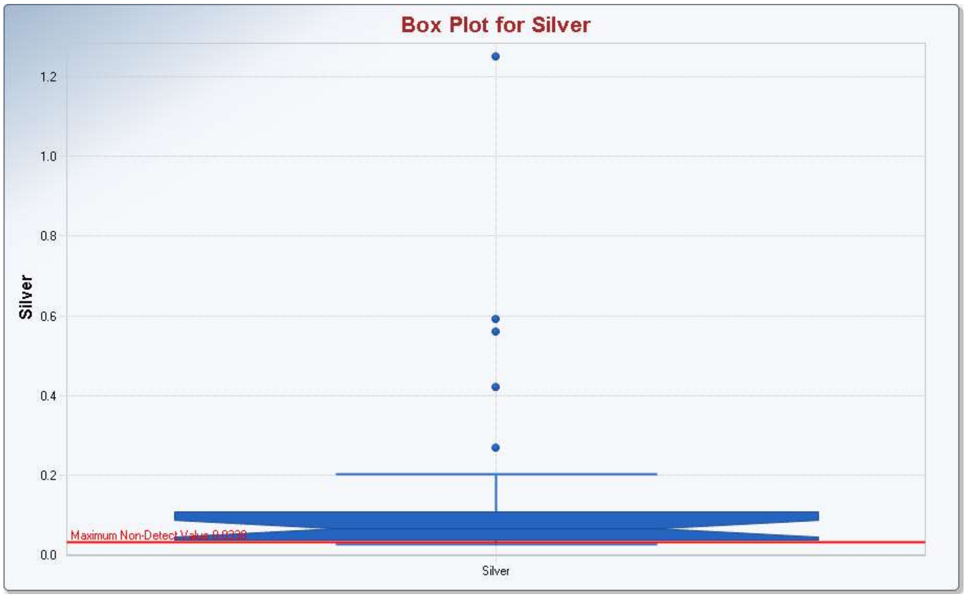

Q-Q Plot for Selenium - 1 Value Removed
Reported values used for nondetects
Selenium1
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)
NDs Displayed with Inverted Triangle
Selenium1
Total Number of Data = 29
Number of Non-Detects = 0
Number of Detects = 29
Detected Mean = 0.731
Detected Sd = 0.258
Slope (displayed data) = 0.263
Intercept (displayed data)= 0.731
Correlation, R = 0.989
Best Fit Line

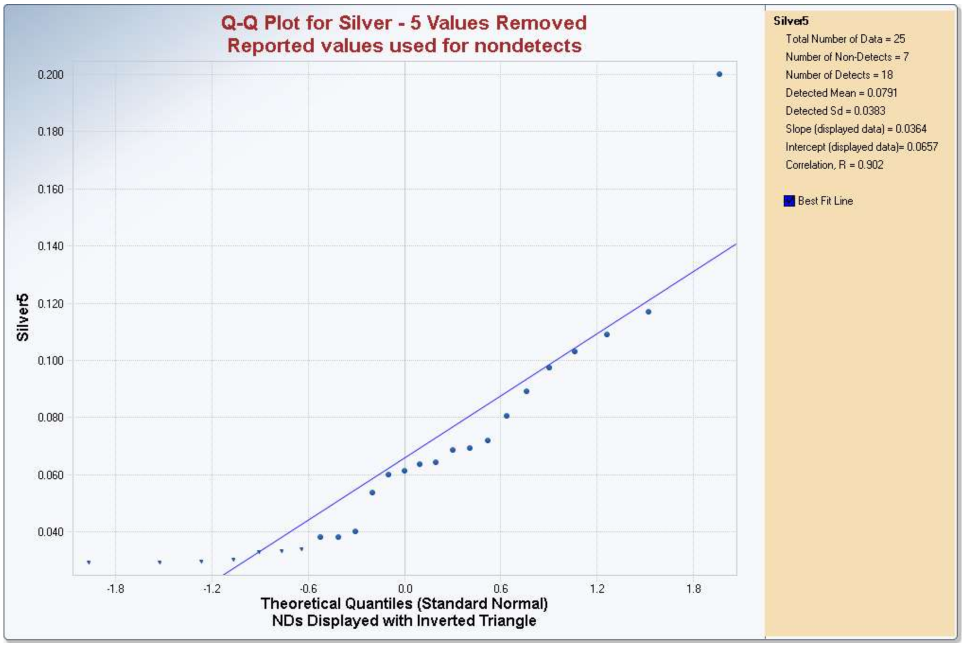

Box Plot for Selenium - 1 Value Removed
Selenium1
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
1

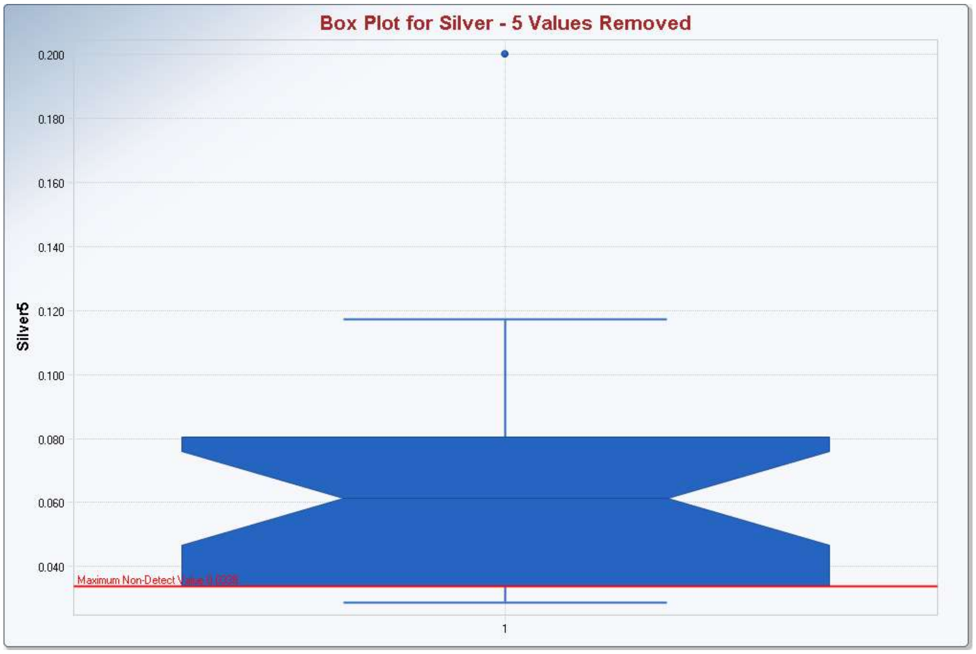
Silver

Five potential high outliers are present in the QQ plot and box plot. Non-detects were evaluated at one-half the reported value. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Results of Rosner's test indicates five statistical outliers. A review of the QQ plot and box plot post removal of five statistical outliers indicated one additional potential high outlier. Subsequently, Rosner's outlier test was run using the full dataset, including non-detects at one-half the reported value. Results of Rosner's test indicates a total of six statistical outliers. *The variability in the background dataset, and the associated outliers, likely represent natural variability within an industrialized site. Based on existing knowledge that these data are from background sample locations, no outliers were removed from the background dataset.*

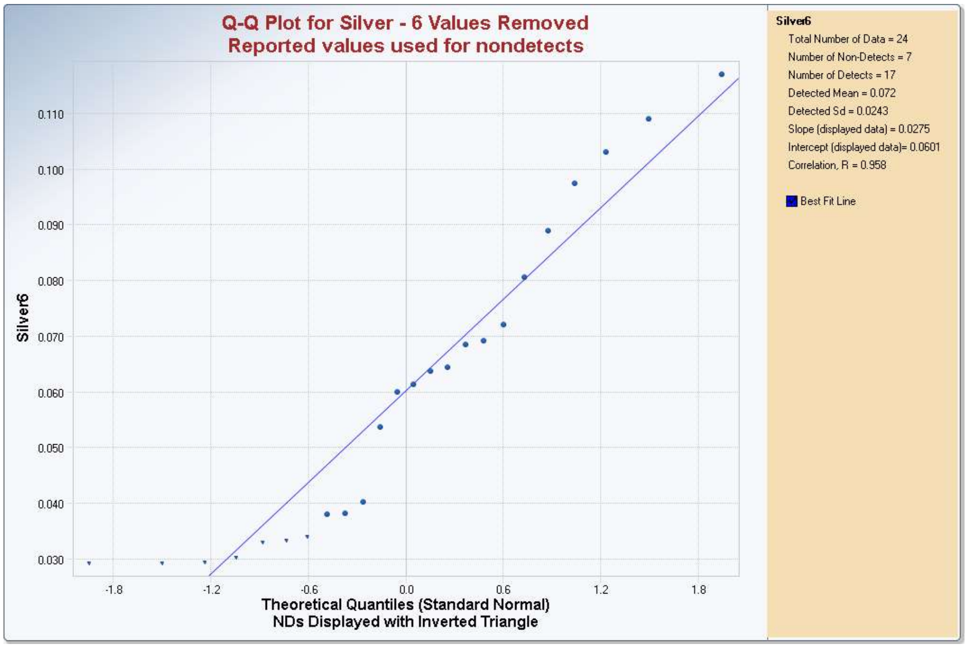




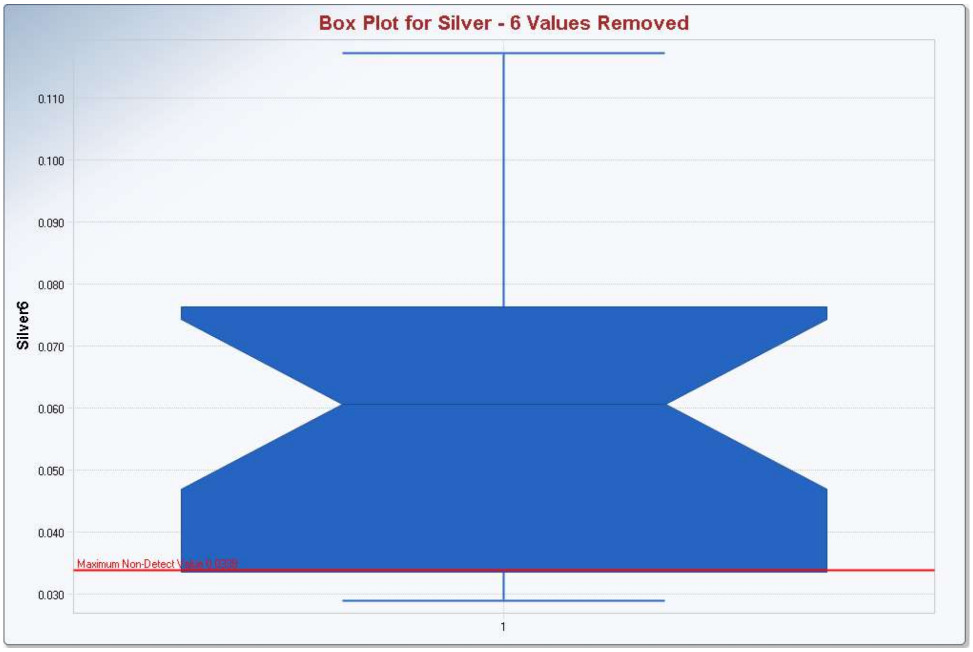

Q-Q Plot for Silver - 5 Values Removed
Reported values used for nondetects
Silver5
0.200
0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)
NDs Displayed with Inverted Triangle
Silver5
Total Number of Data = 25
Number of Non-Detects = 7
Number of Detects = 18
Detected Mean = 0.0791
Detected Sd = 0.0383
Slope (displayed data) = 0.0364
Intercept (displayed data)= 0.0657
Correlation, R = 0.902
Best Fit Line


Box Plot for Silver - 5 Values Removed
Silver5
0.200
0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
Maximum Non-Detect Value
1

Attachment A – Background Threshold Value Derivation

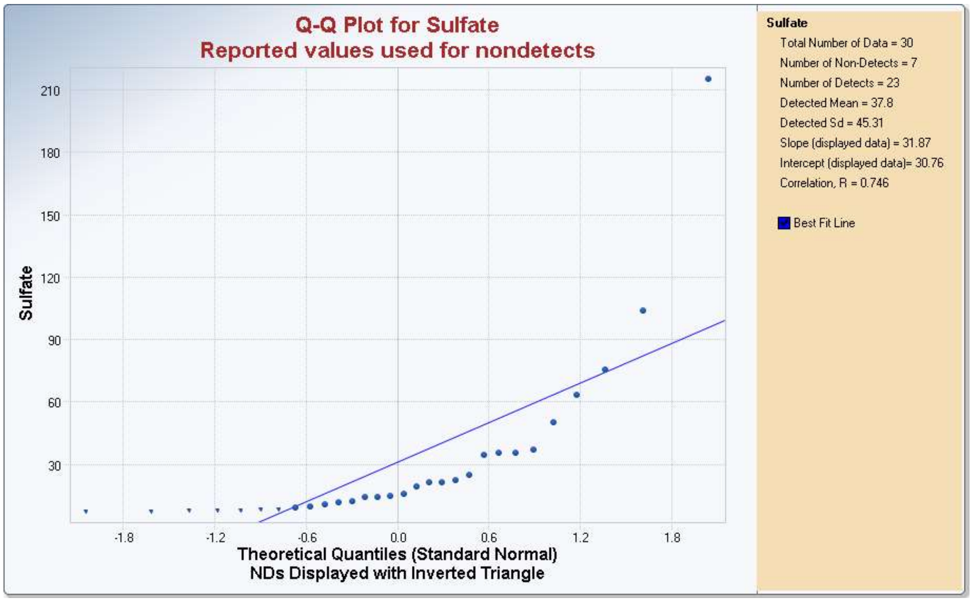


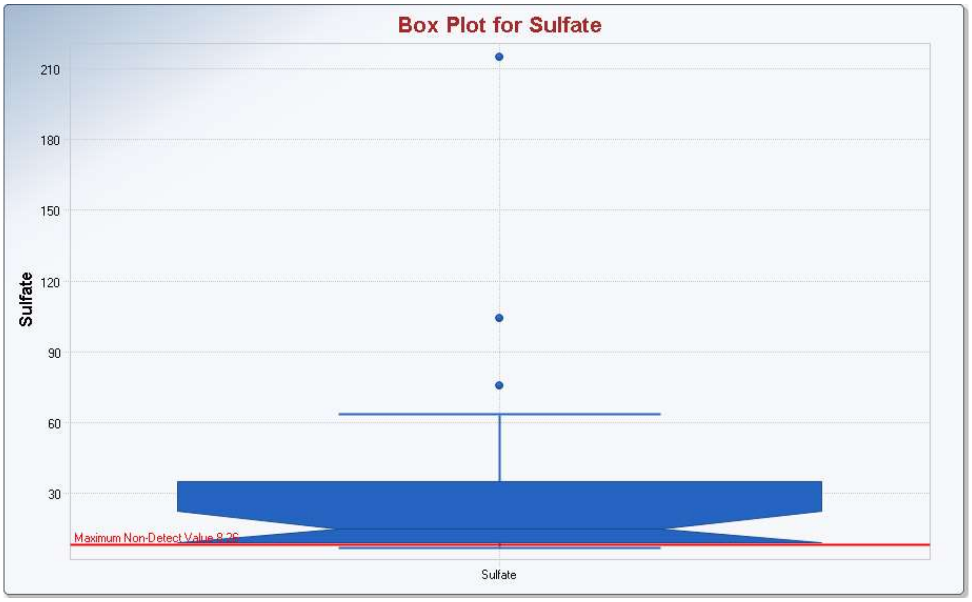
Silver6
Total Number of Data = 24
Number of Non-Detects = 7
Number of Detects = 17
Detected Mean = 0.072
Detected Sd = 0.0243
Slope (displayed data) = 0.0275
Intercept (displayed data)= 0.0601
Correlation, R = 0.958

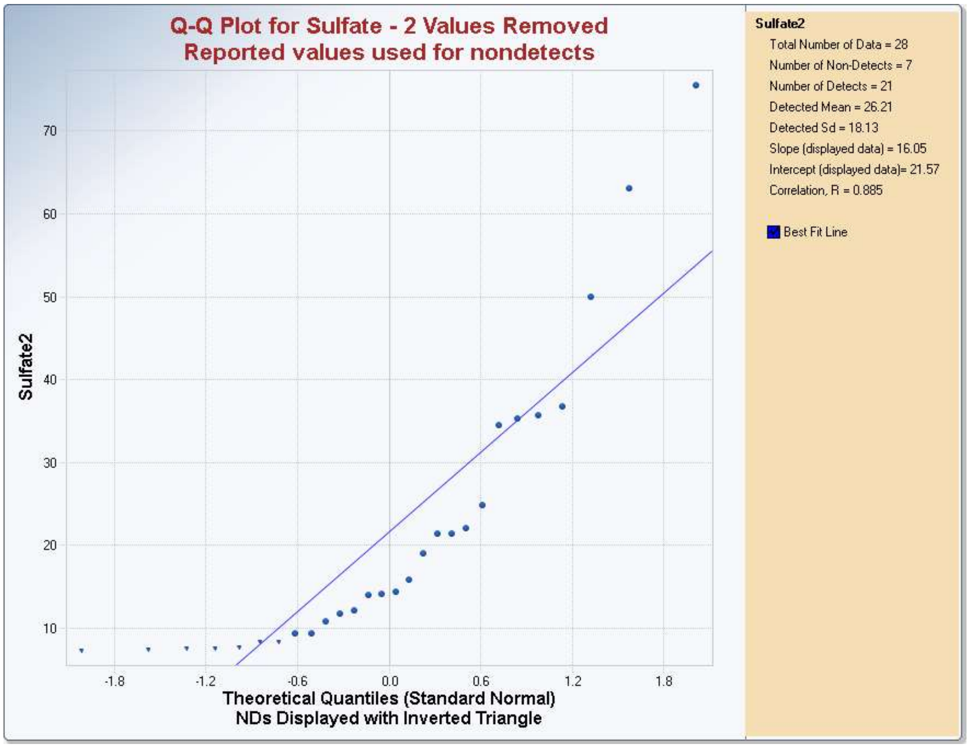


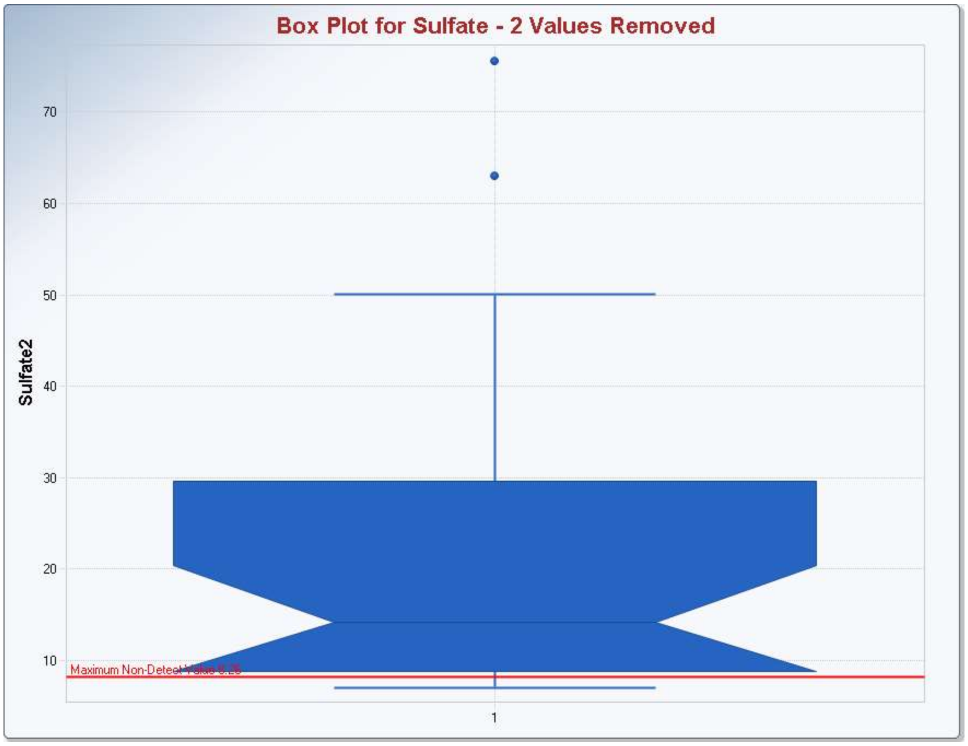
Sulfate

Two potential high outliers are present in the QQ plot and three potential high outliers are present in the box plot. Non-detects were evaluated at one-half the reported value. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Rosner's test indicates four statistical outliers. *The variability in the background dataset, and the associated outliers, likely represent natural variability within an industrialized site. Based on existing knowledge that these data are from background sample locations, no outliers were removed from the background dataset.*

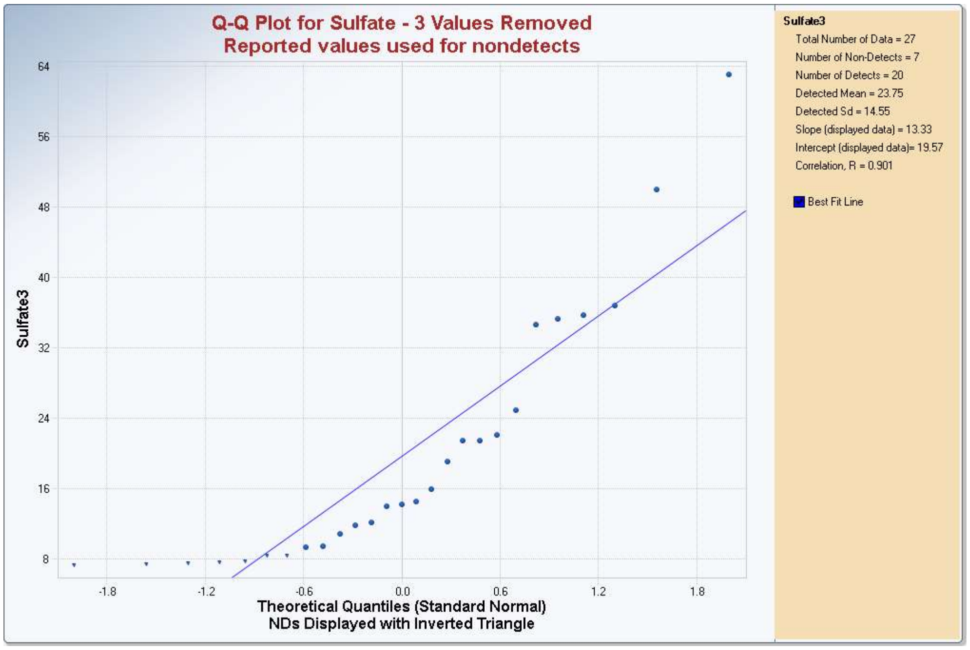


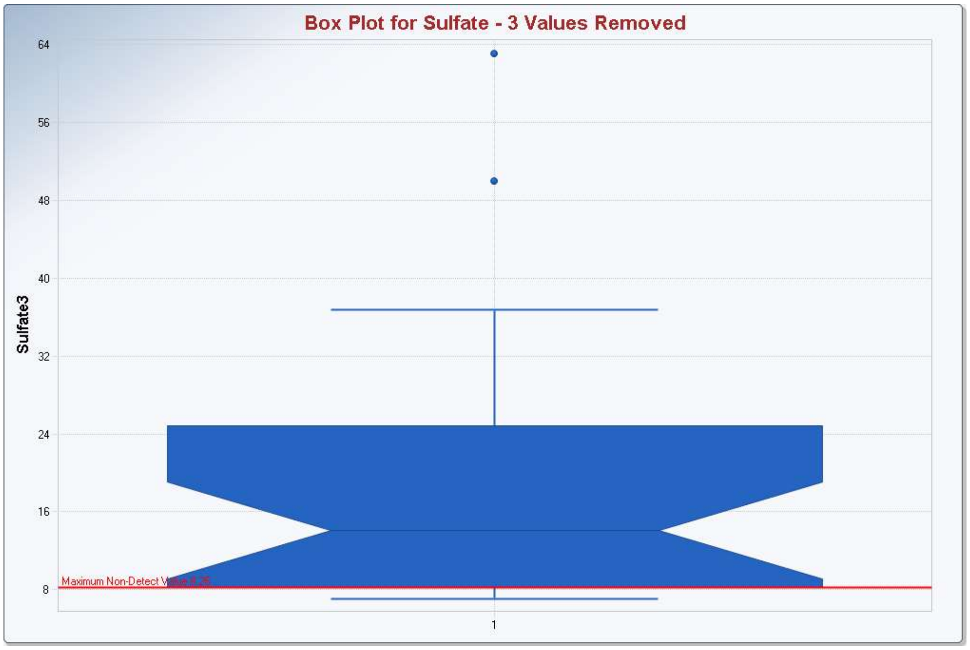



Q-Q Plot for Sulfate - 2 Values Removed
Reported values used for nondetects
Sulfate2
70
60
50
40
30
20
10
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)
NDs Displayed with Inverted Triangle
Sulfate2
Total Number of Data = 28
Number of Non-Detects = 7
Number of Detects = 21
Detected Mean = 26.21
Detected Sd = 18.13
Slope (displayed data) = 16.05
Intercept (displayed data)= 21.57
Correlation, R = 0.885
Best Fit Line

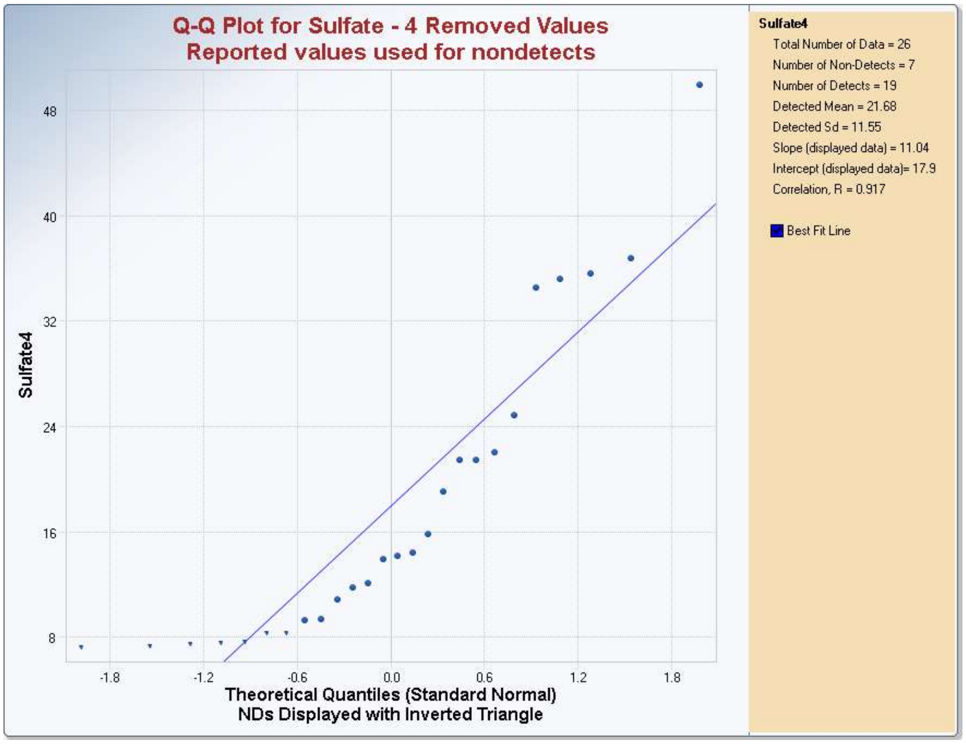

Box Plot for Sulfate - 2 Values Removed
Sulfate2
70
60
50
40
30
20
10
Maximum Non-Detect Value 8.28
1

Attachment A – Background Threshold Value Derivation

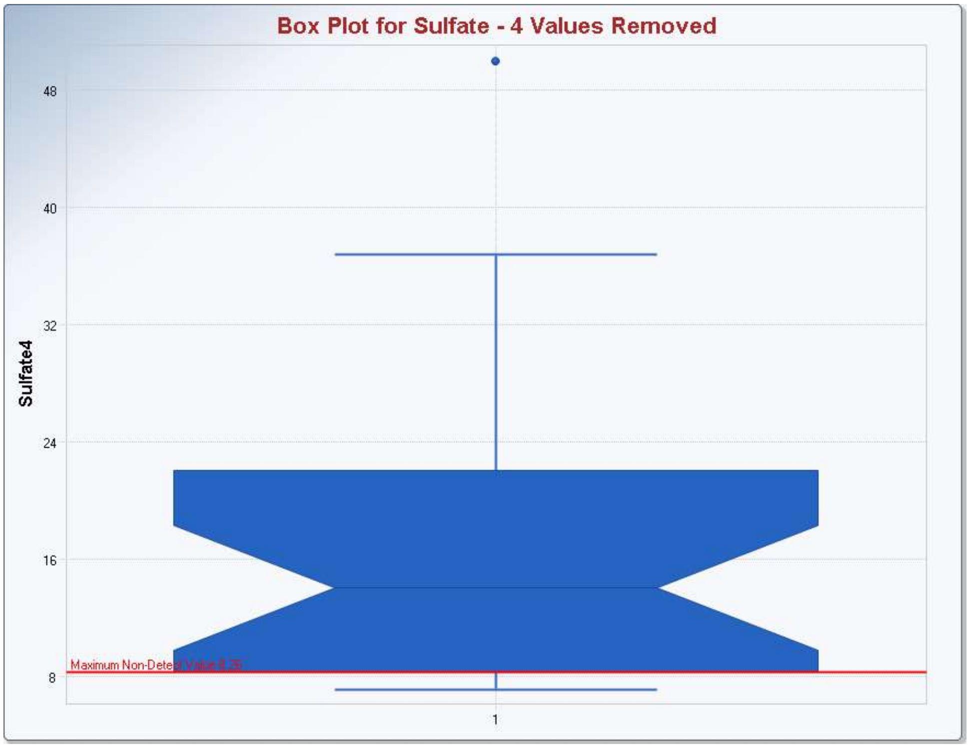




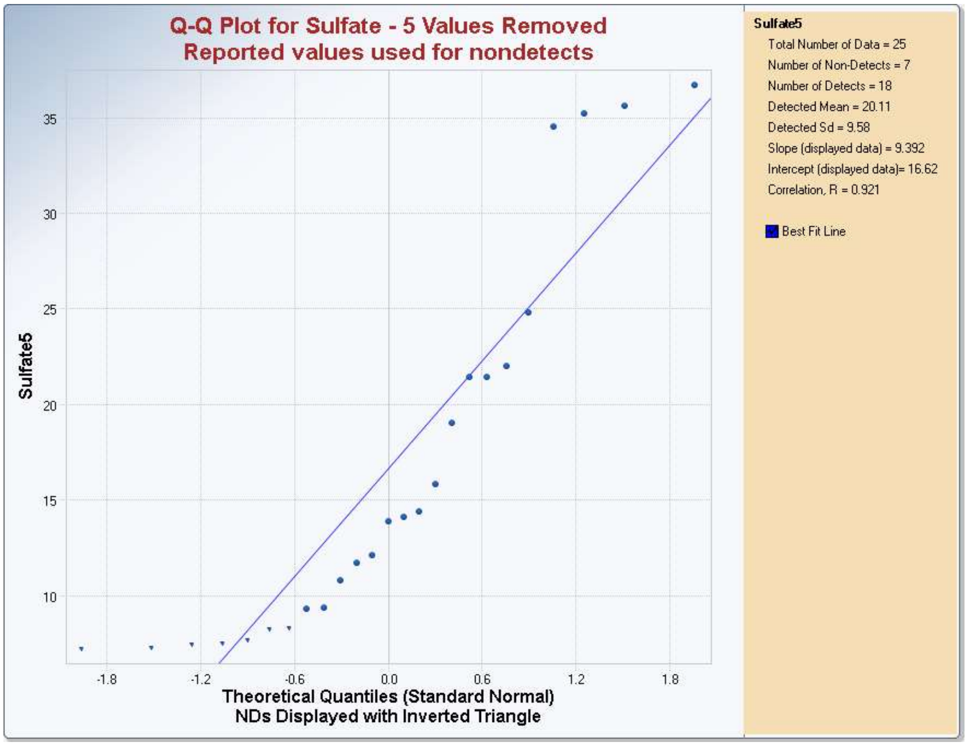
Attachment A – Background Threshold Value Derivation



Q-Q Plot for Sulfate - 4 Removed Values
Reported values used for nondetects

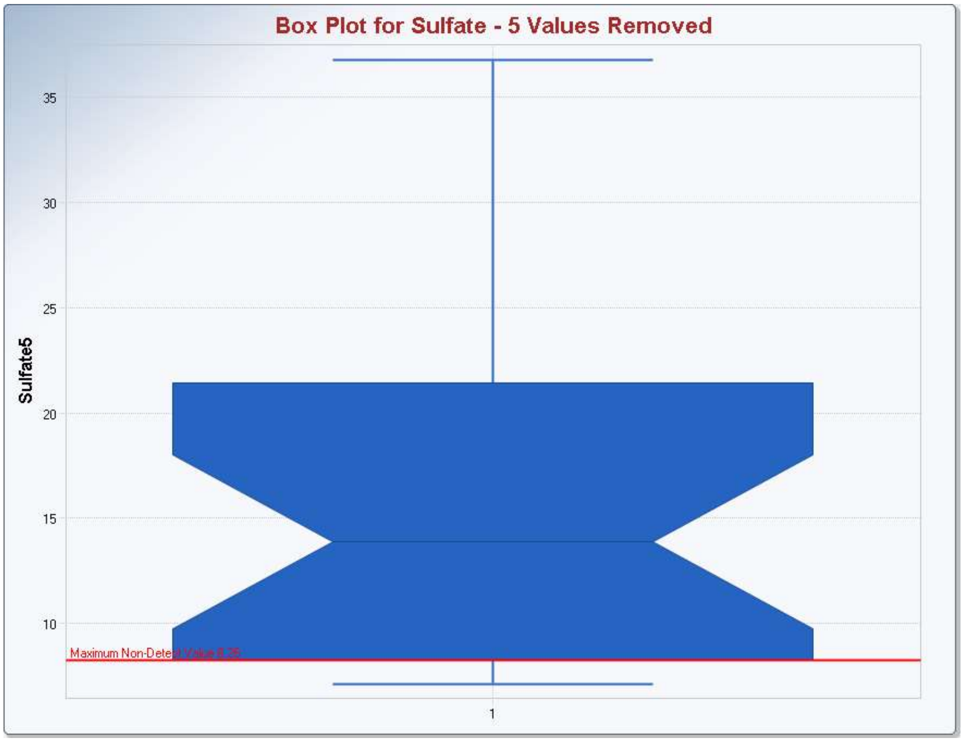


Box Plot for Sulfate - 4 Values Removed



Q-Q Plot for Sulfate - 5 Values Removed
Reported values used for nondetects

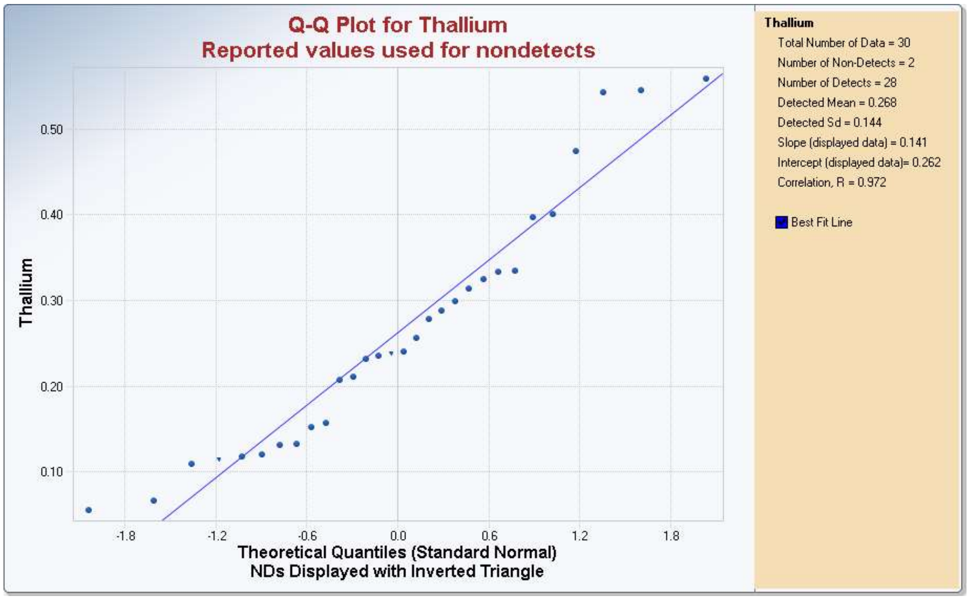
Sulfate5
Total Number of Data = 25
Number of Non-Detects = 7
Number of Detects = 18
Detected Mean = 20.11
Detected Sd = 9.58
Slope (displayed data) = 9.392
Intercept (displayed data)= 16.62
Correlation, R = 0.921

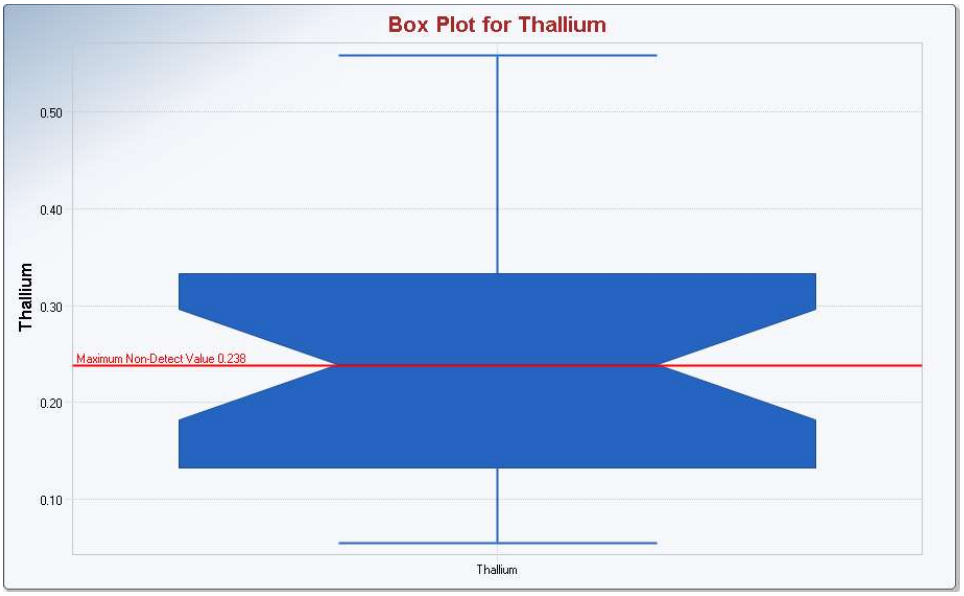


Box Plot for Sulfate - 5 Values Removed

Thallium

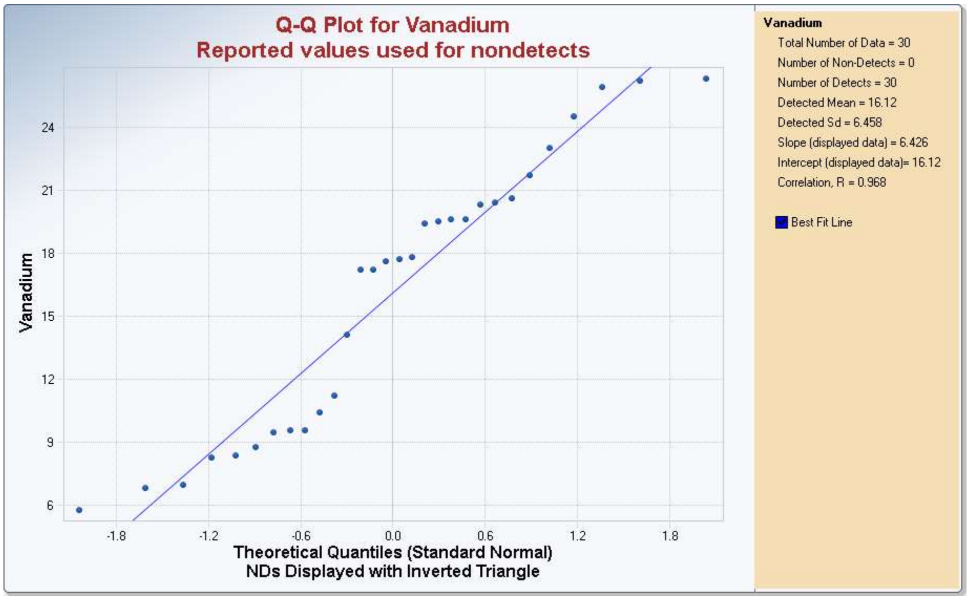
No high outliers are present in the QQ plot or box plot. Non-detects were evaluated at one-half the reported value. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Rosner's test indicates no statistical outliers. *Background dataset is not censored because no statistical outliers were identified.*

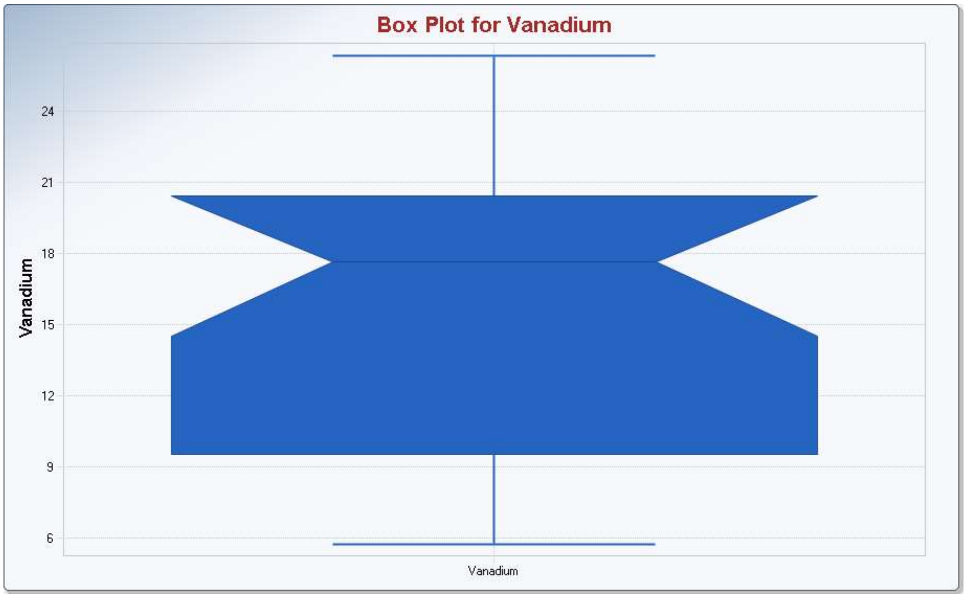




Vanadium

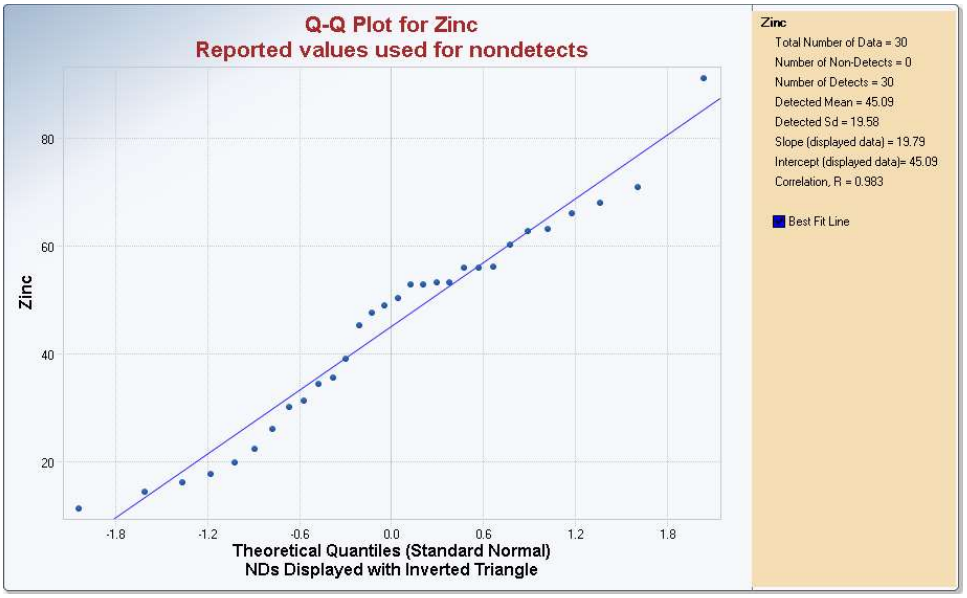
No high outliers are present in the QQ plot or box plot. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Results of Rosner's test indicates no statistical outliers. *Background dataset is not censored because no statistical outliers were identified.*

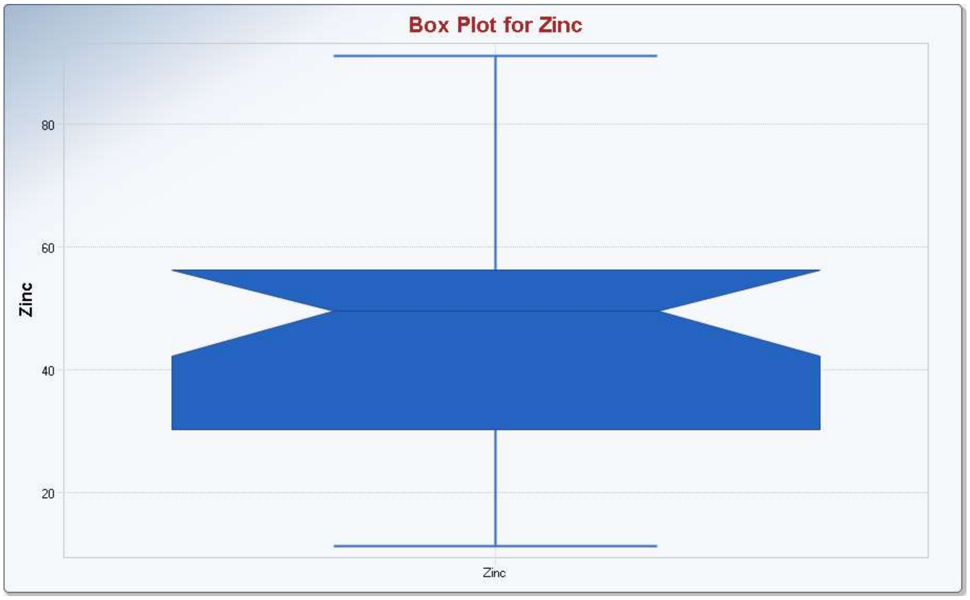


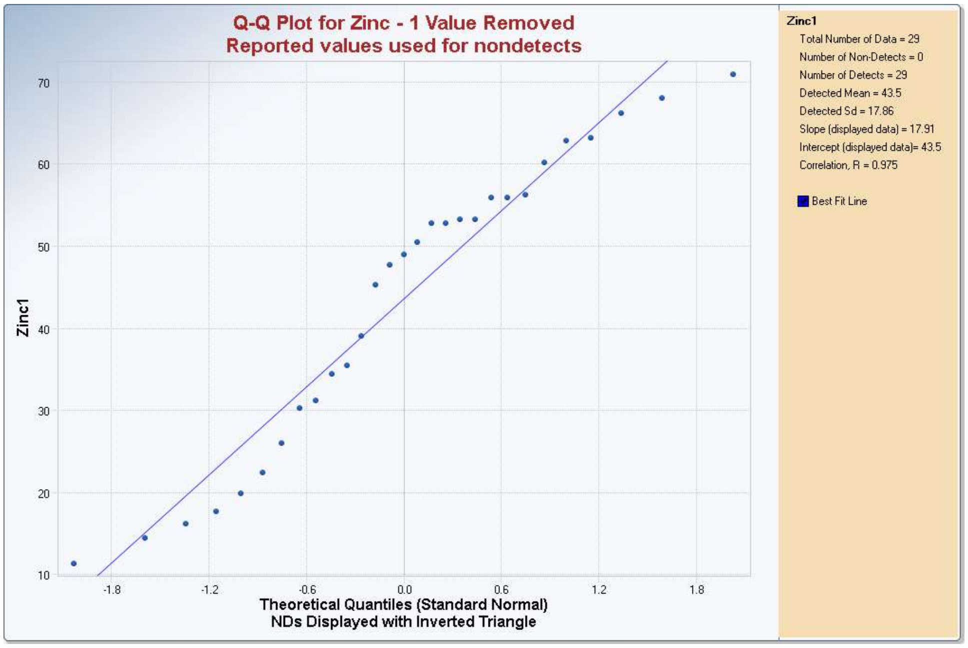


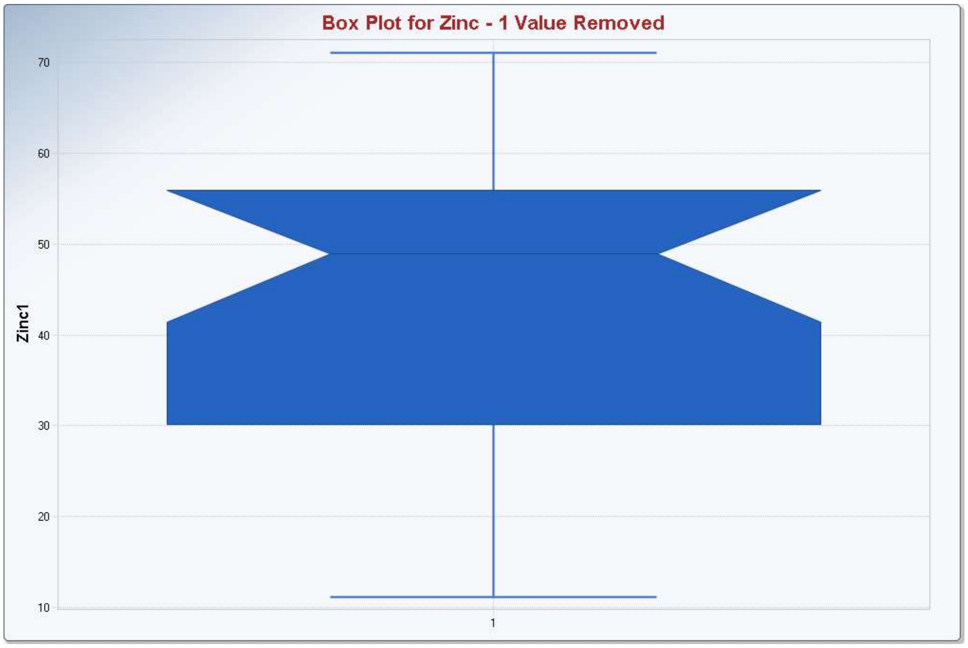
Zinc

One potential high outlier is present in the QQ plot but none are present in the box plot. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Results of Rosner's test indicates no statistical outliers. *Background dataset is not censored because no statistical outliers were identified.*



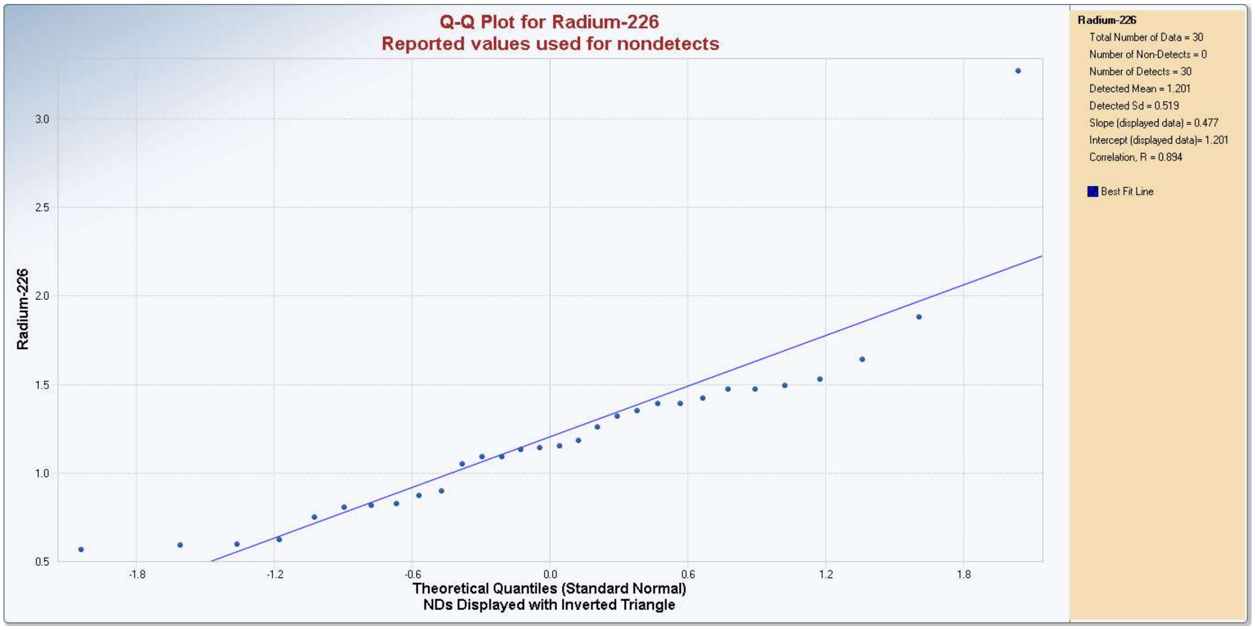


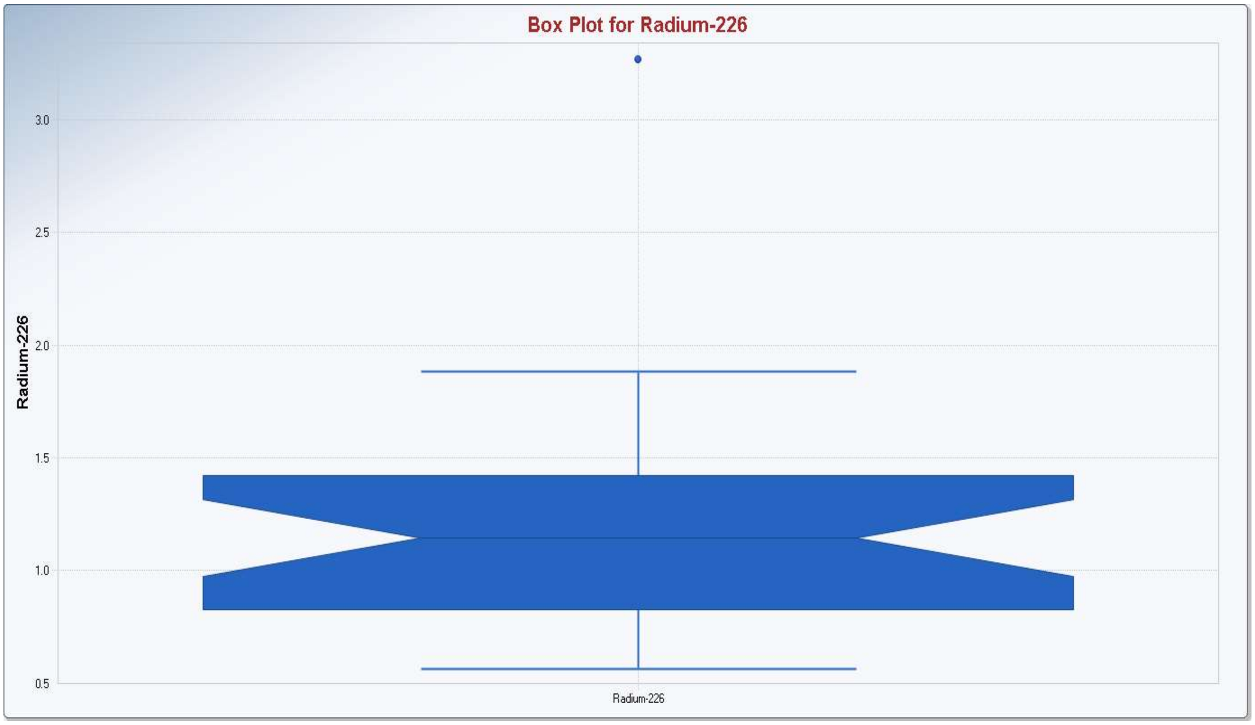

Q-Q Plot for Zinc - 1 Value Removed
Reported values used for nondetects
Zinc1
70
60
50
40
30
20
10
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)
NDs Displayed with Inverted Triangle
Zinc1
Total Number of Data = 29
Number of Non-Detects = 0
Number of Detects = 29
Detected Mean = 43.5
Detected Sd = 17.86
Slope (displayed data) = 17.91
Intercept (displayed data)= 43.5
Correlation, R = 0.975
Best Fit Line

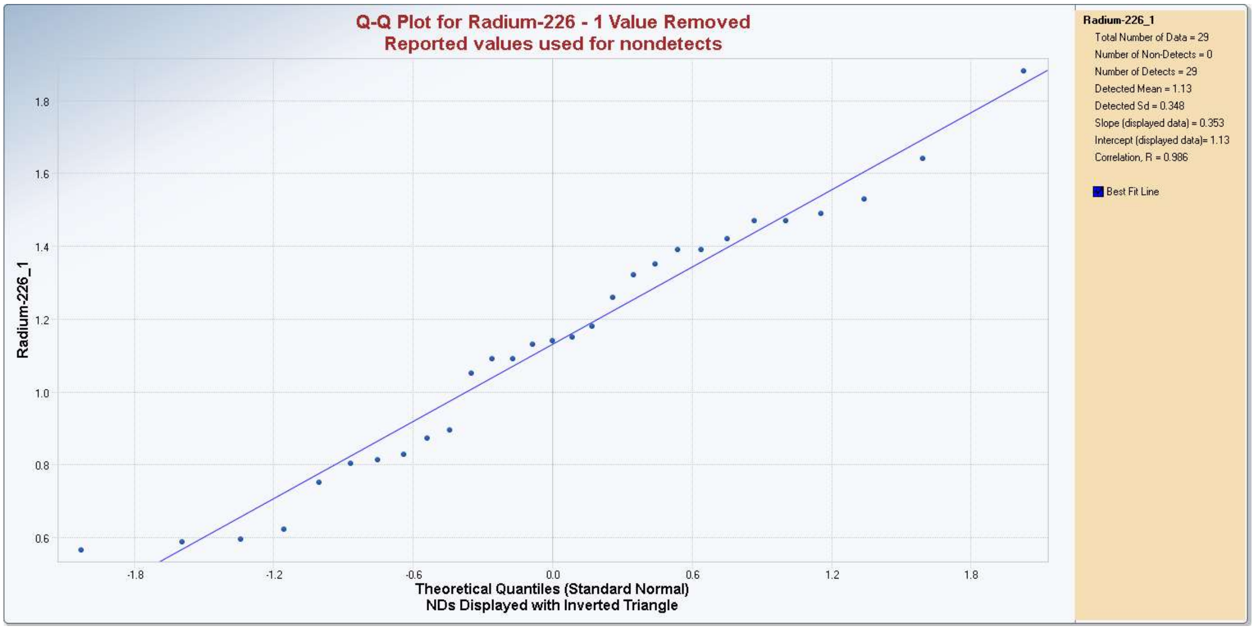

Box Plot for Zinc - 1 Value Removed
Zinc1
70
60
50
40
30
20
10
1

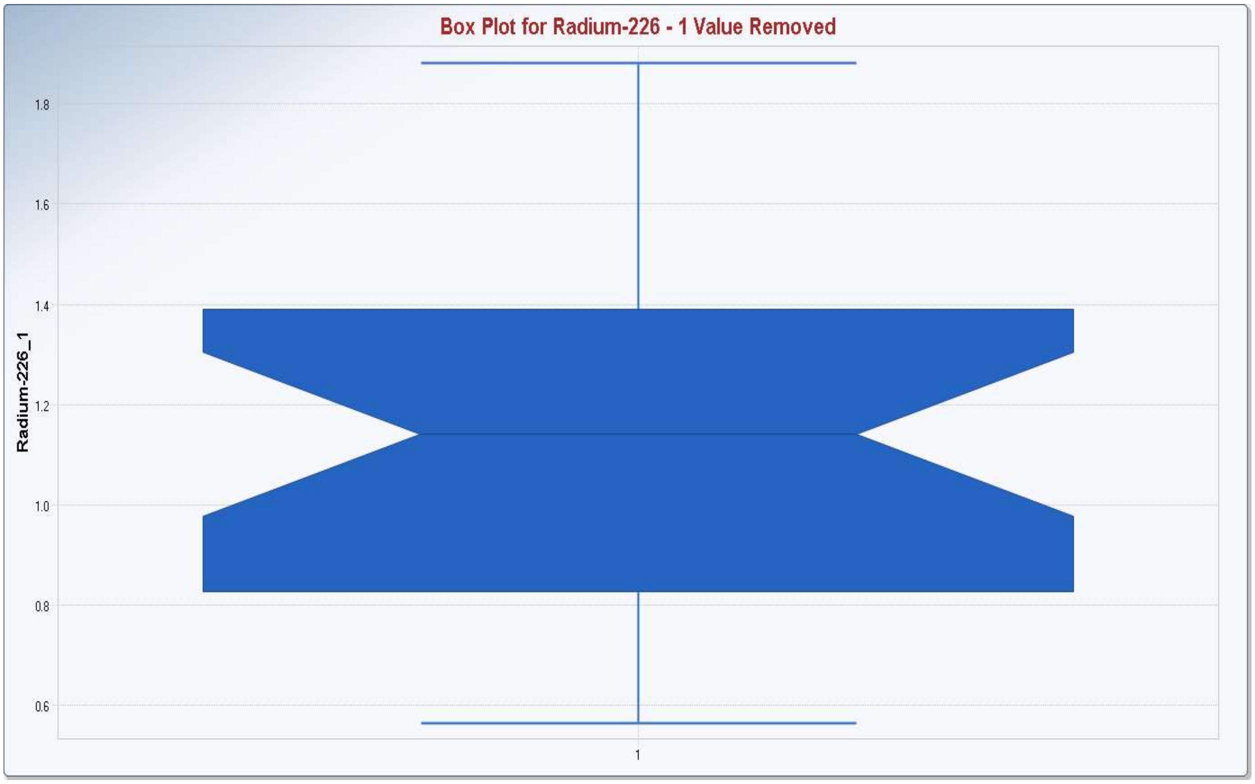
Radium 226

One potential high outlier is present in the QQ plot and box plot. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Results of Rosner's test indicates one statistical outlier. *The variability in the background dataset, and the associated outlier, likely represent natural variability within an industrialized site. Based on existing knowledge that these data are from background sample locations, no outliers were removed from the background dataset.*



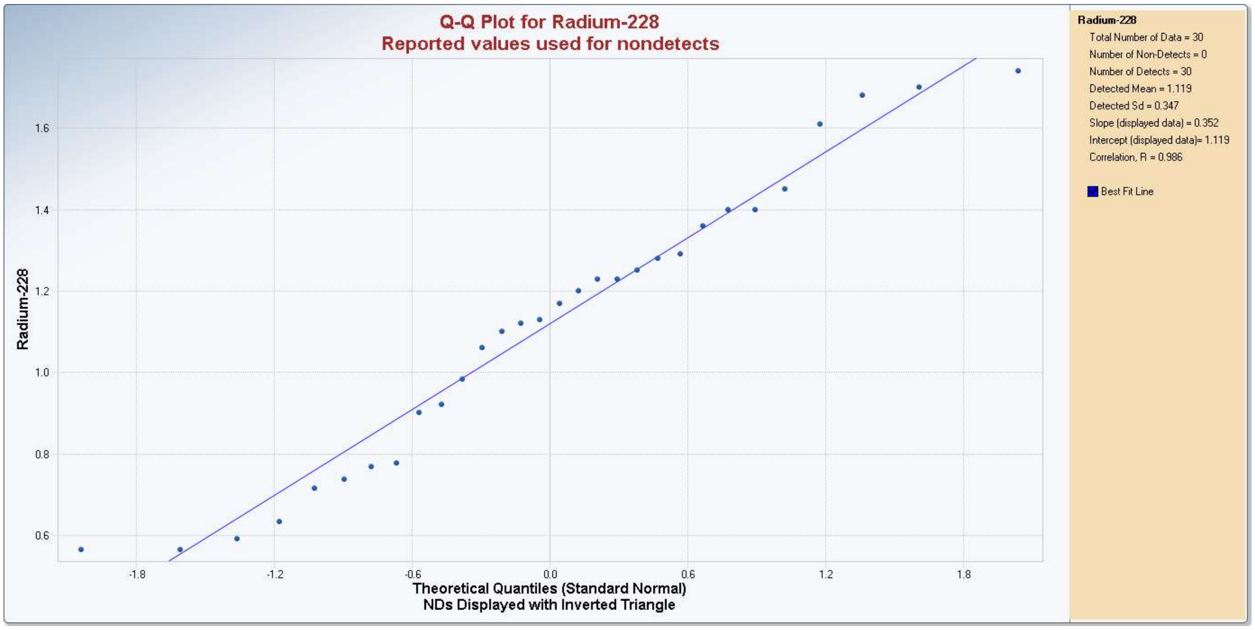


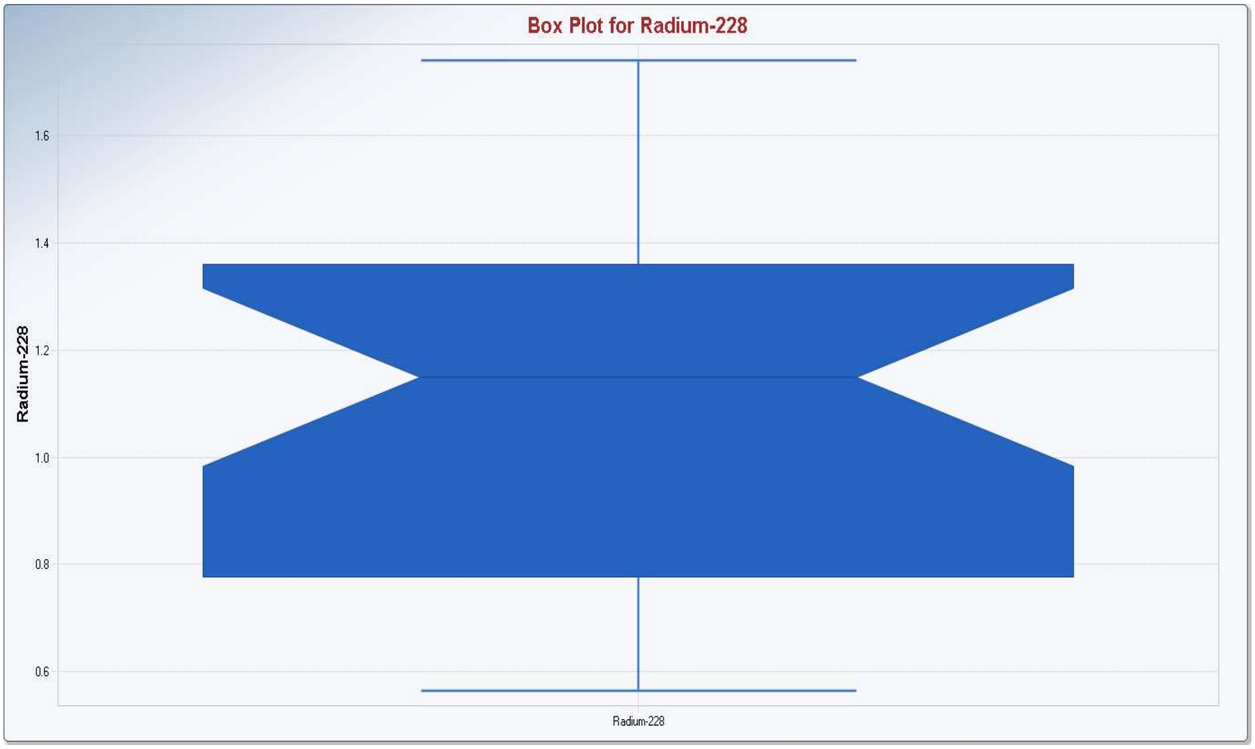

Q-Q Plot for Radium-226 - 1 Value Removed
Reported values used for nondetects
Radium-226_1
1.8
1.6
1.4
1.2
1.0
0.8
0.6
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)
NDs Displayed with Inverted Triangle
Radium-226_1
Total Number of Data = 29
Number of Non-Detects = 0
Number of Detects = 29
Detected Mean = 1.13
Detected Sd = 0.348
Slope (displayed data) = 0.353
Intercept (displayed data)= 1.13
Correlation, R = 0.986
Best Fit Line


Box Plot for Radium-226 - 1 Value Removed
Radium-226_1
1.8
1.6
1.4
1.2
1.0
0.8
0.6
1

Radium 228

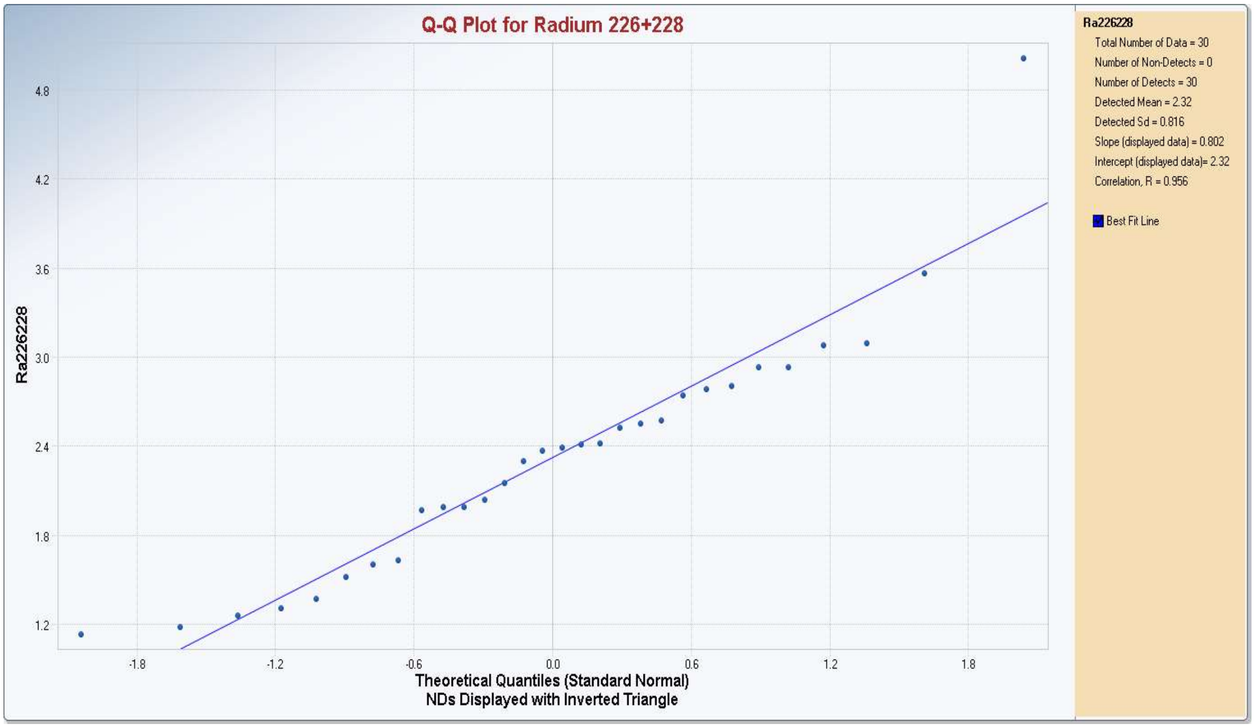
No potential high outliers are present in the QQ plot or box plot. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Results of Rosner's test indicates no statistical outliers. *Background dataset is not censored because no statistical outliers were identified.*

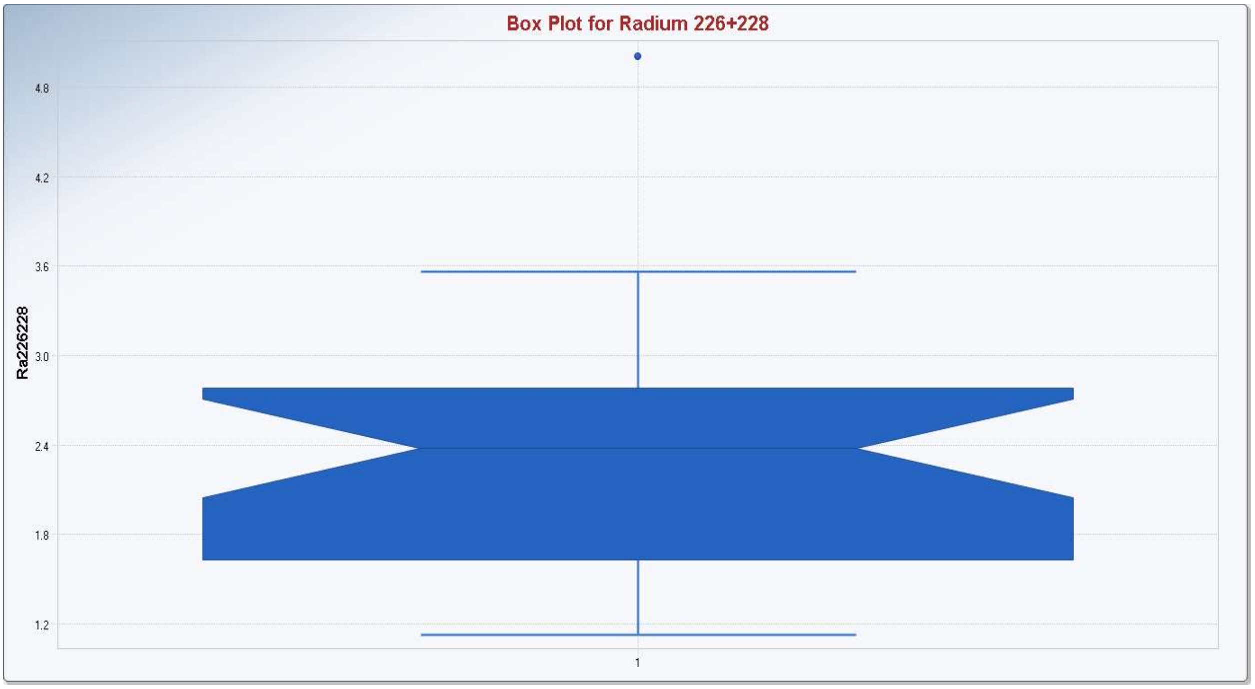


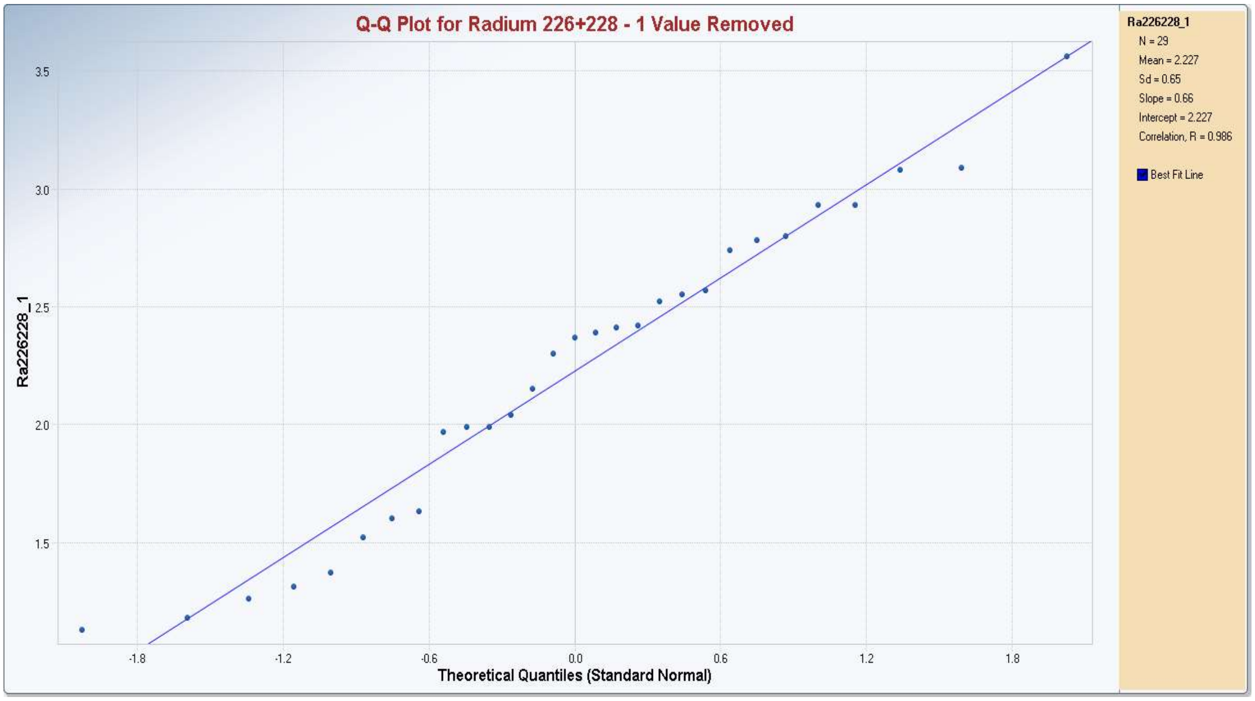


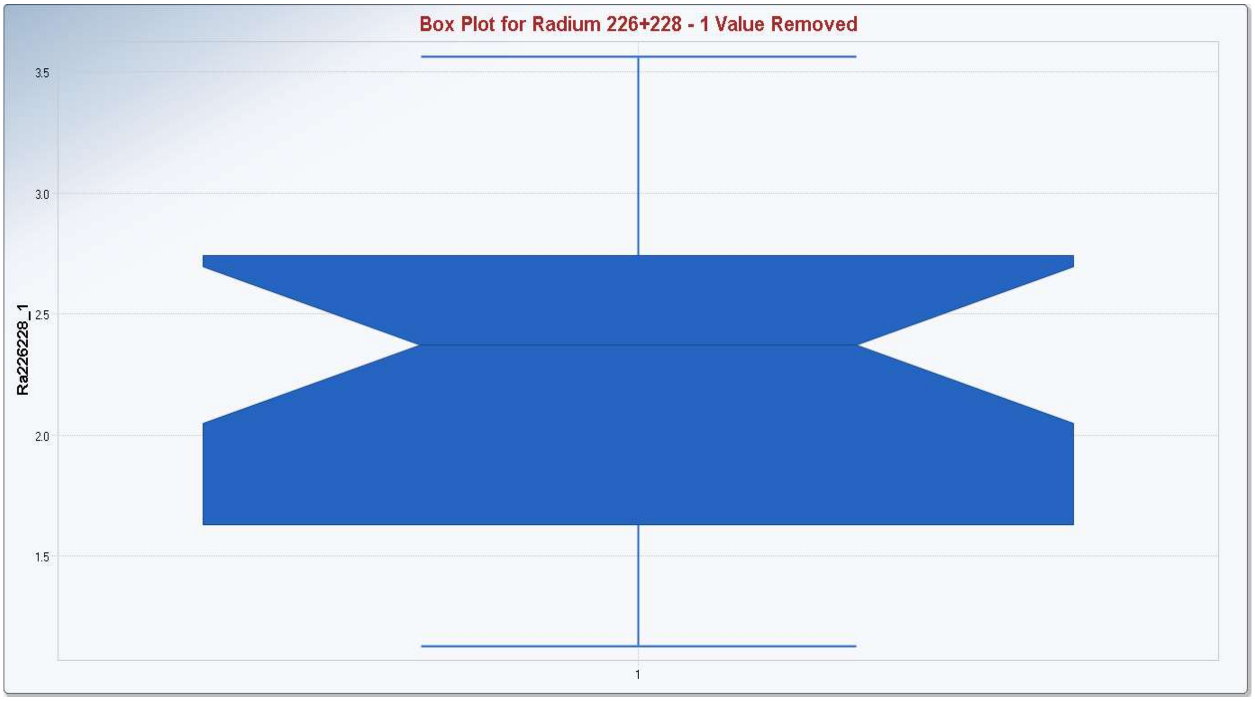
Radium 226+228

One potential high outlier is present in the QQ plot and box plot. Rosner's outlier test was run in USEPA's ProUCL Statistical Software, Version 5.1 (USEPA, 2016). Results of Rosner's test indicates one statistical outlier. *The variability in the background dataset, and the associated outlier, likely represent natural variability within an industrialized site. Based on existing knowledge that these data are from background sample locations, no outliers were removed from the background dataset.*






Q-Q Plot for Radium 226+228 - 1 Value Removed
Ra226228_1
N = 29
Mean = 2.227
Sd = 0.65
Slope = 0.66
Intercept = 2.227
Correlation, R = 0.986
Best Fit Line
Ra226228_1
3.5
3.0
2.5
2.0
1.5
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)


Box Plot for Radium 226+228 - 1 Value Removed
Ra226228_1
3.5
3.0
2.5
2.0
1.5
1

```
                         Outlier Tests for Selected Variables replacing nondetects with 1/2 the Detection Limit
                  User Selected Options
   Date/Time of Computation    ProUCL 5.110/8/2019 8:18:22 PM
                               From File    ProUCL_Input_Chem.xls
                            Full Precision    OFF


                 Rosner's Outlier Test for 1 Outliers in Antimony


                         Total N    30
                     Number NDs      1
                  Number Detects    30
             Mean with NDs=DL/2      0.29
               SD with NDs=DL/2      0.156
                  Number of data   30
   Number of suspected outliers    1
   NDs replaced with half value.

                                   Potential       Obs.        Test     Critical     Critical
      #        Mean          sd      outlier     Number       value   value (5%)   value (1%)
      1        0.29       0.153        0.716         23       2.779         2.91         3.24

 For 5% Significance Level, there is no Potential Outlier

 For 1% Significance Level, there is no Potential Outlier
```

```
                         Outlier Tests for Selected Variables replacing nondetects with 1/2 the Detection Limit
                  User Selected Options
   Date/Time of Computation    ProUCL 5.110/8/2019 8:27:31 PM
                               From File    ProUCL_Input_Chem.xls
                            Full Precision    OFF


                  Rosner's Outlier Test for 1 Outliers in Arsenic


                         Total N    30
                     Number NDs      0
                  Number Detects    30
             Mean with NDs=DL/2      4.918
               SD with NDs=DL/2      2.094
                  Number of data   30
   Number of suspected outliers    1
   NDs replaced with half value.

                                   Potential       Obs.        Test     Critical     Critical
      #        Mean          sd      outlier     Number       value   value (5%)   value (1%)
      1       4.918       2.059         10.5         20       2.711         2.91         3.24

 For 5% Significance Level, there is no Potential Outlier

 For 1% Significance Level, there is no Potential Outlier
```

Outlier Tests for Selected Variables replacing nondetects with 1/2 the Detection Limit

User Selected Options

Date/Time of Computation ProUCL 5.110/8/2019 8:30:01 PM
From File ProUCL_Input_Chem.xls
Full Precision OFF

Rosner's Outlier Test for 1 Outliers in Barium

Total N 30
Number NDs 0
Number Detects 30
Mean with NDs=DL/2 114.4
SD with NDs=DL/2 47.25
Number of data 30
Number of suspected outliers 1
NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	114.4	46.45	24.1	2	1.943	2.91	3.24

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

Outlier Tests for Selected Variables replacing nondetects with 1/2 the Detection Limit

User Selected Options

Date/Time of Computation ProUCL 5.110/8/2019 8:32:34 PM
From File ProUCL_Input_Chem.xls
Full Precision OFF

Rosner's Outlier Test for 1 Outliers in Beryllium

Total N 30
Number NDs 0
Number Detects 30
Mean with NDs=DL/2 0.565
SD with NDs=DL/2 0.261
Number of data 30
Number of suspected outliers 1
NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	0.565	0.256	1	25	1.696	2.91	3.24

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

Outlier Tests for Selected Variables replacing nondetects with 1/2 the Detection Limit

User Selected Options	
Date/Time of Computation	ProUCL 5.110/8/2019 8:40:19 PM
From File	ProUCL_Input_Chem.xls
Full Precision	OFF

Rosner's Outlier Test for 1 Outliers in Boron

Total N	30
Number NDs	1
Number Detects	30
Mean with NDs=DL/2	5.184
SD with NDs=DL/2	2.288
Number of data	30
Number of suspected outliers	1

NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	5.184	2.249	0.755	2	1.969	2.91	3.24

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

Outlier Tests for Selected Variables replacing nondetects with 1/2 the Detection Limit

User Selected Options	
Date/Time of Computation	ProUCL 5.110/8/2019 8:42:26 PM
From File	ProUCL_Input_Chem.xls
Full Precision	OFF

Rosner's Outlier Test for 1 Outliers in Cadmium

Total N	30
Number NDs	0
Number Detects	30
Mean with NDs=DL/2	0.317
SD with NDs=DL/2	0.168
Number of data	30
Number of suspected outliers	1

NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	0.317	0.165	0.8	24	2.919	2.91	3.24

For 5% Significance Level, there is 1 Potential Outlier
Therefore, Observation 0.8 is a Potential Statistical Outlier

For 1% Significance Level, there is no Potential Outlier

Outlier Tests for Selected Variables replacing nondetects with 1/2 the Detection Limit

User Selected Options

Date/Time of Computation ProUCL 5.110/14/2019 11:26:20 AM
From File ProUCL_Input_Chem.xls
Full Precision OFF

Rosner's Outlier Test for 3 Outliers in Calcium

Total N 30
Number NDs 0
Number Detects 30
Mean with NDs=DL/2 5806
SD with NDs=DL/2 4855
Number of data 30
Number of suspected outliers 3
NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	5806	4773	25100	22	4.042	2.91	3.24
2	5141	3265	16900	13	3.602	2.89	3.22
3	4721	2398	13200	7	3.537	2.88	3.2

For 5% significance level, there are 3 Potential Outliers
25100, 16900, 13200

For 1% Significance Level, there are 3 Potential Outliers
25100, 16900, 13200

Outlier Tests for Selected Variables replacing nondetects with 1/2 the Detection Limit

User Selected Options

Date/Time of Computation ProUCL 5.110/8/2019 10:37:06 PM
From File ProUCL_Input_Chem.xls
Full Precision OFF

Rosner's Outlier Test for 1 Outliers in Chloride

Total N 30
Number NDs 30
Number Detects 30
Mean with NDs=DL/2 2.364
SD with NDs=DL/2 0.185
Number of data 30
Number of suspected outliers 1
NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	2.364	0.182	2.73	13	2.009	2.91	3.24

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

Rosner's Outlier Test for 1 Outliers in Chromium

Total N	30
Number NDs	0
Number Detects	30
Mean with NDs=DL/2	10.49
SD with NDs=DL/2	3.983
Number of data	30
Number of suspected outliers	1

NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	10.49	3.916	3.02	2	1.908	2.91	3.24

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

Rosner's Outlier Test for 1 Outliers in Cobalt

Total N	30
Number NDs	0
Number Detects	30
Mean with NDs=DL/2	5.572
SD with NDs=DL/2	2.092
Number of data	30
Number of suspected outliers	1

NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	5.572	2.057	10.4	28	2.348	2.91	3.24

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

Rosner's Outlier Test for 1 Outliers in Copper

Total N	30
Number NDs	0
Number Detects	30
Mean with NDs=DL/2	12.2
SD with NDs=DL/2	6.121
Number of data	30
Number of suspected outliers	1

NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	12.2	6.018	23.8	24	1.928	2.91	3.24

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

Rosner's Outlier Test for 1 Outliers in Fluoride

Total N	30
Number NDs	1
Number Detects	30
Mean with NDs=DL/2	2.57
SD with NDs=DL/2	1.486
Number of data	30
Number of suspected outliers	1

NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	2.57	1.461	5.4	20	1.937	2.91	3.24

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

Rosner's Outlier Test for 1 Outliers in Lead

Total N	30
Number NDs	0
Number Detects	30
Mean with NDs=DL/2	13.33
SD with NDs=DL/2	6.605
Number of data	30
Number of suspected outliers	1

NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	13.33	6.494	28.4	14	2.321	2.91	3.24

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

Rosner's Outlier Test for 1 Outliers in Lithium

Total N	30
Number NDs	0
Number Detects	30
Mean with NDs=DL/2	8.369
SD with NDs=DL/2	3.999
Number of data	30
Number of suspected outliers	1

NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	8.369	3.931	15.6	30	1.839	2.91	3.24

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

Outlier Tests for Selected Variables replacing nondetects with 1/2 the Detection Limit

User Selected Options

Date/Time of Computation	ProUCL 5.110/8/2019 11:03:56 PM
From File	ProUCL_Input_Chem.xls
Full Precision	OFF

Rosner's Outlier Test for 2 Outliers in Mercury

Total N	30
Number NDs	18
Number Detects	30
Mean with NDs=DL/2	0.0362
SD with NDs=DL/2	0.0433
Number of data	30
Number of suspected outliers	2

NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	0.0362	0.0426	0.193	9	3.683	2.91	3.24
2	0.0308	0.0322	0.144	14	3.522	2.89	3.22

For 5% significance level, there are 2 Potential Outliers
0.193, 0.144

For 1% Significance Level, there are 2 Potential Outliers
0.193, 0.144

Outlier Tests for Selected Variables excluding nondetects

User Selected Options

Date/Time of Computation	ProUCL 5.110/9/2019 1:06:42 PM
From File	ProUCL_Input_Chem_chloride-zinc.xls
Full Precision	OFF

Dixon's Outlier Test for Mercury

Total N = 30

Number NDs = 18

Number Detects = 12

10% critical value: 0.49

5% critical value: 0.546

1% critical value: 0.642

Note: NDs excluded from Outlier Test

1. Data Value 0.193 is a Potential Outlier (Upper Tail)?

Test Statistic: 0.457

For 10% significance level, 0.193 is not an outlier.

For 5% significance level, 0.193 is not an outlier.

For 1% significance level, 0.193 is not an outlier.

2. Data Value 0.0151 is a Potential Outlier (Lower Tail)?

Test Statistic: 0.033

For 10% significance level, 0.0151 is not an outlier.

For 5% significance level, 0.0151 is not an outlier.

For 1% significance level, 0.0151 is not an outlier.

Rosner's Outlier Test for 1 Outliers in Molybdenum

Total N	**30**
Number NDs	**1**
Number Detects	**30**
Mean with NDs=DL/2	**0.681**
SD with NDs=DL/2	**0.307**
Number of data	**30**
Number of suspected outliers	**1**

NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	0.681	0.302	1.74	25	3.511	2.91	3.24

For 5% Significance Level, there is 1 Potential Outlier

Therefore, Observation 1.74 is a Potential Statistical Outlier

For 1% Significance Level, there is 1 Potential Outlier

Rosner's Outlier Test for 1 Outliers in Nickel

Total N	30
Number NDs	0
Number Detects	30
Mean with NDs=DL/2	13.84
SD with NDs=DL/2	5.087
Number of data	30
Number of suspected outliers	1

NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	13.84	5.002	23.3	20	1.892	2.91	3.24

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

Rosner's Outlier Test for 1 Outliers in Selenium

Total N	30
Number NDs	0
Number Detects	30
Mean with NDs=DL/2	0.751
SD with NDs=DL/2	0.277
Number of data	30
Number of suspected outliers	1

NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	0.751	0.272	1.34	28	2.164	2.91	3.24

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

Outlier Tests for Selected Variables replacing nondetects with 1/2 the Detection Limit

User Selected Options

Date/Time of Computation ProUCL 5.110/8/2019 11:05:19 PM

From File ProUCL_Input_Chem.xls

Full Precision OFF

Rosner's Outlier Test for 5 Outliers in Silver

Total N	**30**
Number NDs	**7**
Number Detects	**30**
Mean with NDs=DL/2	**0.154**
SD with NDs=DL/2	**0.256**
Number of data	**30**
Number of suspected outliers	**5**

NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	0.154	0.252	1.25	9	4.353	2.91	3.24
2	0.116	0.153	0.592	14	3.1	2.89	3.22
3	0.0993	0.125	0.56	24	3.672	2.88	3.2
4	0.0823	0.0888	0.42	23	3.805	2.86	3.18
5	0.0693	0.0588	0.268	22	3.381	2.84	3.16

For 5% significance level, there are 5 Potential Outliers

1.25, 0.592, 0.56, 0.42, 0.268

For 1% Significance Level, there are 5 Potential Outliers

1.25, 0.592, 0.56, 0.42, 0.268

Outlier Tests for Selected Variables replacing nondetects with 1/2 the Detection Limit

User Selected Options

Date/Time of Computation	ProUCL 5.110/9/2019 1:24:18 PM
From File	ProUCL_Input_Chem_chloride-zinc.xls
Full Precision	OFF

Rosner's Outlier Test for 6 Outliers in Silver

Total N	30
Number NDs	7
Number Detects	30
Mean with NDs=DL/2	0.154
SD with NDs=DL/2	0.256
Number of data	30
Number of suspected outliers	6

NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	0.154	0.252	1.25	9	4.353	2.91	3.24
2	0.116	0.153	0.592	14	3.1	2.89	3.22
3	0.0993	0.125	0.56	24	3.672	2.88	3.2
4	0.0823	0.0888	0.42	23	3.805	2.86	3.18
5	0.0693	0.0588	0.268	22	3.381	2.84	3.16
6	0.0613	0.0434	0.2	21	3.193	2.818	3.134

For 5% significance level, there are 6 Potential Outliers
1.25, 0.592, 0.56, 0.42, 0.268, 0.2

For 1% Significance Level, there are 6 Potential Outliers
1.25, 0.592, 0.56, 0.42, 0.268, 0.2

Outlier Tests for Selected Variables replacing nondetects with 1/2 the Detection Limit

User Selected Options

Date/Time of Computation	ProUCL 5.110/11/2019 3:59:48 PM
From File	ProUCL_Input_Chem.xls
Full Precision	OFF

Rosner's Outlier Test for 4 Outliers in Sulfate

Total N	30
Number NDs	7
Number Detects	30
Mean with NDs=DL/2	29.87
SD with NDs=DL/2	42.09
Number of data	30
Number of suspected outliers	4

NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	29.87	41.38	215	27	4.474	2.91	3.24
2	23.49	23.84	104	11	3.377	2.89	3.22
3	20.61	18.46	75.5	10	2.972	2.88	3.2
4	18.58	15.29	63	22	2.904	2.86	3.18

For 5% significance level, there are 4 Potential Outliers
215, 104, 75.5, 63

For 1% Significance Level, there are 2 Potential Outliers
215, 104

Rosner's Outlier Test for 1 Outliers in Thallium

Total N	30
Number NDs	2
Number Detects	30
Mean with NDs=DL/2	0.256
SD with NDs=DL/2	0.146
Number of data	30
Number of suspected outliers	1

NDs replaced with half value.

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	0.256	0.144	0.558	18	2.099	2.91	3.24

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

```
                Rosner's Outlier Test for 1 Outliers in Vanadium


                   Total N    30
               Number NDs      0
           Number Detects     30
      Mean with NDs=DL/2      16.12
        SD with NDs=DL/2       6.458
           Number of data   30
 Number of suspected outliers   1
 NDs replaced with half value.

                              Potential     Obs.       Test    Critical    Critical
   #      Mean          sd      outlier   Number      value  value (5%)  value (1%)
   1      16.12      6.349        5.75         2      1.633        2.91        3.24

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier


                Rosner's Outlier Test for 1 Outliers in Zinc


                   Total N    30
               Number NDs      0
           Number Detects     30
      Mean with NDs=DL/2      45.09
        SD with NDs=DL/2      19.58
           Number of data   30
 Number of suspected outliers   1
 NDs replaced with half value.

                              Potential     Obs.       Test    Critical    Critical
   #      Mean          sd      outlier   Number      value  value (5%)  value (1%)
   1      45.09      19.25        91.1        24       2.39        2.91        3.24

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

                        Outlier Tests for Selected Variables excluding nondetects
             User Selected Options
   Date/Time of Computation    ProUCL 5.112/16/2019 3:38:47 PM
                       From File    ProUCL_Input_RAD.xls
                   Full Precision    OFF


                Rosner's Outlier Test for 1 Outliers in Radium-226


                   Total N    30
               Number NDs      0
           Number Detects     30
         Mean of Detects       1.201
           SD of Detects       0.519
           Number of data   30
 Number of suspected outliers   1
NDs not included in the following:
```

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	1.201	0.511	3.27	3	4.05	2.91	3.24

For 5% Significance Level, there is 1 Potential Outlier

Therefore, Observation 3.27 is a Potential Statistical Outlier

For 1% Significance Level, there is 1 Potential Outlier

Rosner's Outlier Test for 1 Outliers in Radium-228

Total N	**30**
Number NDs	**0**
Number Detects	**30**
Mean of Detects	**1.119**
SD of Detects	**0.347**
Number of data	**30**
Number of suspected outliers	**1**

NDs not included in the following:

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	1.119	0.341	1.74	3	1.82	2.91	3.24

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

Outlier Tests for Selected Uncensored Variables

User Selected Options

Date/Time of Computation	ProUCL 5.112/20/2019 12:48:31 PM
From File	export20191220_Ra226+228_bkgd.xls
Full Precision	OFF

Rosner's Outlier Test for Ra226228

Mean	**2.32**
Standard Deviation	**0.816**
Number of data	**30**
Number of suspected outliers	**1**

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	2.32	0.803	5.01	27	3.351	2.91	3.24

For 5% Significance Level, there is 1 Potential Outlier

Potential outliers is: 5.01

For 1% Significance Level, there is 1 Potential Outlier

Potential outliers is: 5.01

Attachment B
Background Threshold Value Derivation Output Files

Attachment B, Table B-1
Cancer Based Risk-Based Screening Level Calculations for a Hypothetical Future Construction/Utility Worker Exposed to Soil
Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

						Cancer Slope Factor (mg/kg-day)$^{-1}$		Unit Risk Factor (µg/m^3)$^{-1}$	Soil RBSLs - Cancer [a]			
Analyte	**CAS**	**Soil EPC (mg/kg)**	**Ingestion Dose (mg/kg-day)**	**Dermal Dose (mg/kg-day)**	**Inhalation Concentration (µg/m^3)**	**Oral**	**Dermal**	**Inhalation**	**Soil Ingestion (mg/kg)**	**Dermal Contact (mg/kg)**	**Inhalation (mg/kg)**	**Total (mg/kg)**
Antimony	7440-36-0	1.0E+00	9.7E-09	na	1.6E-07	na	na	na	na	na	na	na
Arsenic	7440-38-2	1.0E+00	5.8E-09	9.3E-10	1.6E-07	1.5E+00	1.5E+00	4.3E-03	1.15E+02	7.15E+02	1.43E+03	9.25E+01
Barium	7440-39-3	1.0E+00	9.7E-09	na	1.6E-07	na	na	na	na	na	na	na
Beryllium	7440-41-7	1.0E+00	9.7E-09	na	1.6E-07	na	na	2.4E-03	na	na	2.56E+03	2.56E+03
Boron	7440-42-8	1.0E+00	9.7E-09	na	1.6E-07	na	na	na	na	na	na	na
Cadmium	7440-43-9	1.0E+00	9.7E-09	3.1E-11	1.6E-07	na	na	1.8E-03	na	na	3.41E+03	3.41E+03
Calcium	7440-70-2	1.0E+00	9.7E-09	na	1.6E-07	na	na	na	na	na	na	na
Chloride	16887-00-6	1.0E+00	9.7E-09	na	1.6E-07	na	na	na	na	na	na	na
Chromium	7440-47-3	1.0E+00	9.7E-09	na	1.6E-07	na	na	na	na	na	na	na
Cobalt	7440-48-4	1.0E+00	9.7E-09	na	1.6E-07	na	na	9.0E-03	na	na	6.83E+02	6.83E+02
Copper	7440-50-8	1.0E+00	9.7E-09	na	1.6E-07	na	na	na	na	na	na	na
Fluoride	16984-48-8	1.0E+00	9.7E-09	na	1.6E-07	na	na	na	na	na	na	na
Lead	7439-92-1	1.0E+00	9.7E-09	na	1.6E-07	na	na	na	na	na	na	na
Lithium	7439-93-2	1.0E+00	9.7E-09	na	1.6E-07	na	na	na	na	na	na	na
Mercury	7439-97-6	1.0E+00	9.7E-09	na	1.6E-07	na	na	na	na	na	na	na
Molybdenum	7439-98-7	1.0E+00	9.7E-09	na	1.6E-07	na	na	na	na	na	na	na
Nickel	7440-02-0	1.0E+00	9.7E-09	na	1.6E-07	na	na	2.6E-04	na	na	2.36E+04	2.36E+04
Selenium	7782-49-2	1.0E+00	9.7E-09	na	1.6E-07	na	na	na	na	na	na	na
Silver	7440-22-4	1.0E+00	9.7E-09	na	1.6E-07	na	na	na	na	na	na	na
Sulfate	14808-79-8	1.0E+00	9.7E-09	na	1.6E-07	na	na	na	na	na	na	na
Thallium	7440-28-0	1.0E+00	9.7E-09	na	1.6E-07	na	na	na	na	na	na	na
Vanadium	7440-62-2	1.0E+00	9.7E-09	na	1.6E-07	na	na	na	na	na	na	na
Zinc	7440-66-6	1.0E+00	9.7E-09	na	1.6E-07	na	na	na	na	na	na	na

Notes:

[a] Cancer based RBSLs were calculated using the equations and parameters shown in Attachment B, Table B-4.

CAS - Chemical Abstracts Service registry number
EPC - exposure point concentration
mg/kg - milligram(s) per kilogram
mg/kg-day - milligram(s) per kilogram per day
µg/m^3 - microgram(s) per cubic meter
na - not available/applicable
RBSL - risk-based screening level

Attachment B, Table B-2

Non-Cancer Based Risk-Based Screening Level Calculations for a Hypothetical Future Construction/Utility Worker Exposed to Soil

Allen Fossil Plant, Tennessee Valley Authority

Memphis, Tennessee

						Subchronic Reference Dose (mg/kg-day)		Subchronic Reference Concentration (mg/m^3)	Soil RBSLs - Non-Cancer [a]			
Analyte	**CAS**	**Soil EPC (mg/kg)**	**Ingestion Dose (mg/kg-day)**	**Dermal Dose (mg/kg-day)**	**Inhalation Concentration (mg/m^3)**	**Oral**	**Dermal**	**Inhalation**	**Soil Ingestion (mg/kg)**	**Dermal Contact (mg/kg)**	**Inhalation (mg/kg)**	**Total (mg/kg)**
Antimony	7440-36-0	1.0E+00	2.9E-06	na	5.0E-08	4.0E-04	6.0E-05	na	1.4E+02	na	na	1.4E+02
Arsenic	7440-38-2	1.0E+00	1.8E-06	2.8E-07	5.0E-08	3.0E-04	3.0E-04	1.5E-05	1.7E+02	1.1E+03	3.0E+02	9.9E+01
Barium	7440-39-3	1.0E+00	2.9E-06	na	5.0E-08	2.0E-01	1.4E-02	5.0E-03	6.8E+04	na	1.0E+05	4.1E+04
Beryllium	7440-41-7	1.0E+00	2.9E-06	na	5.0E-08	5.0E-03	3.5E-05	2.0E-05	1.7E+03	na	4.0E+02	3.3E+02
Boron	7440-42-8	1.0E+00	2.9E-06	na	5.0E-08	2.0E-01	2.0E-01	2.0E-02	6.8E+04	na	4.0E+05	5.8E+04
Cadmium	7440-43-9	1.0E+00	2.9E-06	9.4E-09	5.0E-08	1.0E-03	2.5E-05	1.0E-05	3.4E+02	2.6E+03	2.0E+02	1.2E+02
Calcium	7440-70-2	1.0E+00	2.9E-06	na	5.0E-08	na	na	na	na	na	na	na
Chloride	16887-00-6	1.0E+00	2.9E-06	na	5.0E-08	na	na	na	na	na	na	na
Chromium	7440-47-3	1.0E+00	2.9E-06	na	5.0E-08	1.5E+00	2.0E-02	na	5.1E+05	na	na	5.1E+05
Cobalt	7440-48-4	1.0E+00	2.9E-06	na	5.0E-08	3.0E-03	3.0E-03	2.0E-05	1.02E+03	na	4.04E+02	2.89E+02
Copper	7440-50-8	1.0E+00	2.9E-06	na	5.0E-08	4.0E-02	4.0E-02	na	1.36E+04	na	na	1.36E+04
Fluoride	16984-48-8	1.0E+00	2.9E-06	na	5.0E-08	4.0E-02	4.0E-02	1.3E-02	1.36E+04	na	2.63E+05	1.29E+04
Lead	7439-92-1	1.0E+00	2.9E-06	na	5.0E-08	na	na	na	na	na	na	na
Lithium	7439-93-2	1.0E+00	2.9E-06	na	5.0E-08	2.0E-03	2.0E-03	na	6.79E+02	na	na	6.79E+02
Mercury	7439-97-6	1.0E+00	2.9E-06	na	5.0E-08	2.0E-03	1.4E-04	3.0E-04	6.79E+02	na	6.06E+03	6.10E+02
Molybdenum	7439-98-7	1.0E+00	2.9E-06	na	5.0E-08	5.0E-03	5.0E-03	na	1.70E+03	na	na	1.70E+03
Nickel	7440-02-0	1.0E+00	2.9E-06	na	5.0E-08	2.0E-02	8.0E-04	2.0E-04	6.79E+03	na	4.04E+03	2.53E+03
Selenium	7782-49-2	1.0E+00	2.9E-06	na	5.0E-08	5.0E-03	5.0E-03	2.0E-02	1.70E+03	na	4.04E+05	1.69E+03
Silver	7440-22-4	1.0E+00	2.9E-06	na	5.0E-08	5.0E-03	2.0E-04	na	1.70E+03	na	na	1.70E+03
Sulfate	14808-79-8	1.0E+00	2.9E-06	na	5.0E-08	na	na	na	na	na	na	na
Thallium	7440-28-0	1.0E+00	2.9E-06	na	5.0E-08	4.0E-05	4.0E-05	na	1.36E+01	na	na	1.36E+01
Vanadium	7440-62-2	1.0E+00	2.9E-06	na	5.0E-08	1.0E-02	2.6E-04	1.0E-04	3.39E+03	na	2.02E+03	1.27E+03
Zinc	7440-66-6	1.0E+00	2.9E-06	na	5.0E-08	3.0E-01	3.0E-01	na	1.02E+05	na	na	1.02E+05

Notes:

[a] Non-cancer based RBSLs were calculated using the equations and parameters shown in Attachment B, Table B-4.

CAS - Chemical Abstracts Service registry number

EPC - exposure point concentration

mg/kg - milligram(s) per kilogram

mg/kg-day - milligram(s) per kilogram per day

mg/m^3 - milligram(s) per cubic meter

na - not available/applicable

RBSL - risk-based screening level

Attachment B, Table B-3
Summary of Risk-Based Screening Levels for a Hypothetical Future Construction/Utility Worker Exposed to Soil
Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

		Hypothetical Future Construction/Utility Worker Soil RBSLs Based on Cancer Risk of 1 x 10^{-6} and HQ of 1			
Analyte	**CAS**	**Cancer (mg/kg)**	**Non-Cancer (mg/kg)**	**Lowest (mg/kg)**	**Basis**
Antimony	7440-36-0	na	1.36E+02	1.36E+02	non-cancer
Arsenic	7440-38-2	9.25E+01	9.86E+01	9.25E+01	cancer
Barium	7440-39-3	na	4.06E+04	4.06E+04	non-cancer
Beryllium	7440-41-7	2.56E+03	3.26E+02	3.26E+02	non-cancer
Boron	7440-42-8	na	5.81E+04	5.81E+04	non-cancer
Cadmium	7440-43-9	3.41E+03	1.21E+02	1.21E+02	non-cancer
Calcium	7440-70-2	na	na	na	na
Chloride	16887-00-6	na	na	na	na
Chromium	7440-47-3	na	5.09E+05	5.09E+05	non-cancer
Cobalt	7440-48-4	6.83E+02	2.89E+02	2.89E+02	non-cancer
Copper	7440-50-8	na	1.36E+04	1.36E+04	non-cancer
Fluoride	16984-48-8	na	1.29E+04	1.29E+04	non-cancer
Lead	7439-92-1	na	na	na	na
Lithium	7439-93-2	na	6.79E+02	6.79E+02	non-cancer
Mercury	7439-97-6	na	6.10E+02	6.10E+02	non-cancer
Molybdenum	7439-98-7	na	1.70E+03	1.70E+03	non-cancer
Nickel	7440-02-0	2.36E+04	2.53E+03	2.53E+03	non-cancer
Selenium	7782-49-2	na	1.69E+03	1.69E+03	non-cancer
Silver	7440-22-4	na	1.70E+03	1.70E+03	non-cancer
Sulfate	14808-79-8	na	na	na	na
Thallium	7440-28-0	na	1.36E+01	1.36E+01	non-cancer
Vanadium	7440-62-2	na	1.27E+03	1.27E+03	non-cancer
Zinc	7440-66-6	na	1.02E+05	1.02E+05	non-cancer

Notes:

CAS - Chemical Abstracts Service registry number
HQ - hazard quotient
mg/kg - milligram(s) per kilogram
na - not available/applicable
RBSL - risk-based screening level

Attachment B, Table B-4
Equations and Parameters Used to Calculate Risk-Based Screening Levels
Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

Total Soil RBSL

$$RBSL_{total} = \frac{1}{[(1/RBSL_{ingestion}) + (1/RBSL_{dermal}) + (1/RBSL_{inhal})]}$$

Cancer-Based Soil RBSL - Ingestion

$$RBSL_{ingestion} = TR / (Dose_{ingestion} \times CSF_o)$$

$$Dose_{ingestion} = \frac{EPC_{soil} \times EF \times ED \times IR \times RBA \times 10^{-6}\ kg/mg}{ATc \times BW}$$

Cancer-Based Soil RBSL - Dermal Contact

$$RBSL_{dermal} = TR / (Dose_{dermal} \times CSF_d)$$

$$Dose_{dermal} = \frac{EPC_{soil} \times EF \times ED \times SA \times AF \times ABSd \times 10^{-6}\ kg/mg}{ATc \times BW}$$

Cancer-Based Soil RBSL - Inhalation of Particulates

$$RBSL_{inhal} = TR / (Conc_{inhal} \times URF)$$

$$Conc_{inhal} = \frac{EPC_{soil} \times EF \times ED \times ET \times (1\ day/24\ hours) \times (1/PEF)}{ATc \times (1\ mg/1000\ \mu g)}$$

Non-Cancer-Based Soil RBSL - Ingestion

$$RBSL_{ingestion} = THQ / (Dose_{ingestion} / SubRfD_o)$$

$$Dose_{ingestion} = \frac{EPC_{soil} \times EF \times ED \times IR \times RBA \times 10^{-6}\ kg/mg}{ATnc \times BW}$$

Non-Cancer-Based Soil RBSL - Dermal Contact

$$RBSL_{dermal} = THQ / (Dose_{dermal} / SubRfD_d)$$

$$Dose_{dermal} = \frac{EPC_{soil} \times EF \times ED \times SA \times AF \times ABS_d \times 10^{-6}\ kg/mg}{ATnc \times BW}$$

Non-Cancer-Based Soil RBSL - Inhalation of Particulates

$$RBSL_{inhal} = THQ / (Conc_{inhal} / SubRfC)$$

$$Conc_{inhal} = \frac{EPC_{soil} \times EF \times ED \times ET \times (1\ day/24\ hours) \times (1/PEF)}{ATnc}$$

Parameter	Units	Value	Rationale
ABS_d = dermal absorption factor	unitless	chemical specific	see Table 4
AF = soil adherence factor	mg/cm^2	0.3	see Table 4
ATc = averaging time for carcinogens	days	25,550	see Table 4
ATnc = averaging time for non-carcinogens	days	84	see Table 4
BW = body weight	kg	80	see Table 4
CSF_o = oral cancer slope factor	$(mg/kg\text{-}day)^{-1}$	chemical specific	see Attachment B, Table B-6
CSF_d = dermal cancer slope factor	$(mg/kg\text{-}day)^{-1}$	chemical specific	see Attachment B, Table B-6
ED = exposure duration	years	1	see Table 4
EF = exposure frequency	days/year	60	see Table 4
EPC_{soil}	mg/kg	1.0	assumed
ET = exposure time	hours/day	8	see Table 4
IR = soil ingestion rate	mg/day	330	see Table 4
PEF = particulate emission factor	m^3/kg	4.81E+06	see Attachment B, Table B-5
RBA = relative bioavailability factor	unitless	chemical specific	see Table 4
SA = exposed skin surface area	cm^2	3,527	see Table 4
SubRfC = subchronic reference concentratior	mg/m^3	chemical specific	see Attachment B, Table B-6
$SubRfD_o$ = oral subchronic reference dose	mg/kg-day	chemical specific	see Attachment B, Table B-6
$SubRfD_d$ = dermal subchronic reference dose	mg/kg-day	chemical specific	see Attachment B, Table B-6
THQ = target hazard quotient	unitless	1.0	USEPA, 2019[a]
TR = target risk	unitless	1×10^{-6}	USEPA, 2019[a]
URF = Unit risk factor	$(\mu g/m^3)^{-1}$	unit risk factor	see Attachment B, Table B-6

Notes:

[a] USEPA, 2019 - USEPA RSL Calculator

cm^2 - square centimeters
Conc - concentration
inhal - inhalation
kg - kilogram(s)
m^3/kg - cubic meter(s) per kilogram
mg/cm^2 - milligram(s) per square centimeter
mg/kg - milligram(s) per kilogram
mg/kg-day - milligram(s) per kilogram per day
mg/m^3 - milligram(s) per cubic meter
μg/m^3 - microgram(s) per cubic meter
RSL - regional screening level
RBSL - risk-based screening level
USEPA - United States Environmental Protection Agency

Attachment B, Table B-5
Particulate Emmissions Factor Calculation for a Hypothetical Future On-Site
Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

Site-specific
Construction Worker Equation Inputs for Soil - Other Construction
* Inputted values different from Construction Worker defaults are highlighted.

Variable	Construction Worker Soil - Other Default Value	Form-input Value
$A_{c\text{-}doz}$ (areal extent of dozing) acres	0	0.5
A_{excav} (area of excavation site) m^2	0	2023.42821
$A_{c\text{-}grade}$ (areal extent of grading) acres	0	0.5
A (PEF Dispersion Constant)	2.4538	2.4538
A_{surf} (areal extent of site) m^2	2023.43	2023.43
A_{till} (areal extent of tilling) acres	0	0.5
$B_{l\text{-}doz}$ (dozing blade length) m	0	2.44
$B_{l\text{-}grade}$ (grading blade length) m	0	2.44
B (PEF Dispersion Constant)	17.566	17.566
C (PEF Dispersion Constant)	189.0426	189.0426
d_{excav} (average depth of excavation site) m	0	1
F_D Unitless Dispersion Correction Factor	0.185837208	0.187853235
F(x) (function dependant on U_m/U_t derived using Cowherd et al. (1985))	0.194	0.194
$M_{m\text{-}doz}$ (Gravimetric soil moisture content) %	7.9	7.9
$M_{m\text{-}excav}$ (Gravimetric soil moisture content) %	12	12
M_{wind} (dust emitted by wind erosion) g	51288.84717	51288.84717
$N_{A\text{-}doz}$ (number of times site was dozed)	0	2
$N_{A\text{-}dump}$ (number of times soil is dumped)	2	2
$N_{A\text{-}grade}$ (number of times site was graded)	0	2
$N_{A\text{-}till}$ (number of times soil is tilled)	2	2
Q/C_{sa} (inverse of the ratio of the geometric mean air concentration to the emission flux at the center of a square source) g/m^2-s per kg/m^3	14.31407	14.31407
ρ_{soil} (density) g/cm^3 - chemical-specific	1.68	1.68
s_{doz} (soil silt content) %	6.9	6.9
AF_{cw} (skin adherence factor - construction worker) mg/cm^2	0.3	0.3
AT_{cw} (averaging time - construction worker) days	365	84
BW_{cw} (body weight - construction worker) kg	80	80
ED_{cw} (exposure duration - construction worker) yr	1	1
EF_{cw} (exposure frequency - construction worker) day/yr	250	60
ET_{cw} (exposure time - construction worker) hr/day	8	8
THQ (target hazard quotient) unitless	0.1	1
IRS_{cw} (soil ingestion rate - construction worker) mg/day	330	330
LT (lifetime) yr	70	70
SA_{cw} (surface area - construction worker) cm^2/day	3527	3527
TR (target cancer risk) unitless	0.000001	0.000001
S_{doz} (dozing speed) kph	11.4	11.4
S_{grade} (grading speed) kph	11.4	11.4
s_{till} (soil silt content) %	18	18

Attachment B, Table B-5
Particulate Emmissions Factor Calculation for a Hypothetical Future On-Site
Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

Site-specific
Construction Worker Equation Inputs for Soil - Other Construction
* Inputted values different from Construction Worker defaults are highlighted.

Variable	Construction Worker Soil - Other Default Value	Form-input Value
t_c (overall duration of construction) hours	8400	2016
T_c (overall duration of construction) s	30240000	7257600
T (time over which traffic occurs) s	7200000	1728000
T_t (overall duration of traffic) s	7200000	1728000
U_m (mean annual wind speed) m/s	4.69	4.69
U_t (equivalent threshold value) m/s	11.32	11.32
V (fraction of vegetative cover)	0	0
Particulate Emission Factor (m^3/kg)	-	**4.81E+06**

Output generated 12DEC2019:22:58:00

Notes:

The particulate emission factor (PEF) was calculated using the inputs shown and the Regional Screening Level (RSL) Calculator Construction Worker - Other Construction Activities scenario. https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search

% - percent
cm^2 - square centimeter(s)
hr - hour(s)
g - gram(s)
g/cm^2 - gram(s) per square centimeter
g/cm^3 - gram(s) per cubic centimeter
g/m^2-s per kg/m^3 - gram(s) per square meter - second per kilogram per cubic meter
kg - kilogram(s)
kph - kilometer(s) per hour
m - meter(s)
m^2 - square meter(s)
m^3/kg - cubic meter(s) per kilogram
mg - milligram(s)
mg/cm^2 - milligram(s) per square centimeter(s)
m/s - meter(s) per second
s - second(s)
yr - year(s)

Attachment B, Table B-6
Toxicity Values Used in Soil Risk-Based Screening Level Calculations
Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

		Cancer Slope Factor (mg/kg-d)$^{-1}$				URF (μg/m^{3})$^{-1}$		Chronic RfD (mg/kg-d)				Chronic RfC (mg/m^{3})		Subchronic RfD^{a} (mg/kg-d)				Subchronic RfC^{a} (mg/m^{3})		ABS$_{GI}$^{b}
Analyte	CAS	Oral		Dermal^{c}		Inhalation		Oral		Dermal^{c}		Inhalation		Oral		Dermal^{c}		Inhalation		(%)
Antimony	7440-36-0	na	na	na	na	na	na	4.0E-04	I	6.0E-05	R	na	na	4.0E-04	P	6.0E-05	R	na	na	15%
Arsenic	7440-38-2	1.5E+00	I	1.5E+00	R	4.3E-03	I	3.0E-04	I	3.0E-04	R	1.5E-05	C	3.0E-04	cr	3.0E-04	R	1.5E-05	cr	100%
Barium	7440-39-3	na	na	na	na	na	na	2.0E-01	I	1.4E-02	R	5.0E-04	H	2.0E-01	A	1.4E-02	R	5.0E-03	H	7%
Beryllium	7440-41-7	na	na	na	na	2.4E-03	I	2.0E-03	I	1.4E-05	R	2.0E-05	I	5.0E-03	H	3.5E-05	R	2.0E-05	cr	0.7%
Boron	7440-42-8	na	na	na	na	na	na	2.0E-01	I	2.0E-01	R	2.0E-02	H	2.0E-01	A	2.0E-01	R	2.0E-02	H	100%
Cadmium (soil)	7440-43-9	na	na	na	na	1.8E-03	I	1.0E-03	I	2.5E-05	R	1.0E-05	A	1.0E-03	cr	2.5E-05	R	1.0E-05	cr	2.5%
Calcium	7440-70-2	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Chloride	16887-00-6	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Chromium	7440-47-3	na	na	na	na	na	na	1.5E+00	I	2.0E-02	R	na	na	1.5E+00	H	2.0E-02	R	na	na	1.3%
Cobalt	7440-48-4	na	na	na	na	9.0E-03	P	3.0E-04	P	3.0E-04	R	6.0E-06	P	3.0E-03	P	3.0E-03	R	2.0E-05	P	100%
Copper	7440-50-8	na	na	na	na	na	na	4.0E-02	H	4.0E-02	R	na	na	4.0E-02	cr	4.0E-02	R	na	na	100%
Fluoride	16984-48-8	na	na	na	na	na	na	4.0E-02	C	4.0E-02	R	1.3E-02	C	4.0E-02	cr	4.0E-02	R	1.3E-02	cr	100%
Lead	7439-92-1	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	100%
Lithium	7439-93-2	na	na	na	na	na	na	2.0E-03	P	2.0E-03	R	na	na	2.0E-03	P	2.0E-03	R	na	na	100%
Mercury^{d}	7439-97-6	na	na	na	na	na	na	3.0E-04	I	2.1E-05	R	3.0E-04	I	2.0E-03	A	1.4E-04	R	3.0E-04	H	7%
Molybdenum	7439-98-7	na	na	na	na	na	na	5.0E-03	I	5.0E-03	R	na	na	5.0E-03	H	5.0E-03	R	na	na	100%
Nickel	7440-02-0	na	na	na	na	2.6E-04	I	2.0E-02	I	8.0E-04	R	9.0E-05	A	2.0E-02	H	8.0E-04	R	2.0E-04	A	4%
Selenium	7782-49-2	na	na	na	na	na	na	5.0E-03	I	5.0E-03	R	2.0E-02	C	5.0E-03	H	5.0E-03	R	2.0E-02	cr	100%
Silver	7440-22-4	na	na	na	na	na	na	5.0E-03	I	2.0E-04	R	na	na	5.0E-03	H	2.0E-04	R	na	na	4%
Sulfate	14808-79-8	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Thallium	7440-28-0	na	na	na	na	na	na	1.0E-05	X	1.0E-05	R	na	na	4.0E-05	X	4.0E-05	R	na	na	100%
Vanadium	7440-62-2	na	na	na	na	na	na	5.0E-03	U	1.3E-04	R	1.0E-04	A	1.0E-02	A	2.6E-04	R	1.0E-04	cr	2.6%
Zinc	7440-66-6	na	na	na	na	na	na	3.0E-01	I	3.0E-01	R	na	na	3.0E-01	A	3.0E-01	R	na	na	100%

Sources:

A Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk levels as cited in the USEPA RSL Calculator (USEPA, 2019a)
C California Environmental Protection Agency (CalEPA) Toxicity Values as cited in the USEPA RSL Calculator (USEPA, 2019a)
cr chronic value
H Health Effects Assessment Summary Tables (HEAST) as cited in the USEPA RSL Calculator (USEPA, 2019a)
I Integrated Risk Information System (IRIS) Database as cited in the USEPA RSL Calculator (USEPA, 2019a)
P Provisional Peer Reviewed Toxicity Values (PPRTVs) as cited in the USEPA RSL Calculator (USEPA, 2019a)
R route extrapolation
U Regional Screening Levels (RSLs) User's Guide (USEPA, 2019a)
X Screening values in chemical-specific PPRTV Appendices as cited in the USEPA RSL Calculator (USEPA, 2019a)

Attachment B, Table B-6
Toxicity Values Used in Soil Risk-Based Screening Level Calculations
Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

		Cancer Slope Factor (mg/kg-d)$^{-1}$		URF (μg/m^3)$^{-1}$	Chronic RfD (mg/kg-d)		Chronic RfC (mg/m^3)	Subchronic RfD[a] (mg/kg-d)		Subchronic RfC[a] (mg/m^3)	ABS$_{GI}$[b]
Analyte	**CAS**	**Oral**	**Dermal[c]**	**Inhalation**	**Oral**	**Dermal[c]**	**Inhalation**	**Oral**	**Dermal[c]**	**Inhalation**	**(%)**

Notes:

[a] Subchronic RfDs and RfCs were obtained from the USEPA RSL Calculator (USEPA, 2019a). Where a subchronic RfD/RfC is less than the chronic value or not available, the chronic RfD/RfC is used for the subchronic RfD/RfC.

[b] Values are from USEPA Risk Assessment Guidance for Superfund (RAGS) Part E. Where no specific ABS$_{GI}$ is available, the ABS$_{GI}$ is assumed to be 100 percent (USEPA,

[c] The following equations are used as recommended by the USEPA (2004) to estimate dermal CSFs and RfDs from the ingestion toxicity values when ABS$_{GI}$ is less than 50 percent

Dermal RfD = Oral RfD x ABS$_{GI}$ and Dermal CSF = Oral SF/ABS$_{GI}$.

When ABS$_{GI}$ is greater than 50 percent, the dermal CSF and/or RfD is assumed to be equal to the oral CSF and/or RfD (USEPA, 2004).

[d] Mercuric chloride used as a surrogate

% - percent
ABS$_{GI}$ - oral absorption efficiency
CAS - Chemical Abstracts Service registry number
CSF - cancer slope factor
mg/kg-d - milligram(s) per kilogram per day
mg/m^3 - milligram(s) per cubic meter
μg/m^3 - microgram(s) per cubic meter
na - not available/applicable
RfD - reference dose
RfC - reference concentration
USEPA - United States Environmental Protection Agency
URF - unit risk factor

Attachment B, Table B-7
Calculator Input for On-Site Commercial Worker Soil PRG
Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

Variable	Composite Worker Soil Default Value	Form-input Value
A (PEF Dispersion Constant)	16.2302	12.4964
B (PEF Dispersion Constant)	18.7762	18.4476
City (Climate Zone)	Default	Little Rock, AR (6)
C (PEF Dispersion Constant)	216.108	210.2128
F(x) (function dependent on U_m/U_t) unitless	0.194	0.0145
PEF (particulate emission factor) m^3/kg	1359344438	31134709702
Q/C_{wind} (g/m^2-s per kg/m^3)	93.77	71.39908179
A_s (acres)	0.5	0.5
ED_w (exposure duration - composite worker) yr	25	25
EF_w (exposure frequency - composite worker) day/yr	250	250
ET_w (exposure time - composite worker) hr/day	8	8
IRA_w (inhalation rate - composite worker) m^3/day	60	60
IRS_w (soil intake rate - composite worker) mg/day	100	100
t_w (time - composite worker) yr	25	25
TR (target cancer risk) unitless	0.000001	0.000001
U_m (mean annual wind speed) m/s	4.69	3.58
U_t (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

Notes:

Composite worker assuming secular equilibrium throughout chain (no decay) scneario from USEPA Preliminary Remediation Goals for Radionuclide Contaminants at Superfund Sites. Accessed September 2019. https://epa-prgs.ornl.gov/radionuclides/

g/m^2-s per kg/m^3 - gram(s) per square meter - second per kilogram per cubic meter
hr - hour(s)
m - meter(s)
m/s - meter(s) per second
m^3/kg - cubic meter(s) per kilogram
PRG - preliminary remediation goal
USEPA - United States Environmental Protection Agency
yr - year(s)

Attachment B, Table B-8
Calculator Output for On-Site Commercial Worker Soil PRG
Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

Isotope	Ingestion PRG TR=1E-06 (pCi/g)	Inhalation PRG TR=1E-06 (pCi/g)	External Exposure PRG TR=1E-06 (pCi/g)	Total PRG TR=1E-06 (pCi/g)
Secular Equilibrium PRG for Ra-226	***6.86E-01***	***4.21E+03***	***2.09E-02***	***2.03E-02***
Secular Equilibrium PRG for Ra-228	***1.92E+00***	***1.32E+03***	***1.54E-02***	***1.53E-02***

Notes:

Composite worker assuming secular equilibrium throughout chain (no decay) scneario from USEPA Preliminary Remediation Goals for Radionuclide Contaminants at Superfund Sites. Accessed September 2019. https://epa-prgs.ornl.gov/radionuclides/

pCi/g - picocuries per gram
PRG - preliminary remediation goal
Ra-226 - radium-226
Ra-228 - radium-228
TR - target risk
USEPA - United States Environmental Protection Agency

Attachment B, Table B-9
Calculator Input for Hypothetical Future On-Site Construction/ Utility Worker Soil PRG
Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

Variable	Default Value	Form-input Value
A_{c-doz} (areal extent of dozing) acres		0.5
A_{excav} (area of excavation site) m^2		2023.42821
$A_{c-grade}$ (areal extent of grading) acres		0.5
A (PEF Dispersion Constant)	2.4538	2.4538
A_{surf} (areal extent of site) m^2	2023.43	2023.43
A_{till} (areal extent of tilling) acres		0.5
B_{l-doz} (dozing blade length) m		2.44
$B_{l-grade}$ (grading blade length) m		2.44
B (PEF Dispersion Constant)	17.566	17.566
C (PEF Dispersion Constant)	189.0426	189.0426
Cover layer thickness for GSF (gamma shielding factor) cm	0 cm	0 cm
d_{excav} (average depth of excavation site) m		1
F_D Unitless Dispersion Correction Factor	0.185837208	0.187853235
F(x) (function dependant on U_m/U_t derived using Cowherd et al. (1985))	0.194	0.194
M_{m-doz} (Gravimetric soil moisture content) %	7.9	7.9
$M_{m-excav}$ (Gravimetric soil moisture content) %	12	12
M_{wind} (dust emitted by wind erosion) g	51288.84717	51288.84717
N_{A-doz} (number of times site was dozed)		2
N_{A-dump} (number of times soil is dumped)	2	2
$N_{A-grade}$ (number of times site was graded)		2
N_{A-till} (number of times soil is tilled)	2	2
Q/C_{sa} (inverse of the ratio of the geometric mean air concentration to the emission flux at the center of a square source) g/m^2-s per kg/m^3	14.31407	14.31407
p_{soil} (density) g/cm^3 - chemical-specific	1.68	1.68
s_{doz} (soil silt content) %	6.9	6.9
Site area for ACF (area correction factor) m^2	1000029 m^2	20001 m^2
ED_{cw} (exposure duration - construction worker) yr	1	1
EF_{cw} (exposure frequency - construction worker) day/yr	250	60
ET_{cw} (exposure time - construction worker) hr/day	8	8
IRA_{cw} (soil inhalation rate - construction worker) m^3/day	60	60
IRS_{cw} (soil ingestion rate - construction worker) mg/day	330	330
t_{cw} (time - construction worker) yr	1	1
TR (target cancer risk) unitless	0.000001	0.000001
S_{doz} (dozing speed) kph	11.4	11.4
S_{grade} (grading speed) kph	11.4	11.4
s_{till} (soil silt content) %	18	18
t_c (overall duration of construction) hours	8400	2016
T (time over which traffic occurs) s	7200000	7200000
U_m (mean annual wind speed) m/s	4.69	4.69
U_t (equivalent threshold value) m/s	11.32	11.32
V (fraction of vegetative cover)	0	0

Notes:

Construction worker soil - other construction activities assuming secular equilibrium throughout chain (no decay) scenario from USEPA Preliminary Remediation Goals for Radionuclide Contaminants at Superfund Sites. Accessed December 2019. https://epa-prgs.ornl.gov/radionuclides/

% - percent
cm - centimeter
g - gram(s)
g/cm^3 - gram(s) per cubic centimeter(s)
g/m^2-s per kg/m^3 - gram(s) per square meter - second per kilogram per cubic meter
hr - hour(s)
kph - kilometer(s) per hour
m - meter(s)
m^2 - square meter
m/s - meter(s) per second
m^3/day - cubic meter(s) per day
mg/day - milligram(s) per day
PRG - preliminary remediation goal
s - second(s)
USEPA - United States Environmental Protection Agency
yr - year(s)

Attachment B, Table B-10
Calculator Output for Hypothetical Future On-Site Construction/ Utility Worker Soil PRG
Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

Isotope	Ingestion PRG TR=1E-06 (pCi/g)	Inhalation PRG TR=1E-06 (pCi/g)	External Exposure PRG TR=1E-06 (pCi/g)	Total PRG TR=1E-06 (pCi/g)
Secular Equilibrium PRG for Ra-226	*2.16E+01*	*2.82E+02*	*2.32E+00*	*2.08E+00*
Secular Equilibrium PRG for Ra-228	*6.06E+01*	*8.87E+01*	*1.69E+00*	*1.61E+00*

Notes:

Construction worker soil - other construction activities assuming secular equilibrium throughout chain (no decay) scenario from USEPA Preliminary Remediation Goals for Radionuclide Contaminants at Superfund Sites. Accessed December 2019. https://epa-prgs.ornl.gov/radionuclides/

pCi/g - picocuries per gram
PRG - preliminary remediation goal
Ra-226 - radium-226
Ra-228 - radium-228
TR - target risk
USEPA - United States Environmental Protection Agency

Attachment B, Table B-11
Calculator Input for Tapwater PRG and SSL
Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

Variable	Default Value	Form-input Value
DAF (dilution attenuation factor) unitless	1	1
ED_{res} (exposure duration) yr	70	70
I (infiltration rate) m/yr	0.18	0.18
p_b (dry soil bulk density) kg/L	1.5	1.5
t_{res} (time - resident) yr	26	26
$Theta_w$ (water-filled soil porosity) L_{water}/L_{soil}	0.3	0.3
$DFA_{res\text{-}adj}$ (age-adjusted immersion factor - resident) hr	6104	6104
$ED_{res\text{-}a}$ (exposure duration - resident adult) yr	20	20
$ED_{res\text{-}c}$ (exposure duration - resident child) yr	6	6
$EF_{res\text{-}a}$ (exposure frequency - resident adult) day/yr	350	350
$EF_{res\text{-}c}$ (exposure frequency - resident child) day/yr	350	350
$ET_{res\text{-}a}$ (exposure time - resident adult) hr/day	24	24
$ET_{res\text{-}c}$ (exposure time - resident child) hr/day	24	24
$EV_{res\text{-}a}$ (bathing events per day - resident adult) event/day	1	1
$EV_{res\text{-}c}$ (bathing events per day - resident child) event/day	1	1
F (irrigation period) unitless	0.25	0.25
$IFA_{res\text{-}adj}$ (age-adjusted inhalation factor - resident) m^3	161000	161000
I_f (interception fraction) unitless	0.42	0.42
$IFW_{res\text{-}adj}$ (adjusted intake factor - resident) L-yr/kg-day	19138	19138
$IRA_{res\text{-}a}$ (inhalation rate - resident adult) m^3/day	20	20
$IRA_{res\text{-}c}$ (inhalation rate - resident child) m^3/day	10	10
I_r (irrigation rate) L/m^2-day	3.62	3.62
$IRW_{res\text{-}a}$ (water intake rate - resident adult) L/day	2.5	2.5
$IRW_{res\text{-}c}$ (water intake rate - resident child) L/day	0.78	0.78
K (volatilization factor of Andelman) L/m^3	0.5	0.5
$Lambda_{HL}$ (soil leaching rate) 1/day	0.000027	0.000027
P (area density for root zone) kg/m^2	240	240
T (translocation factor) unitless	1	1
$ET_{event\text{-}res\text{-}a}$ (duration of bathing event - adult) hr/event	0.71	0.71
t_b (long term deposition and buildup) day	10950	10950
$ET_{event\text{-}res\text{-}c}$ (duration of bathing event - child) hr/event	0.54	0.54
TR (target cancer risk) unitless	0.000001	0.000001
t_v (above ground exposure time) day	60	60
t_w (weathering half-life) day	14	14
Y_v (plant yield - wet) kg/m^2	2	2

Notes:

Resident assuming secular equilibrium throughout chain (no decay) scneario from USEPA Preliminary Remediation Goals for Radionuclide Contaminants at Superfund Sites. Accessed September 2019. https://epa-prgs.ornl.gov/radionuclides/

Attachment B, Table B-11
Calculator Input for Tapwater PRG and SSL
Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

Variable	Default Value	Form-input Value

g/m^2-s per kg/m^3 - gram(s) per square meter - second per kilogram per cubic meter
hr - hour(s)
hr/event - hour(s) per event
kg/L - kilogram(s) per liter
kg/m^2 - kilogram(s) per square meter
L/day - liter(s) per day
L/m^2-day - liter(s) per square meter per day
L/m^3 - liter(s) per cubic meter
L-yr/kg-day - liter(s) per year per kilogram(s) per day
m/yr - meter(s) per year
m^3 - cubic meter(s)
PRG - preliminary remediation goal
USEPA - United States Environmental Protection Agency
yr - year(s)

Attachment B, Table B-12
Calculator Output for Tapwater PRG and SSL
Allen Fossil Plant, Tennessee Valley Authority
Memphis, Tennessee

Isotope	Ingestion PRG TR=1E-06 (pCi/L)	Inhalation PRG TR=1E-06 (pCi/L)	Immersion PRG TR=1E-06 (pCi/L)	Produce Consumption PRG TR=1E-06 (pCi/L)	Tap Water PRG TR=1E-06 (pCi/L)	SSL Risk-based TR=1E-06 (pCi/g)	SSL MCL-based (pCi/g)
Secular Equilibrium PRG for Ra-226	***1.71E-02***	***4.41E-04***	***8.54E+04***	-	***4.30E-04***	***5.27E-07***	***5.96E-03***
Secular Equilibrium PRG for Ra-228	***3.90E-02***	***1.10E-03***	***6.27E+04***	-	***1.07E-03***	***1.28E-06***	***4.42E-03***

Notes:

Resident assuming secular equilibrium throughout chain (no decay) scneario from USEPA Preliminary Remediation Goals for Radionuclide Contaminants at Superfund Sites. Accessed September 2019. https://epa-prgs.ornl.gov/radionuclides/

MCL - maximum contaminant level
pCi/g - picocuries per gram
pCi/L - picocuries per liter
PRG - preliminary remediation goal
Ra-226 - radium-226
Ra-228 - radium-228
SSL - soil screening level
TR - target risk
USEPA - United States Environmental Protection Agency

Attachment C
Surface Water Dilution Attenuation Factor

Attachment C - Surface Water Dilution Attenuation Factor

Risk-Based Closure Approach for the East Ash Disposal Area, TVA Allen Fossil Plant (ALF)

January 6, 2020

The ALF groundwater flow model was used to estimate a dilution attenuation factor (DAF) between groundwater and surface water (McKellar Lake) hydraulically down gradient of the East Ash Disposal Area. To calculate an estimated DAF, the following equation was used:

$$DAF = \frac{Q_R}{Q_{XX}}$$

Table 1 summarizes the estimated DAFs proximal to the East Ash Disposal Area.

Table 1. Input Summaries and DAF Calculations

Symbol	Description	Discharge (ft^3/s)	DAF*
Q_R	Lake McKellar Discharge	260	-
Q_{ET}	East Ash Disposal Area Total Discharge	1.56	166.67
Q_{EU}	East Ash Disposal Area Upper Alluvium Discharge	0.13	2000
Q_{EL}	East Ash Disposal Area Lower Alluvium Discharge	1.43	181.82

* Dilution Attenuation Factor (DAF) = Surface Water Discharge (Q_R)/Groundwater Discharge (Q_{XX})

The QR was estimated using the U.S. Geological Survey's StreamStat online interactive tool which can be used to delineate a watershed and its estimated mean annual discharge. This tool identified two watersheds discharging into McKellar Lake upgradient of the Site with a combined estimated mean annual discharge of approximately 260 cubic feet per second (ft^3/s). The StreamStat online tool has limitations, particularly in an urban setting as it does not take into account the discharge that occurs through sewer systems routed to McKellar Lake and streams that discharge into McKellar Lake; therefore, the estimated discharge of 260 ft^3/s may underestimate the discharge associated with McKellar Lake. This is a limitation in the DAF calculations estimated and presented in Table 1. For comparison, the USGS station located on the Mississippi River up-river from the TVA ALF has a reported mean annual flow of 400,000 cfs.

The ALF groundwater flow model (Draft, Stantec; 2019) was used to estimate the groundwater discharge from the East Ash Disposal Area to McKellar Lake. The discharge was conservatively estimated during a period when McKellar Lake was at a seasonal low (October 2017) when groundwater discharge is inferred to be near a maximum. The average stage of McKellar Lake during this period was approximately 176.8 feet.

The total groundwater discharge represents the estimated discharge to McKellar Lake from the full thickness of the alluvial aquifer. This was further broken down into the upper and lower alluvium. The East Ash Disposal Area is constructed into the upper alluvium only. However, groundwater is believed to discharge to McKellar Lake from the full saturated thickness.

The DAF for total discharge of groundwater that may flow from the East Ash Disposal Area to McKellar Lake was estimated as 166.67.