TETRA TECH

WORK PLAN

REMEDIAL INVESTIGATION/FEASIBILITY STUDY

AT THE

FORMER KILGORE MANUFACTURING COMPANY PROPERTY

WESTERVILLE, OHIO

Performed for:

OTTERBEIN UNIVERSITY
Westerville, Ohio

Prepared by:

Tetra Tech
Foster Plaza 7
661 Andersen Drive
Pittsburgh, Pennsylvania 15220-2745

December 10, 2010

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DECEMBER 10, 2010

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1.0 INTRODUCTION

This Remedial Investigation/Feasibility Study (RI/FS) Work Plan and associated documents were prepared by Tetra Tech NUS, Inc. (TtNUS) on behalf of Otterbein University (Otterbein)for the former Kilgore Manufacturing Company Facility (the Site) located at 400 North Spring Road in Westerville, Ohio (Figure 1-1). The facility ceased operations in 1962, and the property was donated to Otterbein College. Otterbein is conducting environmental investigations at the following eight areas of concern (AOCs) at the Site:

- AOC 1 – Unidentified Rectangular Features
- AOC 2 – Drainage Ditch Near Former Manufacturing Area
- AOC 3 – Burial Area
- AOC 4 – Burn Pit
- AOC 5 – Manufacturing Area – Former UST Location.
- AOC 6 – Former Experimental Area
- AOC 7 – Cinder Area
- AOC 8 – Former Burial Trench Area

This Work Plan and associated documents presents a strategy for the investigations to be conducted at each AOC. The Work Plan includes the following:

- **Section 2: Site Background**
  - Describes potential or suspected sources of contamination,
  - Summarizes available information regarding physical site conditions and the types and concentrations of contaminants detected in the environmental media: and
  - Identifies potential exposure pathways (for human and ecological receptors).

- **Section 3: Initial Evaluation/ Conceptual Site Model**

- **Section 4: Work Plan Rationale**
  - Problem statement
  - RI sampling strategy and data use
  - Data quality objectives
  - Decision rules

- **Section 5: Remedial Investigation/Feasibility Study Tasks**

- **Section 6: Human Health Risk Assessment**

- **Section 7: Ecological Risk Assessment**

- **Section 8: Feasibility Study**

- **Section 9: Key Assumptions**

- **Sections 10: Schedule**

- **Section 11: Project Management organizational chart and roles/responsibilities**

- **Section 12: References**

- **Attachment A: Pre-Investigation Evaluation Report (PER)**
  - August 10, 2010 PER
  - OEPA comments to the PER
  - (The PER has not been modified; however, the OEPA PER comments have been incorporated into the CSM, site evaluation, and work rationale described in this Work Plan.)

- **Attachment B: Field Sampling Plan**

- **Attachment C: Quality Assurance Project Plan (QAPP)**

- **Attachment D: Health and Safety Plan**
  - Previously submitted HASP
  - OEPA Comments to HASP
  - Responses to OEPA HASP Comments

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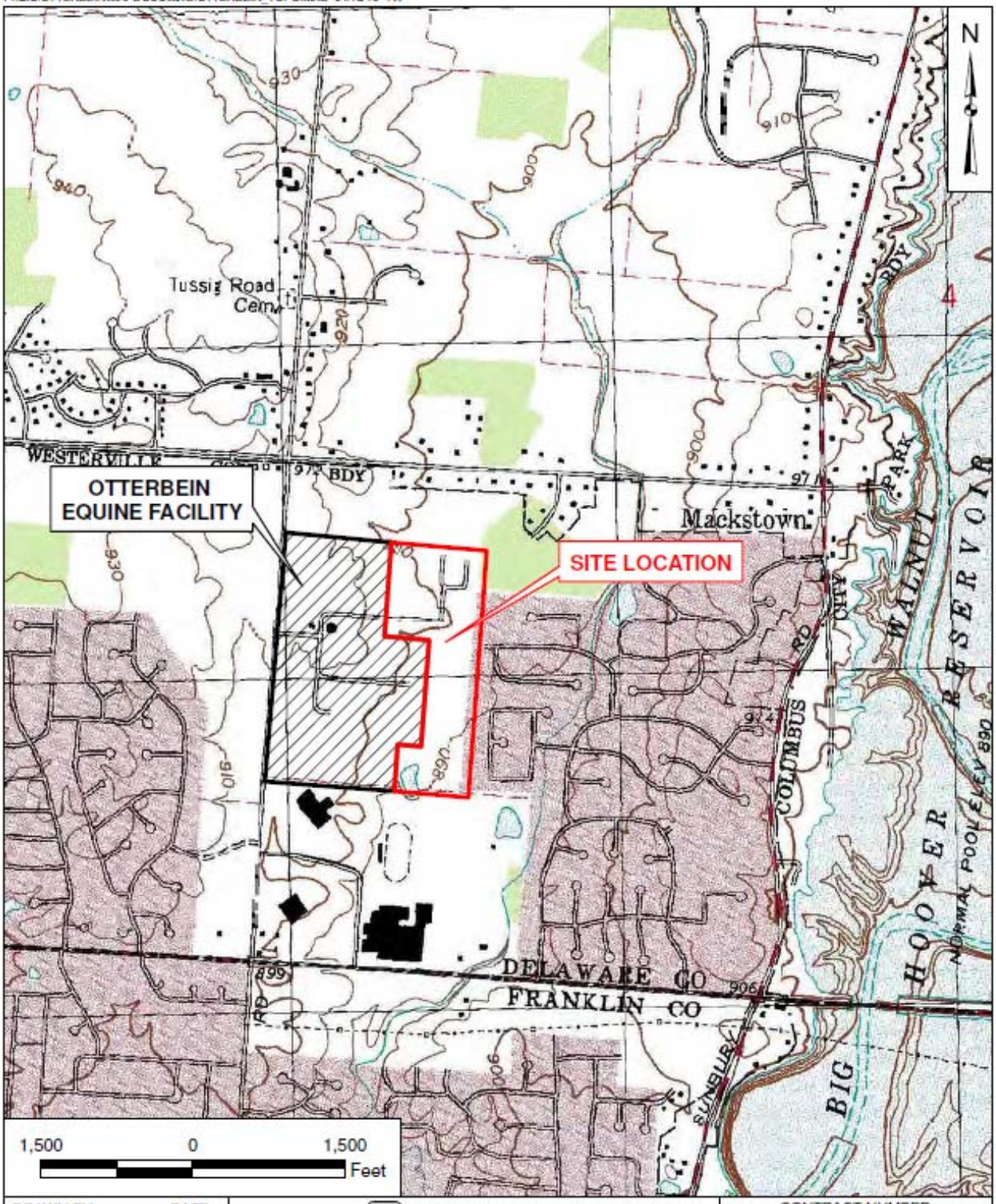

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CHECKED BY S. HILL	DATE 04/15/10	USGS TOPOGRAPHIC MAP	APPROVED BY — DATE —
COST/SCHEDULE AREA		FORMER KILGORE MANUFACTURING SITE WESTERVILLE, OHIO	APPROVED BY — DATE —
SCALE AS NOTED			FIGURE NO. FIGURE 1 / REV 0

TETRA TECH

SITE LAYOUT
FORMER KILGORE MANUFACTURING SITE
WESTERVILLE, OHIO

DRAWN BY	DATE	SCALE
J. ENGLISH	12/07/10	AS NOTED
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FIGURE 1-2		0 / 12/07/10

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2.0 SITE BACKGROUND

The background information is summarized from the recently published Pre-Investigation Evaluation Report (PER) for the Kilgore Manufacturing Company Facility, Westerville Ohio [Tetra Tech (TtNUS), August 2010] or from documents referenced in the PER. Unless noted otherwise, the tables, figures, and appendices referenced in Part 1 are those presented in the PER; and are not presented again in this Work Plan, instead the PER is included in Attachment A. The PER and many historical documents describing the conditions at the AOCs have referenced the Ohio Environmental Protection Agency (OEPA) Voluntary Action Program (VAP) standards as points of comparison. In accordance with recent conversations with OEPA, future data evaluation/risk assessment documents prepared for the AOCs will use United States (US) EPA regional screening levels (RSLs) as screening levels for environmental contamination. In many cases, the VAP standards referenced in the PER and the following narrative are similar to the RSLs.

Information regarding site background, site history, and the environmental setting common to the eight AOCs is presented in Sections 3-4 through 3-10.

2.1 SITE BACKGROUND AND HISTORY

The Kilgore Farm property is located in the City of Westerville, in Delaware County central Ohio (Figure 1-1). In 1941, in response to the needs of the Army Chemical Warfare Service for World War II, Kilgore Manufacturing purchased the 111 acre former farm for conversion to a pyrotechnics and ordnance manufacturing facility. This facility consisted of a network of small magazines, concrete buildings (including a boiler house), Quonset huts, a water tower, and other ancillary support facilities. On site activities conducted by Kilgore Manufacturing included experimental work on explosives and other energetic materials, and the manufacture and assembly of explosives, incendiary items, and detonation devices. Over the course of operations, various types of flares were manufactured including parachute, floating, photoflash, battlefield, trip, high altitude, 3-minute, and highway emergency flares for military and civilian uses. Incendiary bombs included thermite and magnesium explosive bomb clusters and for a short period of time, the facility experimented with the production of shaped charges (Kuis, 2003). Other specific products built or stored included 155 millimeter (mm) illuminating shells, hand and smoke grenade fuses and primers, M1 flame throwers, rocket line launchers, phosphorous float lights, and M112 photoflash cartridges (Kuis, 2003). Pelletization of black powder also took place. Typical types/descriptions of MEC that may be present are described below (UXB, January and March, 2000). Previous indications that land mines may also have been produced (Lawhon & Associates, 1996) were later discredited.

After World War II, Kilgore Manufacturing made toy cap guns and pyrotechnics for public use and illuminating flares for civilian and military use until 1961 when the facility closed. Figure 3-1 of the PER (Attachment A) shows an aerial photograph of the Site in 1958 before it was closed. Otterbein College has owned the 111-acre former Kilgore Farm property since it was donated to the college in 1962 by the owner, Commercial Credit Corporation after operations ceased. Farming, notably of beans and corn, resumed after 1967 and ceased in 1986. In 2007, Otterbein successfully obtained a zoning change from rural residential to planned Neighborhood District for the entire 111 acres to allow the Site to be used for college expansion. Phase I of Site development included a 69.145-acre parcel adjacent to the Site that is the location of Otterbein's equine science field operations. Phase II Site development is associated with the remaining 39.818-acre Site parcel. The intended future use of the property is recreational/educational. Residential development of the property is expected to be prohibited by deed restriction.

Wastes generated during operations included burning/disposal of produced wastes, such as material from settling sumps in the manufacturing area, and those items not meeting military standards of acceptability. Waste disposal records are incomplete. Most information regarding the types and quantities of wastes produced, disposed, or treated on site have been derived from a series of cleanups and investigations that spanned from 1962 to 2007, including the removal of foundations and other building structures in 1996. Eight specific AOCs have been identified (Figure 1-2). Environmental investigations included geophysical surveys; an ordnance survey; on-site testing to determine if the materials found were shock sensitive; friction sensitive, or flammable; trenching to visually identify the limits of waste disposal areas and to assess buried geophysical anomalies; and chemical sampling of soil, groundwater, and surface water.

The AOC locations have been well researched and established. However, poor waste handling/disposal procedures were evident during site cleanups and investigations and based on unrecorded disposal of: both containerized and non-containerized materials, materials disposed in various forms, and various disposal practices including surface placement, shallow burial and burning of materials. After more than 40 years, some objects brought to the surface by plowing have displayed ignitability; therefore, time has not completely eliminated hazards associated with these wastes. In 2000, UBX International conducted an unexploded ordnance (UXO) assessment and trenching investigation and concluded that there was "...a very low risk of detonations on the surface." The report went on to conclude that the overall UXO threat assessment was "medium" with a "potential hazard to local population if not cleared" Moreover, elevated concentrations of metals, sulfateand phosphorus are present in soil samples. Some soil samples had a pH low enough to be classified as corrosive and at least one sample exceeded the Toxicity Characteristic Leaching Procedure (TCLP) regulatory level for chromium.

Potential chemicals of concern associated with the operations of the Kilgore Manufacturing Facility are presented in Table 2-1.

TABLE 2-1

HISTORIC VAP/MCL EXCEEDANCES OF REGULATORY STANDARDS
FORMER KILGORE MANUFACTURING COMPANY FACILITY
WESTERVILLE, OHIO

AOC Number	Soil	Temp Wells (1988/1996) (AOC 8) and Ph 2 (2000)		Permanent Wells Ph 2 (2005)	
		AOC Wells (Depth to GW/ Screen Interval	Ph 2 GW (Max conc. µg/L)	AOC Wells (Depth to GW/ Screen Interval	Ph2 GW (Max conc. µg/L)
AOC 1 Unidentified Rectangular Features	Sb: 120 As: 41 Pb: 1080 Zn: 130000 Cr: 111000 Cr6: NA	GW: MEB 2-7 (1.28/1.0-10.92) MEB 2-8 (1.68/1.0-19.10) MEB 2-9 (2.61/1.0-11.19) MEB 2-10 (1.68/1-19.86) SW: SW-1	GW: As: 30 Pb: 19 Sb: 48 SW: Sb: 48	MW-5 (13.8/13-18)	Incomplete based on well MW-5, which was only analyzed for VOCs, Cr, and perchlorate w/ no exceedances
AOC 2 Drainage Ditch Near Mfg. Area	Sb:460000 As: 41 Pb: 2230				
AOC 3 Burial Area ESE of Burn Pit	Sb: 710 As: As	MEB 3-2 (2.26/1.0-15.36)	NA	MW-9 (19.62/22-27)	None based on well MW-9
AOC 4 Burn Pit	As: 25*	NA	As: 12 (nominal)	MW-6 (27.48/35-40) MW-7 (39.2/35-40) MW-8 (4.34/21-26)	None based on well MW-6, MW-7, and MW-8. MW-6 and MW-7 were only analyzed for VOCs, Cr, and perchlorate

TABLE 2-1

HISTORIC VAP/MCL EXCEEDANCES OF REGULATORY STANDARDS
FORMER KILGORE MANUFACTURING COMPANY FACILITY
WESTERVILLE, OHIO

AOC Number	Soil	Temp Wells (1988/1996) (AOC 8) and Ph 2 (2000)		Permanent Wells Ph 2 (2005)	
		AOC Wells (Depth to GW/ Screen Interval	Ph 2 GW (Max conc. µg/L)	AOC Wells (Depth to GW/ Screen Interval	Ph2 GW (Max conc. µg/L)
AOC 5 UST in Former Mfg. Area	As :22.8*	MEB 5-2 (Unknown)	Sb:<300 As: 910 Pb: 1900 Zn:: 10800 Cr: 1000 Cr6: NA Ni: 2000 Th:28.6** Cd: 37 Hg: 7.9 Be: 33 Ba: 6300	MW-1 (2.95/15-20) MW-2 (3.70/10-15) MW-3 (4.95/16-21)	None based on Wells MW-1, MW-2, and MW-3; however these wells appear to be upgradient of the site
AOC 6 Former Experimental Area	As: 22.7* Pb: 487 PAHs	MEB 6-5 (Unknown)	Sb:<300 As: 830 Pb: 710 Zn: 6400 Cr:1100 Cr6:1300 Ni: 1500 Th: 30** Cd: 69 Hg: 4.1 Be: 18 Ba: 3200	MW-4 (7.68/22-27)	VAP: Based on MW-4 Th: 5.6**
AOC 7 Cinder Area SE of Burn Pit	None	NA	NA	MW-10 (6.44/19-24)	None based on Wells MW-10; however this well appears to be upgradient of the site.

TABLE 2-1

HISTORIC VAP/MCL EXCEEDANCES OF REGULATORY STANDARDS
FORMER KILGORE MANUFACTURING COMPANY FACILITY
WESTERVILLE, OHIO

AOC Number	Soil	Temp Wells (1988/1996) (AOC 8) and Ph 2 (2000)		Permanent Wells Ph 2 (2005)	
		AOC Wells (Depth to GW/ Screen Interval	Ph 2 GW (Max conc. µg/L)	AOC Wells (Depth to GW/ Screen Interval	Ph2 GW (Max conc. µg/L)
AOC 8 Former Burial Trench Area	None	N well (1988) W well (1988) S well (1988) SE well (1988) None from 1996	Pb: 1100 (1988)	NA	NA
Quonset Hut Area	NA	NA	NA	NA	NA
Farm/Former Residence Area	None	NA	NA	NA	NA

Note: Groundwater samples were analyzed for metals, perchlorate, VOCs w/ketones, SVOCs, and hexavalent chromium.

* Arsenic included as exceedance for Preliminary Phase 2 Sampling (Metcalf&Eddy, 2005) but. Subsequent Phase I Property Assessment Otterbein College Equine Facility (Brown and Caldwell, 2007) suggests that concentrations are indicative of background, statistically established at 25.3 mg/kg.
** Thallium believed to be a laboratory artifact.

3.0 INITIAL EVALUATION/CONCEPTUAL SITE MODEL

The sections below provide preliminary evaluations of the various AOCs at the site and in many cases reference earlier data to VAP standards, as was appropriate for the data evaluation at the times at which the data were developed and evaluated. Otterbein understands that VAP standards are not the appropriate standards for making decisions in the current RI/FS.

3.1 OVERVIEW OF PREVIOUS ENVIRONMENTAL INVESTIGATIONS

Phase I Assessments were performed by S. E. A., Inc. in 1986, and by Lawhon & Associates, Inc. in 1991.

A VAP Phase I investigation of the entire 111 acre property was conducted by Metcalf & Eddy, Inc. (M&E) in 1988 but the findings were not submitted to OEPA. The 1988 investigation identified 14 AOCs; however, further investigation reduced this number to 11. Four areas on the current Equine Center parcel were later determined to require no further action. The Former Burial Trench Area (AOC 8) was subsequently added to the list, resulting in eight AOCs on the current 40 acre eastern parcel. In 1998, M&E conducted a Site reconnaissance and issued a Phase I Property Assessment Amendment (M&E, 1998). The 1998 report added additional historical background, but did not suggest any significant changes to the original Phase I findings concerning contamination at the Site. The 1998 report is included in the PER as APPENDIX A (Attachment A).

In 1999 and 2000, M&E conducted field investigations that led to the completion of the Preliminary Phase II Property Assessment (M&E, 2003) for the Ohio VAP (see Figure 4-1 and Table 4-1 in the PER; Attachment A). This report provides the bulk of the available soil and groundwater assessment data (included as APPENDIX B to the PER [Attachment A]), and the data for individual AOCs are tabulated in tables presented in the PER.

M&E also prepared a VAP Phase I Property Assessment Amendment in June, 2005; however, no new characterization data was provided in the 2005 report. This report M&E, 2005, is included in the PER as APPENDIX C (Attachment A). The second and third volumes of the report are included in the PER as APPENDICES D and E, and a VAP Checklist is included in the PER as APPENDIX F (Attachment A).

In 2007, Brown and Caldwell prepared a Phase I Property Assessment specifically for the Equine Center property (Brown & Caldwell, 2007), just to the west of the Site. This report includes information pertaining to the 40 acre Site and is included in the PER as APPENDIX F for additional background information (Attachment A).

Results of the previous investigations where data is available are described in the Conceptual Site Model (CSM) identified by AOC.

3.2 CONCEPTUAL SITE MODEL

This CSM was revised following comments on the PER by the OEPA, and supersedes the CSM in the PER (Attachment A).

AOC-specific CSMs are presented below. A pictorial CSM is presented as attached Figure 3-1. This pictorial CSM depicts the general Site and AOC location, a simplified geologic cross section, and the potential human and ecological receptors for the Site. Relevant exposure pathways for current and future human receptors of concern (identified in the pictorial CSM) are listed in attached Table 3-1.

The Site is located on the east side of Spring Road, approximately 700 feet south of Maxtown Road in a residential area of Westerville, Ohio and is currently vacant. The Site is partially wooded and overgrown with dense grasses and brush. The majority of the Site is covered with mature woodland. Remnants of gravel roads are still visible but all above-ground structures have been razed. Site topography is generally level, with relief less than 10 feet (898 to 890 feet above mean sea level) from west to east across the Site.

The Site is surrounded by a mix of residential and school properties, vacant fields and wooded land [Figure 3-3 in the PER (Attachment A)]:

- North: Domestic housing and vacant field and wooded land
- East: Domestic housing
- South: Westerville North High School and Heritage Middle Schools
- West: The Otterbein University Equine Science Facility

The regional climate is cold in the winter and warm to hot in the summer. The average winter temperature is 31 degrees Fahrenheit (F) while the average summer temperature is 72 degrees F. The prevailing wind is from the south-southwest with an average wind speed of 11 miles per hour. The total annual precipitation is approximately 38 inches, of which 60 percent usually falls from April through September. The average annual snowfall is 28 inches, which occurs from late November until early March.

3.2.1 Hydrology

There are no permanently flowing rivers or streams on the Site, but there is an intermittent stream that flows in the northwest corner of the property during wet times of the year. The stream was formerly connected by a tile drain to a drainage ditch on the northern portion of the property (AOC 2). The tile drain is apparently plugged, causing overland flow toward the former drainage ditch. This overland flow reportedly initiates the largest wetland on the site. (Section 3.2.4) There is no sediment on the property; the material in the drainage ditch (AOC 2) becomes saturated during wet periods, but is most properly characterized as soil, as it consists mainly of topsoil and not material transported by moving water. Hoover Reservoir, located approximately 2,000 feet east of the Site is the nearest major surface water body; there are no direct drainage ways that connect the property to Hoover Reservoir, or other surface water bodies.

3.2.2 Geology

Site surface soils are brown weathered silty clay with varying amounts of sand and gravel/shale fragments. The weathered soil horizon extends to approximately 10 feet below ground surface (bgs). Beneath the weathered soils, the unweathered soils are of the same composition but are gray in color. There is approximately 50 feet of glacial drift above the bedrock. Figure 3-4 in the PER displays the location of geologic cross-sections at the Site and Figures 3-5 through 3-8 in the PER show cross-sections A-A', B-B', C-C', and D-D' (Attachment A).

3.2.3 Hydrogeology

The Site is in an area that contains thin lenses of sand and gravel interbedded in thick layers of clay and silt. Domestic and farm supply wells are generally 100 feet deep or less in glacial overburden. The Site is adjacent to an area with meager, often inadequate supplies of groundwater. Previous Site investigations have noted the presence of discontinuous sand seams in several different groundwater flow zones in the glacial till and none of the identified sand seams were found to be extensive. Site groundwater flow is to the east-southeast, consistent with regional flow direction.

3.2.4 Wetlands

A portion of the Site is covered by wetlands. A preliminary Jurisdictional Opinion (PJO) was conducted by Civil and Environmental Consultants, Inc. (CEC) in 2005 for the entire 111 acre former Kilgore Manufacturing property owned by Otterbein College. This report (included as Appendix G of the PER [Attachment A]) designates three areas of the Site as wetlands. Wetland A was described as a forested/scrub/shrub/emergent wetland covering approximately 14 acres in the forested, eastern portion of the Site. Wetland B was described as a forested/scrub/shrub wetland covering 2 acres in the

southwestern corner of the Site. The third was Wetland C, described as an aquatic bed/scrub/shrub wetland located in the southeastern corner of the Site.

A wetland delineation was conducted on the 70 acre parcel of the former Kilgore property, just west of the current Site prior to construction of the current Otterbein Equine Center. This study conducted by MAD, Scientist & Associates LLC is in Appendix H in the PER (Attachment A).

Another wetland delineation and request for a Jurisdictional Opinion (JO) is being conducted at the site by CEC for Otterbein at the onset of the RI/FS process. The study will define the types and extent of wetlands on the site, as well as all surface water bodies. Although the wetlands delineation study is not complete, the outline of the delineated wetlands is displayed on Figure 3-2 and on the proposed sampling location map provided with this Work Plan.

3.3 AOC 1 UNIDENTIFIED RECTANGULAR FEATURE

AOC 1 is located in the northeast portion of the Site, south of the former Manufacturing Area (AOC 5), and is defined by two rectangular features of unknown past use (M & E, 2005). No evidence remains of these horizontal structures. The original source(s) of potential contaminant releases in this area are unknown. Brown & Caldwell, (July 2007), using visual identification of “green material encountered in borings and trenches” (described below), estimated the size of AOC 1 to be:

Dimensions (feet)			Volume (cubic yard)*	Tonnage/Acreage
Length	Width	Depth		
75	125	3	1,094	1,860/0.22

* Includes 5 percent contingency

Previous Investigations

In late 1999 to mid-2005, a Preliminary Phase II Property Assessment was conducted at the Site. Geophysical results showed several anomalies attributed to surface metal debris; therefore, three trenches were excavated at the locations of the potential metallic anomalies with no finding of buried items. However, a prominent green silty material with orange sand was present and exceeded the unrestricted residential use standards under VAP for several metals. The chromium TCLP analysis also exceeded the solid waste toxicity standard. Approximately 35 hand auger borings were subsequently completed within the AOC (Brown & Caldwell, 2007 and M & E, 2005). Results of the most recent (and most complete) sampling at AOC 1 are presented in Table 4-3 in the PER (Attachment A).

3.4 AOC 2 DRAINAGE DITCH NEAR FORMER MANUFACTURING AREA

AOC 2 is a drainage ditch located in the northeast portion of the Site, between the former Manufacturing (AOC 5) and Experimental (AOC 6) Areas where wastes were reportedly buried. The burial reportedly consisted of off-specification material, buried parallel to and within 8 to 10 feet of either side of the ditch. The ditch has some flow, northwest to southeast, after precipitation events; however, there is no sediment in the ditch. The material in the drainage ditch becomes saturated during wet periods, but is most properly characterized as soil because it consists mainly of topsoil and not material transported by moving water (M & E, 2005). The original source(s) of releases in this area are unknown. The AOC 2 size was estimated by Brown & Caldwell (July 2007) based on the observed limits of waste in trenches and the boring results (see below) and the depth of the deepest waste in a given trench.

Dimensions (feet)			Volume (cubic yard)*	Tonnage/acreage
Length	Width	Depth		
400	30	3	1,400	2,380/0.28

* Includes 5 percent contingency

Previous Investigations

Geophysical investigations at AOC 2 revealed a few potential metallic anomalies, the most significant being at the eastern limit of the ditch. Higher conductivity areas outside the main ditch line may represent disturbed soils. Seven trenches were subsequently excavated and ordnance was identified both on the surface and at depth. Additional surface debris included glass, laboratory crockery, metal, brick and concrete. Buried debris included ordnance, gray and purple silt-like material, black granular material, white crystalline material, red and orange stained soils, metal, glass, and ceramic debris. Several metals exceeded the VAP standards.

Further investigation of AOC 2 included the installation of 10 borings, collection of a surface water sample, and a sample of the saturated soil from the drainage ditch. An additional trench was completed in a round feature located west of the former Manufacturing Area, where concrete and fill dirt were encountered. No analytical testing was conducted because the materials in the feature were identified in the field as construction debris. Two intact and potentially live primers were identified south of the western edge of the ditch. Soil samples were obtained from the trenches and from 10 borings. Soil exceeded the unrestricted residential use standards under VAP for several metals. Some of the soils had such a low pH that the soils would be classified as corrosive. Results of the most recent (and most complete) sampling at AOC 2 are presented in Tables 4-4 through 4-6 in the PER (Attachment A).

Groundwater samples were collected from four temporary wells and analytical results exceeded maximum contaminant levels (MCLs) and VAP unrestricted use standards for several metals; however, the groundwater samples collected from these wells had high turbidity. Thus, the available data were not believed to be representative of actual groundwater chemistry. A surface water sample from the ditch exceeded the MCL for antimony (Brown & Caldwell, 2007 and M & E, 2005).

3.5 AOC 3 BURIAL AREA

AOC 3 is a former Burial Area, reportedly used to dispose of cinders and nonflammable materials generated at the facility. The source(s) of wastes for AOC 3 is reportedly the Burn Pit (AOC 4) that was used once a week to burn off-specification materials and waste. AOC 4 was periodically excavated and resulting cinders and nonflammable material were buried in trenches at AOC 3 and/or AOC 8 (M & E, 2005). Purple powder, white crystalline material, and gray and black ash were observed in this area. This AOC was reportedly excavated to a depth of 10 feet and backfilled with clean soil (M & E, 2005). Brown & Caldwell, July 2007, estimated the size of AOC 3 using observed limits of waste in the trenches, and the depth of native material, as well as the soil boring analytical.

Dimensions (feet)			Volume (cubic yard)*	Tonnage
Length	Width	Depth		
100	100	5	1,945	3,112

* Includes 5 percent contingency

Previous Investigations

Fourteen borings (by direct push and hand auger) were installed within and around the waste.

The soil exceeded the unrestricted residential use standards under VAP for several metals and perchlorate. One sample was found to be flammable and “produced copious amounts of white smoke.” Another sample was “not flammable but produced red smoke when heated” (Brown & Caldwell, 2007 and M & E, 2005). Results of the most recent (and most complete) sampling at AOC 3 are presented in Tables 4-7 and 4-8 of the PER (Attachment A).

Geophysical investigations at AOC 3 revealed a potential for large amounts of buried metallic objects and areas of high conductivity associated with potentially disturbed soils. Three trenches were subsequently completed in the area. Several 55-gallon drums and drum fragments were located on the surface and numerous metallic objects and debris were excavated within the limits of the waste. The materials included ordnance, drum fragments, metal debris, wood, glass, burned debris, a white crystalline substance, purple powder, black to gray ash, slag, cinders, black granular material, and bright red silty

material. Five-gallon pails filled with unidentified residue were also observed. Ordnance was observed both on the surface and at depth and included flares, blasting caps, and canisters.

Groundwater samples were collected from a temporary well in 2000 and a permanent VAP-compliant well, MW-9, in 2005. Due to low well yield and slow recovery, this well was analyzed for only volatile organic compounds (VOCs), chromium, and perchlorate with no exceedances (Brown & Caldwell, 2007 and M & E, 2005).

3.6 AOC 4 BURN PIT

AOC 4 is a burn pit located east of the former Quonset hut site. According to a former employee (employed 1946 to 1961), the burn pit was used once a week to burn flares, caps, and other off-specification materials and waste. Extreme care was apparently taken to ensure that all materials in the burn pit were completely destroyed during each burning event in order to prevent accidents from occurring during the next burn event. The pit was periodically excavated and the cinders and nonflammable material was buried in trenches (AOC 8) (M & E, 2005). Prior to 1962, contaminated soil from the burn pit was excavated to a depth of 10 feet. The excavated material was disposed off=site and the excavation was backfilled (M & E, 1998). The AOC 4 size was estimated by Brown & Caldwell (July 2007):

Dimensions (feet)			Volume (cubic yard)*	Tonnage/Acreage
Length	Width	Depth		
100	75	10	2,187	3,500/0.17

* Includes 5 percent contingency

The potential contaminant source was reportedly removed more than 45 years ago. Unless contaminated fill was used in backfilling the excavation, no source of contamination remains at AOC 4.

Previous Investigations

Results of the most recent (and most complete) sampling at AOC 4 are presented in Tables 4-9 and 4-10 of the PER. No intrusive environmental investigations had been conducted at AOC 4 prior to 1998. The location of the burn pit was determined from aerial photographs, and a sizeable area of potentially disturbed soil was subsequently identified south of the Burn Pit in an electromagnetic survey. No metallic debris was identified by the geophysics.

Due to the reported excavation depths of the Burn Pit during its operation (up to 10 feet), trenching was not conducted at this AOC. Ten borings were installed in and around the Burn Pit and the associated

anomaly (potentially disturbed area) to the south. Silty clay fill was encountered to depths of approximately 10.5 feet bgs, below which native fill (dense silty clay) was encountered. Three soil samples collected exceeded the VAP residential standard for arsenic, although concentrations were noted as typical of native Ohio soils.

Groundwater samples were collected from three permanent VAP-compliant wells, MW-6, MW-7 and MW-8, in 2005. Wells MW-6 and MW-8 produced enough water for a full suite of analyses (VOCs, semi volatile organic compounds (SVOCs), inorganics, and perchlorate); however, due to low well yield and slow recovery, the MW-7 well was analyzed only for VOCs, chromium, and perchlorate. No VAP exceedances were noted except for thallium which was believed to be a laboratory artifact (Brown & Caldwell, 2007 and M & E, 2005).

3.7 AOC 5 MANUFACTURING AREA FORMER UNDERGROUND STORAGE TANK LOCATION

AOC 5 is associated with a former 2,500 gallon underground storage tank (UST) located in the northeast corner of the Site within the former Manufacturing Area. The tank was used for fuel oil storage. The former UST area represents a small portion of the AOC 5 outline presented on Figure 3-1. Because it was a fuel oil tank, it was unregulated by the State. The UST was abandoned in 1962 (Lawhon & Associates, 1991) and removed in 1997 along with surrounding contaminated soil (M & E, 2005). The tank was approximately 47 years old at the time of removal. During removal of the UST, water and residual petroleum product were pumped from the tank and disposed of as petroleum-contaminated liquids. Visibly contaminated soils were excavated, segregated from “clean” soils, and stockpiled on plastic sheeting. Verification soil samples were collected from the soil surrounding the tank and results led to the removal of additional soil, which was hauled off-site for disposal. A total of 104 cubic yards of impacted soils were removed from this former UST location. The area was designated as a Category 3 Site and a closure report was filed with the OEPA (Lawhon & Associates, 1997). The residual concentrations of petroleum constituents in the soil were determined to be below the Category 3 Action Levels and below the VAP Generic Numeric Cleanup Standards (M&E, 2003).

This former UST location continues to be identified as an AOC primarily as a result of hydrocarbon odors detected in soils recovered from a soil boring advanced at the location of the former tank. Brown & Caldwell (2007) did not recommend removal of soil in this area; therefore there is no estimate of the size of any impacted soil area.

Previous Investigations

During the Preliminary Phase II Property Assessment, one soil boring installed in 2000 at the location of the former fuel oil tank had a strong hydrocarbon odor in soils from 19 to 24 feet bgs; however, no samples were collected from this boring. Four additional borings were installed in 2004 and soils consisted of mostly silty clay or clayey silt with some thin sand and gravel lenses. Soil samples exceeded the VAP residential standard for arsenic. Results of the most recent (and most complete) sampling at AOC 5 are presented in Tables 4-11 and 4-12 in the PER (Attachment A).

Groundwater samples were collected from one temporary well located downgradient of the UST. Analytical results for the sample exceeded MCLs and VAP unrestricted use standards for several metals; however, groundwater samples were highly turbid and the available data were not believed to be representative of actual groundwater chemistry. Three permanent VAP-compliant wells, MW-1, MW-2 and MW-3 were installed and sampled. No VAP exceedances were detected in these wells except for thallium, which was believed to be a laboratory artifact (Brown & Caldwell, 2007 and M & E, 2005).

3.8 AOC 6 FORMER EXPERIMENTAL AREA

This area, located north of the former Quonset huts, was used to conduct research and testing of new products and processes. Surface waste observed at this AOC included drums, construction debris, ash, slag, cinders, and black, loose granular materials (M & E, 2005). The AOC 6 size was estimated by Brown & Caldwell (July 2007):

Dimensions (feet)			Volume (cubic yard)*	Tonnage/Acreage
Length	Width	Depth		
50	50	2	194	311/0.057

* Includes 5 percent contingency

Previous Investigations

Surficial waste was observed in the vicinity of AOC 6 during the Phase II investigation, and included drums and drum fragments, construction debris, 1-to 3-gallon metal cans, burned debris, ash, slag, cinders, and a black loose granular material. Samples were collected of black residue from inside a drum, of soils beneath a pile of the 1-to 3-gallon containers, and of soil beneath spilled material. During the excavation of burial trenches, drum fragments, construction debris, burned debris, ash, slag, cinders, and black granular material, flare casings, and black caps were removed. Scattered casings and caps were present on the ground surface. Approximately 100 black canisters were identified during a Site walk. Lead and polycyclic aromatic hydrocarbon (PAH) concentrations associated with the discarded

containers exceeded VAP standards. Three borings were installed to a depth of 16 feet and only arsenic VAP standards were exceeded. Results of the most recent (and most complete) sampling at AOC 6 are presented in Table 4-14 in the PER (Attachment A).

Groundwater samples were collected from one temporary well and in 2005, a VAP-compliant well, MW-4, was installed and sampled. Several metals in the groundwater samples exceeded MCLs and VAP unrestricted use standards and the regulatory action level for copper was also exceeded. However, the exceedances, except for thallium, all occurred in a highly turbid sample from the temporary well. Consequently, the data from the well are not believed to have been representative of actual groundwater chemistry. Thallium is believed to have been a laboratory artifact.

3.9 AOC 7 CINDER AREA

This AOC is defined by cinders, coal fragments, and slag found on top of native soils. The area is located near the southeast corner of the Site (M & E, 2005). MEC is not expected at AOC 7 based on information collected to date. The AOC 7 size was estimated by Brown & Caldwell (July 2007):

Dimensions (feet)			Volume (cubic yard)*	Tonnage/Acreage
Length	Width	Depth		
25	25	2	48	77/0.014

* Includes 5 percent contingency

Previous Investigations

Results of the most recent (and most complete) sampling at AOC 7 are presented in Tables 4-15 and 4-16 in the PER (Attachment A).

Cinders, coal fragments, and slag were found overlying the native clay loam soils in the latest investigation of AOC 7. The area was investigated using a hand auger. Coal fragments and slag were below VAP standards for SVOCs and metals, but orange and red fragments were present in the cinders and slag (Brown and Caldwell, 2007).

A VAP-compliant monitoring well, MW-10, was installed and sampled in 2005. There were no exceedances of MCLs or VAP unrestricted use standards in the groundwater samples collected from this well.

3.10 AOC 8 FORMER BURIAL TRENCH AREA

AOC 8, located in the southeast corner of the Site, was used as a burial area allocated for the disposition of waste including rejected materials from Site operations. The area was capped at the cessation of historical Site activities in the 1950s (M & E, 2005). The recorded disposition of waste and rejected materials is complete only from January, 1951 through May 1953 (Lawhon & Associates, 1991).

Wastes buried at AOC 8 were generally from settling sumps and consisted of mixtures of various chemicals used in the manufacturing process, primarily mixtures of red phosphorous, potassium chlorate, gum, and antimony trisulphide. Such mixtures, when dry, are highly explosive; therefore, much of the waste was packaged wet in cans, laid in open trenches and covered over with earth. The largest can used for burying was approximately 15 inches in diameter and 30 inches long.

Rejected materials, such as pyrotechnical devices, primary explosives, scrap powder, primers, detonators, and liquid flares were also placed in open trenches and covered with earth. The most dangerous of the buried materials was photoflash cartridges. For the most part, the trenches were oriented in the same direction and were equidistant apart (Lawhon & Associates, 1991 and W.R. Grace and Company, 1961). According to a former employee (employed 1952 to 1961), the trench burial area consisted of 20 trenches, 200 feet long by 3 feet wide by 5 feet deep (M & E, 1998). As new trenches were dug, excavated soil from the new trench was used to cover up the last trench.

The size of A0C 8 has been reported as small as 2.5 acres and as large as 8 acres. Impacted material was previously noted at depths up to 10 feet bgs (Brown & Caldwell, July 2007).

Previous Investigations

The initial (1962) clean-up of AOC 8 consisted of the excavation of known trenches. Over 120 tons of explosives and flares were removed and destroyed, including 3,500 boosters and 200,000 fuses. A cap mix (red phosphorous, potassium chlorate gum, and antimony trisulphide), black powder, magnesium flares, phosphorus sweepings, ammonium and potassium picrate, caps and primers, M1 flamethrowers, M112 photoflash cartridges, land flares, 155 mm illuminating shells, 3-minute flares, and M6, MK5, and M501-type materials were destroyed on the property by burning and/or detonation and the trenches were backfilled (Lawhon & Associates, 1991). Subsequent information sources clarified that some materials were destroyed by burning and/or detonation and the remaining materials were relocated to an area near the easternmost Quonset hut for staging prior to shipment from the Site (M & E, 2005).

In 1985, a Site visit associated with the potential sale of the farm resulted in the discovery of approximately 70 flare canisters that had apparently been dug up by plow blades during farming activities.

One of the canisters was detonated as a test by the Ordnance Department at Wright-Patterson Air Force Base (AFB). In September 1985, the canisters were delivered to Wright-Patterson AFB. In 1986, an additional 80 flare canisters were encountered and removed by Wright-Patterson AFB (Lawhon & Associates, 1991).

In January 1988, S.E.A, Inc. was contracted by Westerville Schools, which was interested in purchasing a portion of the farm, to conduct an environmental study of the Site, including the Burial Trench Area. This investigation included monitoring well installation and groundwater sampling. From this, it determined that groundwater contamination was not an environmental concern. One area investigated with a metal detector revealed the presence of many small unidentifiable metal objects. Excavation of this area occurred and a variety of waste materials related to Kilgore operations were encountered including parachute flares (dated 1954), black plastic caps, short cylinders composed of gray/blue/purple cylindrical-shaped material, gray-white layered solid granular substance, aluminum flitter/sodium nitrate, sulfur, and many filled aluminum canisters. Trenches were dug throughout the burial area but only a few pieces of debris were encountered. The trenches were not backfilled. Examination of the excavated items by the Columbus Bomb Squad found that materials could not be exploded (Lawhon & Associates, 1991).

As part of the Phase I Environmental Audit, a magnetic survey was conducted over the property and it was determined that several anomalies still existed in the southeast corner of the Site where the old burial trenches (AOC 8) were located (Lawhon & Associates, 1991).

In the 1996/1997 Phase I Environmental Site Assessment, 15 trenches were excavated, each 3 feet wide by 6 feet deep and of variable length, for a total excavation of 3,330 linear feet. A pit measuring 30 feet by 40 feet by 5 feet deep was also excavated. Six drums of miscellaneous materials were removed, including a 5-gallon bucket of material that segregated and thought to be potentially energetic; these materials were detonated. Empty M112 photoflash casings, M56 projectile fuses, various pyrotechnic debris, and two 55-gallon drums of reddish material, assumed to be red phosphorous, were removed. Excavated materials were staged at Quonset huts near the old farmhouse.

Groundwater in this area was sampled from three wells installed immediately following the trenching (previous wells had been abandoned); groundwater samples were analyzed for VOCs, SVOCs, and Resource Conservation and Recovery Act (RCRA) 8 metals. Data from three wells previously installed during the 1998 Phase I Property Assessment are of minimal value due to conflicting locational information; limited analytical suite (Extractional Procedure (EP) Toxicity metals only); the exclusion of some primary metals of concern such as antimony, elevated detection limits; and use of a chemical test

kit for nitrate. Target analytes in groundwater and soil samples were either nondetect and/or at concentrations suspected to represent natural conditions (Brown and Caldwell, 2007 and M & E, 2005).

This AOC was not included in the Preliminary Phase II Property Assessment conducted from late 1999 to mid-2005 because the area was capped and groundwater was not deemed to be contaminated (M & E, 2005).

TABLE 3-1

POTENTIAL HUMAN EXPOSURE PATHWAYS
FORMER KILGORE MANUFACTURING COMPANY FACILITY
WESTERVILLE, OHIO

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current	Surface Soil	Surface Soil	On-site	Trespassers	Adolescents	Ingestion Dermal	Quant Quant	Trespassers may contact surface soil while at the site.
			Off-site	Residents	Child	Ingestion Dermal	None None	Off-site residents do not have contact with on-site surface soil (unless they are the trespassers specified above).
					Adult	Ingestion Dermal	None None	
		Air	On-site	Trespassers	Adolescents	Inhalation	Quant	Adolescent trespassers may be exposed to fugitive dust and volatile emissions while at the site.
			Off-site	Residents	Child	Inhalation	Qual	Off-site residents may be exposed to fugitive dust and volatile emissions from the site.
					Adult	Inhalation	Qual	
	Subsurface Soil	Subsurface Soil	On-site	Trespassers	Adolescents	Ingestion Dermal	None None	Trespassers do not have contact subsurface soil while at the site.
			Off-site	Residents	Child	Ingestion Dermal	None None	Off-site residents do not have contact with on-site subsurface soil.
					Adult	Ingestion Dermal	None None	
		Air	On-site	Trespassers	Adolescents	Inhalation	None	Trespassers do not have contact subsurface soil while at the site.
			Off-site	Residents	Child	Inhalation	None None	Off-site residents do not have contact with on-site subsurface soil (unless they are the trespassers specified above).
					Adult	Inhalation	None None	
	Groundwater	Groundwater	On-site	Trespassers	Adolescents	Ingestion Dermal	None None	Adolescent trespassers are not exposed to COPC that have volatilized from groundwater.
			Off-site	Residents	Child	Ingestion Dermal	TBD TBD	Based on currently available information, off-site residents do not have contact with on-site groundwater. This conclusion is pending the results of the Remedial Investigation.
					Adult	Ingestion Dermal	TBD TBD	
		Air	On-site	Trespassers	Adolescents	Inhalation	None None	Adolescent trespassers do not have contact with groundwater.
			Off-site	Residents	Child	Inhalation	TBD TBD	Based on currently available information, off-site residents do not have contact with on-site groundwater. This conclusion is pending the results of the Remedial Investigation.
					Adult	Inhalation	TBD TBD	
			Off-site Vapor Intrusion	Residents	Child	Inhalation	TBD TBD	Based on currently available information, off-site residents do not have contact with on-site groundwater. This conclusion is pending the results of the Remedial Investigation.
					Adult	Inhalation	TBD TBD	

TABLE 3-1

POTENTIAL HUMAN EXPOSURE PATHWAYS
FORMER KILGORE MANUFACTURING COMPANY FACILITY
WESTERVILLE, OHIO

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
	Surface Water	Surface Water	On-site	Trespassers	Adolescents	Ingestion Dermal	Quant Quant	Adolescent trespassers may have contact with surface water.
			Off-site	Residents	Child	Ingestion Dermal	TBD TBD	Off-site residents do not have contact with on-site surface water (unless they are the trespassers specified above). If the wetlands investigation determines the on-site wetlands are connected to the off-site wetlands, then this pathway will be quantitatively evaluated for off-site residents.
					Adult	Ingestion Dermal	TBD TBD	
	Sediment	Sediment	On-site	Trespassers	Adolescents	Ingestion Dermal	Quant Quant	Adolescent trespassers may have contact with sediment.
			Off-site	Residents	Child	Ingestion Dermal	TBD TBD	Off-site residents do not have contact with on-site sediment (unless they are the trespassers specified above). If the wetlands investigation determines the on-site wetlands are connected to the off-site wetlands, then this pathway will be quantitatively evaluated for off-site residents.
					Adult	Ingestion Dermal	TBD TBD	
Future	Surface Soil	Surface Soil	On-site	Construction Workers	Adult	Ingestion Dermal	Quant Quant	Construction workers may have contact with surface soil during excavation activities.
				Industrial Worker	Adult	Ingestion Dermal	Quant Quant	Industrial workers may contact surface soil during normal work activities.
				Recreational Users	Child	Ingestion Dermal	Quant Quant	Recreational users may contact surface soil while at the site.
					Adult	Ingestion Dermal	Quant Quant	
				Residents	Child	Ingestion Dermal	Quant Quant	Although a future residential scenario is considered unlikely at the site, this scenario is included to aid in future risk management decisions. (Residential land use will be prohibited by deed restriction.)
					Adult	Ingestion Dermal	Quant Quant	
			Off-site	Residents	Child	Ingestion Dermal	Quant Quant	Off-site residents do not have contact with on-site surface soil.
					Adult	Ingestion Dermal	Quant Quant	
		Air	On-site	Construction Workers	Adult	Inhalation	Quant	Construction workers may be exposed to fugitive dust and volatile emissions during construction activities.
				Industrial Worker	Adult	Inhalation	Quant	Industrial workers may be exposed to fugitive dust and volatile emissions during work activities.
				Recreational Users	Child	Inhalation	Quant	Recreational users may be exposed to fugitive dust and volatile emissions while at the site.
					Adult	Inhalation	Quant	
				Residents	Child	Inhalation	Quant Quant	Although a future residential scenario is considered unlikely at the site, this scenario is included to aid in future risk management decisions. (Residential land use will be prohibited by deed restriction.)
					Adult	Inhalation	Quant Quant	

TABLE 3-1

POTENTIAL HUMAN EXPOSURE PATHWAYS
FORMER KILGORE MANUFACTURING COMPANY FACILITY
WESTERVILLE, OHIO

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
			Off-site	Residents	Child	Inhalation	Qual	Off-site residents may be exposed to fugitive dust and volatile emissions from the site.
					Adult	Inhalation	Qual	
	Subsurface Soil	Subsurface Soil	On-site	Construction Workers	Adult	Ingestion Dermal	Quant Quant	Construction workers may have contact with subsurface soil during excavation activities.
				Industrial Worker	Adult	Ingestion Dermal	Quant Quant	Although exposure to subsurface soil by industrial workers is considered unlikely at the site, this scenario is included to aid in future risk management decisions.
				Recreational Users	Child	Ingestion Dermal	Quant Quant	Although exposures to subsurface soil by recreational users is considered unlikely at the site, this scenario is included to aid in future risk management decisions.
					Adult	Ingestion Dermal	Quant Quant	
Future	Subsurface Soil	Subsurface Soil	On-site	Residents	Child	Ingestion Dermal	Quant Quant	Although a future residential scenario is considered unlikely at the site, this scenario is included to aid in future risk management decisions. (Residential land use will be prohibited by deed restriction.)
					Adult	Ingestion Dermal	Quant Quant	
			Off-site	Residents	Child	Ingestion Dermal	Quant Quant	Off-site residents do not have contact with on-site subsurface soil.
					Adult	Ingestion Dermal	Quant Quant	
		Air	On-site	Construction Workers	Adult	Inhalation	Quant	Construction workers may be exposed to fugitive dust and volatile emissions during construction activities.
				Industrial Worker	Adult	Inhalation	Quant	Although exposure to subsurface soil by industrial workers is considered unlikely at the site, this scenario is included to aid in future risk management decisions.
				Recreational Users	Child	Inhalation	Quant	Although exposure to subsurface soil by recreational users is considered unlikely at the site, this scenario is included to aid in future risk management decisions.
					Adult	Inhalation	Quant	
				Residents	Child	Inhalation	Quant Quant	Although a future residential scenario is considered unlikely at the site, this scenario is included to aid in future risk management decisions. (Residential land use will be prohibited by deed restriction.)
					Adult	Inhalation	Quant Quant	
			Off-site	Residents	Child	Inhalation	None	Off-site residents do not have contact with on-site subsurface soil.
					Adult	Inhalation	None	

TABLE 3-1

POTENTIAL HUMAN EXPOSURE PATHWAYS
FORMER KILGORE MANUFACTURING COMPANY FACILITY
WESTERVILLE, OHIO

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
	Groundwater	Groundwater	On-site	Construction Workers	Adult	Ingestion	None	Construction workers are not expected to ingest groundwater.
						Dermal	Quant	Construction workers may have dermal contact with ground water during excavation activities.
				Industrial Worker	Adult	Ingestion	None	Industrial workers are not expected to have contact with groundwater.
						Dermal	None	
				Recreational Users	Child	Ingestion	None	Recreational users are not expected to be exposed to groundwater.
						Dermal	None	
					Adult	Ingestion	None	
						Dermal	None	
				Residents	Child	Ingestion	Quant	Although a future residential scenario is considered unlikely at the site, this scenario is included to aid in future risk management decisions. (Residential land use will be prohibited by deed restriction.)
						Dermal	Quant	
					Adult	Ingestion	Quant	
						Dermal	Quant	
			Off-site	Residents	Child	Ingestion	TBD	Based on currently available information, off-site residents are not exposed to on-site groundwater. This conclusion is pending the results of the Remedial Investigation.
						Dermal	TBD	
					Adult	Ingestion	TBD	
						Dermal	TBD	
Future	Groundwater	Air	On-site	Construction Workers	Adult	Inhalation	Quant	Construction workers may be exposed to COPC that have volatilized from groundwater during excavation activities.
				Industrial Worker	Adult	Inhalation	Quant	Industrial workers are not expected to be exposed to COPC that have volatilized from groundwater.
							Quant	
				Recreational Users	Child	Inhalation	Quant	Recreational users are not expected to be exposed to COPC that have volatilized from groundwater.
							Quant	
					Adult	Inhalation	Quant	
							Quant	
				Residents	Child	Inhalation	Quant	Although a future residential scenario is considered unlikely at the site this scenario is included to aid in future risk management decisions. (Residential land use will be prohibited by deed restriction.)
					Adult	Inhalation	Quant	
			Off-site	Residents	Child	Inhalation	TBD	Based on currently available information, off-site residents are not exposed to on-site groundwater. This conclusion is pending the results of the Remedial Investigation.
					Adult	Inhalation	TBD	
			Off-site Vapor Intrusion	Residents	Child	Inhalation	TBD	Based on currently available information, off-site residents are not exposed to on-site groundwater. This conclusion is pending the results of the Remedial Investigation.
					Adult	Inhalation	TBD	

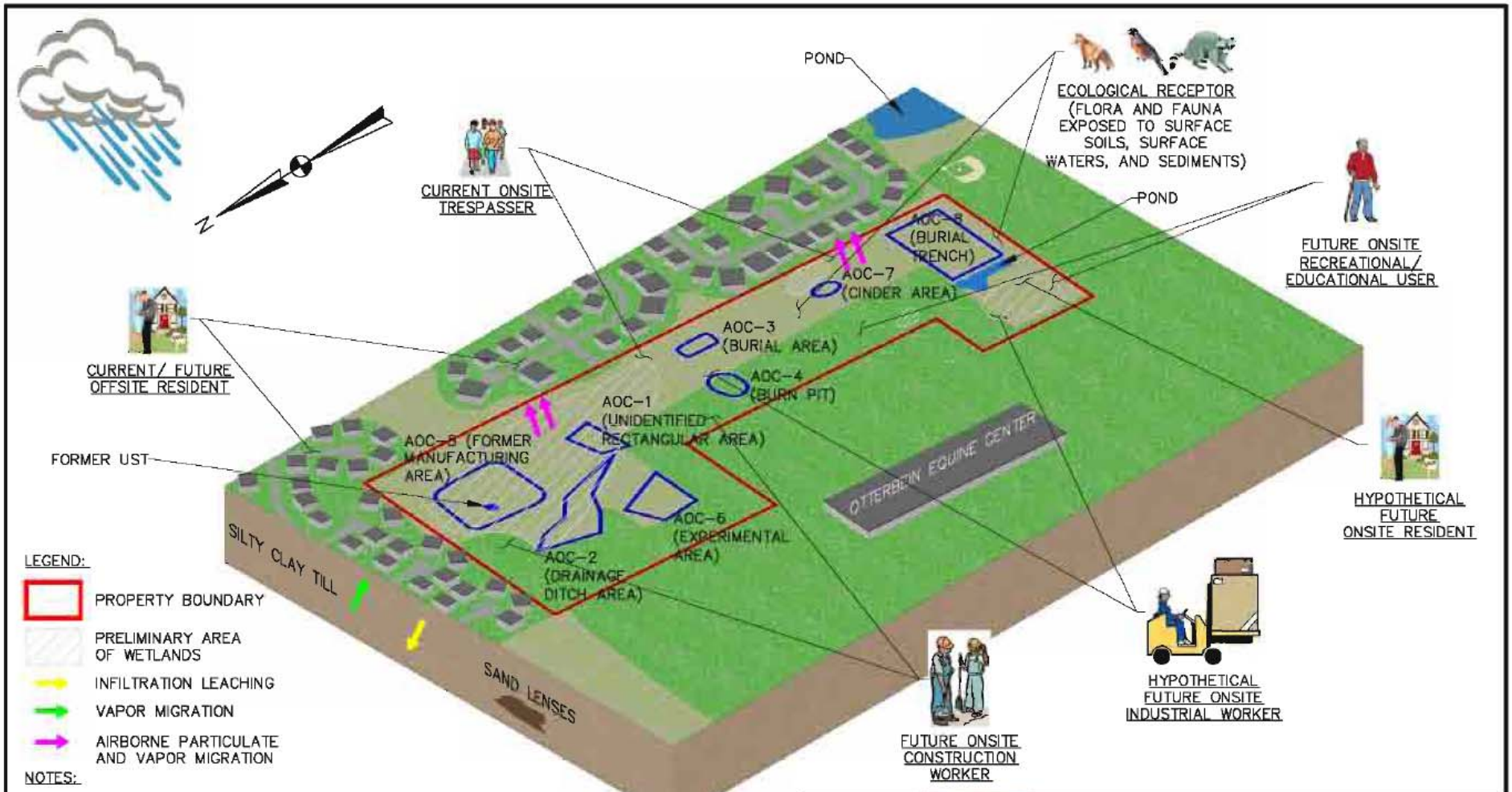
TABLE 3-1

POTENTIAL HUMAN EXPOSURE PATHWAYS
FORMER KILGORE MANUFACTURING COMPANY FACILITY
WESTERVILLE, OHIO

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
			On-site Vapor Intrusion	Industrial Worker	Adult	Inhalation	Quant	Industrial workers may be exposed to COPC that have volatilized from groundwater and migrated through building foundations into indoor air.
				Residents	Child	Inhalation	Quant	Although a future residential scenario is considered unlikely at the site, this scenario is included to aid in future risk management decisions. (Residential land use will be prohibited by deed restriction.)
					Adult	Inhalation	Quant	
	Surface Water	Surface Water	On-site	Construction Workers	Adult	Ingestion Dermal	Quant Quant	Construction workers may be exposed to surface water during excavation activities.
				Industrial Worker	Adult	Ingestion Dermal	Quant Quant	Industrial workers may have contact with surface water.
				Recreational Users	Child	Ingestion Dermal	Quant Quant	Recreational users may have contact with surface water
					Adult	Ingestion Dermal	Quant Quant	
				Residents	Child	Ingestion Dermal	Quant Quant	Although a future residential scenario is considered unlikely at the site, this scenario is included to aid in future risk management decisions. (Residential land use will be prohibited by deed restriction.)
					Adult	Ingestion Dermal	Quant Quant	
			Off-site	Residents	Child	Ingestion Dermal	TBD TBD	Off-site residents do not have contact with on-site surface water. If the wetlands investigation determines the on-site wetlands are connected to the off-site wetlands, then this pathway will be quantitatively evaluated for off-site residents.
					Adult	Ingestion Dermal	TBD TBD	
Future	Sediment	Sediment	On-site	Construction Workers	Adult	Ingestion Dermal	Quant Quant	Construction workers may be exposed to sediment during excavation activities.
				Industrial Worker	Adult	Ingestion Dermal	Quant Quant	Industrial workers may have contact with sediment.
				Recreational Users	Child	Ingestion Dermal	Quant Quant	Recreational users may have contact with sediment
					Adult	Ingestion Dermal	Quant Quant	
				Residents	Child	Ingestion Dermal	Quant Quant	Although a future residential scenario is considered unlikely at the site, this scenario is included to aid in future risk management decisions. (Residential land use will be prohibited by deed restriction.)
					Adult	Ingestion Dermal	Quant Quant	
			Off-site	Residents	Child	Ingestion Dermal	None None	Off-site residents do not have contact with on-site sediment. If the wetlands investigation determines the on-site wetlands are connected to the off-site wetlands, then this pathway will be quantitatively evaluated for off-site residents.
					Adult	Ingestion Dermal	None None	

Notes

Quant - Quantitative. Qual - Qualitative. COPC - Chemical of potential concern. TBD - To be determined.



NOTES:

1. IT IS ASSUMED THAT RECEPTORS ARE NOT AT RISK TO MEC.
2. EXPOSURE PATHWAYS ARE PRESENTED IN TABLE 1.
3. HYPOTHETICAL FUTURE INDUSTRIAL WORKERS AND RESIDENTS WILL BE EVALUATED IN THE RISK ASSESSMENTS FOR PURPOSES OF COMPLETENESS.
4. WETLAND AREAS ARE FROM HISTORICAL DOCUMENT. FINAL DELINEATION TO BE DETERMINED FALL, 2010

DRAWN BY ND	DATE 10-29-10	CONCEPTUAL SITE MODEL LOCATIONS OF AREAS OF CONCERN FORMER KILGORE MANUFACTURING SITE WESTERVILLE, OHIO	CONTRACT NO. 2927
CHECKED BY	DATE		OWNER NO.
REVISED BY	DATE		APPROVED BY / DATE
SCALE NOT TO SCALE		NAVFAC	DRAWING NO. FIGURE 3-1 / REV. 0

R:\2927 - Former Kilgore Manufacturing Site\CSM\2927CSM01.dwg PIT NICHOLE.DILLA 12/6/2010 9:32:40 AM

Approximate Wetland Determination Test Pit
Approximate Ditch Location
Approximate Swale Feature
Approximate Wetland Boundary
Approximate Site Boundary

200 0 200 400 Feet

SOURCE: PORTION OF THE ESRI ONLINE ARCGIS MAPPING WEBSITE SERVICE - "WORLD_IMAGERY" - AERIALS EXPRESS - COLUMBUS 2009.

CEC
Civil & Environmental Consultants, Inc.
Cincinnati, OH
(513) 985-0226 (800) 759-5614
Pittsburgh, PA Chicago, IL Cleveland, OH Columbus, OH Detroit, MI
Export, PA Indianapolis, IN Nashville, TN St. Louis, MO

Figure 3-2 Preliminary Wetlands Delineation

OTTERBEIN COLLEGE

Kilgore Tract - Westerville
Westerville, Delaware County, Ohio

DWN. BY: MJB	SCALE:	DATE:	PROJECT NO:	APPENDIX:
CHKD. BY: KD	1 " = 400 '	11/30/2010	101-641	A

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4.0 WORK PLAN RATIONALE

Results from earlier investigations have suggested the presence of a variety of constituents of concern (COC) at each of the eight AOCs. The earlier investigations compared the analytical results with the Ohio VAP standards, and these comparisons have been cited in both historical reports and the current PER, Technical Memorandum and this Work Plan. The VAP standards were used to determine the severity of impact at the various AOCs; however, the proposed RI/FS will evaluate both the historical and newly-acquired analytical results against RSLs.

In the case of each AOC a boring will be performed at the location of the historical soil sample with the highest concentration of a COC. The results of samples from this boring will serve to validate the earlier sample results. The validation boring and additional borings will be performed to gather additional data (including expanded analytical testing) for the site characterization.

4.1 AOC 1 – UNIDENTIFIED RECTANGULAR FEATURE

Problem Statement

Previous investigations indicate that surface and subsurface soil are contaminated with metals at unacceptable concentrations. It is unknown if other COCs such as explosives are present. It is also unknown if the previously detected chromium contamination is in the more toxic hexavalent form. The amount of MEC present, if any, is also unknown. COCs present in shallow soils could infiltrate vertically deeper into the subsurface soil, and potentially leach from the soil into shallow groundwater.

4.2 AOC 2 DRAINAGE DITCH NEAR FORMER MANUFACTURING AREA

Problem Statement

Surface and subsurface soil were determined to contain metals at unacceptable concentrations. It is unknown if other contaminants such as explosives are also present. Contaminants could infiltrate vertically deeper into the subsurface soil and leach from the soil into the shallow groundwater. MEC is known to be present at the Site and would be dangerous if contacted. Previous investigations may not have identified and removed all MEC, and the total amount of MEC potentially present is unknown.

4.3 AOC 3 BURIAL AREA

Problem Statement

Surface and subsurface soil were determined to contain metals at unacceptable concentrations. Because this area was used for the disposal of materials burned in the former Burn Pit (AOC 4) there exists the potential for combustion-related COCs such as dioxins and furans, which have not been previously investigated. It is unknown if other contaminants such as explosives are present at AOC 3. Also, COCs could leach from soils/munitions items and further potentially impact soil and groundwater.

MEC is a known risk at the surface and subsurface but previous investigations may not have identified and removed all items and the total amount remaining is unknown. It will be difficult to remove the MEC risk without completely excavating the soils in this AOC.

4.4 AOC 4 BURN PIT

Problem Statement

Materials at the former burn pit were removed routinely from the area and disposed of in a separate area (AOC 7). In addition, all of the soil was removed and replaced with fill more than 45 years ago. During previous investigations, only arsenic was detected at concentrations exceeding a VAP standard. Further evaluation of the reported arsenic concentration indicates that the concentration is less than the background concentration established for the Site (Brown & Caldwell, 2007). Groundwater concentrations in the area were determined to be within acceptable limits, with the exception of a nominal VAP exceedance of arsenic. MEC is not expected at the Site based on Site use history and the previous remediation efforts.

Surface and subsurface soil at AOC 4 are not perceived to be contaminated based on the Site historical source removal effort and a review of available data from Site investigations. Therefore, there does not appear to be an environmental contamination problem at this AOC. However, if additional soil sampling will be conducted to confirm this finding. In addition, if the proposed sampling of AOC 3 indicates the presence of dioxins and furans in materials that were routinely excavated from the burn pit, the burn pit will then be investigated for dioxins and furans.

4.5 AOC 5 MANUFACTURING AREA FORMER UST LOCATION

Problem Statement

The former fuel oil UST and surrounding contaminated soil were removed and a closure report was submitted to OEPA more than 12 years ago and only arsenic in soil was cited as exceeding the VAP standard in soil borings at AOC 5. Further evaluation of the arsenic concentration indicates that the concentration is less than the background concentration established after the investigation (Brown & Caldwell, 2007). Because the UST and surrounding contaminated soils have been removed, only residual impacted groundwater should remain. While several fuel oil constituents were detected, such as benzene and toluene, concentrations were well below unrestricted land use standards.

MEC is not expected to be present at the Site based on Site history, previous investigations and remediation efforts. Surface and subsurface soil are not considered to be contaminated based on Site historical source removal efforts and a review of available data from Site investigations. Residual groundwater contamination appears to be at acceptable levels. Therefore, there does not appear to be an environmental contamination problem at the former UST location within this AOC.

4.6 AOC 6 FORMER EXPERIMENTAL AREA

Problem Statement

Surface and subsurface soil have been found to contain COCs at concentrations exceeding VAP residential standards (PAHs and lead). These contaminants could also infiltrate further vertically into the subsurface soil and potentially leach from the soil into the shallow groundwater. It is unknown if other contaminants such as explosives are present. MEC is a known risk at the surface and subsurface. Previous investigations may not have identified and removed all MEC items and the total amount of MEC potentially remaining at this AOC is unknown. A UXO assessment has not been conducted to date. It will be difficult to remove potential MEC at this AOC without completely excavating the Site soils.

4.7 AOC 7 CINDER AREA

Problem Statement

Solid wastes were disposed at AOC 7 although the sample analyses completed to date do not indicate exceedances of VAP criteria. It is unknown if explosive residuals are present. The orange and red fragments may be of concern because they remain unidentified. The amount of MEC, if any, is unknown, and a UXO assessment has not been conducted to date. Although MEC has not been encountered to date, the uncertain history of the AOC and the proximity to MEC findings reported for nearby AOC 2 make

the presence of MEC suspect. Also, munitions constituents (MC) and other chemical constituents could leach from munitions items and further contaminate the soil.

4.8 AOC 8 FORMER BURIAL TRENCH AREA

Problem Statement

Although soil and groundwater VAP standards were not exceeded in samples collected from AOC 8, it is reasonable to assume that at least some portion of the soils at this AOC are impacted with wastes from the Kilgore manufacturing process. Moreover, there may be unknown COCs not previously investigated present in the area. For example, groundwater and soil samples were not previously collected and analyzed for explosives constituents. The outer perimeter of the AOC is not clearly defined, an important data gap considering the large size of the AOC, which could greatly impact the evaluation of remedial alternatives.

The impacted materials at AOC 8 may extend to a depth of approximately 10 feet bgs. Any COCs present in the surface/shallow subsurface zones could infiltrate further vertically into the subsurface soil and leach from the soil into the shallow groundwater. Although groundwater samples collected to date have been previously evaluated as acceptable, this observation is questionable considering the limited analyses conducted to date and unknown well construction methodology. Moreover, the age of the data is important. The area has been disturbed and conditions may have changed over time. These factors may impact the potential for contaminant migration to and with the groundwater underlying AOC 8. Moreover, AOC 8 is of extra concern since it is at the property boundary and contamination, if present in the groundwater could migrate off- site.

MEC is a known risk at the surface and subsurface. The previous investigations have not likely identified and removed all MEC. The total amount of potentially remaining MEC is unknown.

5.0 REMEDIAL INVESTIGATION/FEASIBILITY STUDY TASKS

The following tasks have or will be completed by TtNUS as part of the RI/FS study in compliance with the OEPA guidelines:

5.1 CLIENT / REGULATORY MEETINGS

The initial task related to the RI/FS was a meeting between representatives of Otterbein and TtNUS to discuss the pending Consent Agreement with the State of Ohio and the expected requirements of the RI/FS specified in the Agreement. TtNUS subsequently developed a preliminary scope of work designed to meet the requirements of the Agreement and the anticipated future use of the site by Otterbein.

A meeting was held at the site on July 12, 2010, with representatives of OEPA, Otterbein, and TtNUS in attendance. Following a short presentation of anticipated RI/FS tasks by Tetra Tech, the OEPA Site Coordinator, Robin Roth outlined the expectations of OEPA and informed Otterbein of various permit issues related to planned site investigations. At the completion of the meeting, the group toured the site.

TtNUS conducted a file review of the OEPA files related to the site later in the same day (July 12, 2010).

Two conference calls were held between OEPA, Otterbein and TtNUS following the OEPA review of the PER. The purpose of the calls was to gain concurrence on the scope of the RI/FS.

5.2 PRE-INVESTIGATION EVALUATION REPORT AND TECHNICAL MEMORANDUM

The first deliverable of the RI/FS process was the PER, which was submitted by Otterbein to OEPA on August 10, 2010. The PER is a document designed to present the environmental data known about the site and the results of the preliminary scoping tasks, thus establishing the framework for subsequent development of the RI/FS Work Plan. OEPA responded to Otterbein with comments related to the PER by September 28 and the PER comments led to the two conference calls between representatives of Otterbein and OEPA about the findings of the PER and the structure of the RI/FS. It was decided that Otterbein should prepare an interim document which would clarify the Otterbein proposed RI/FS approach. The PER and the OEPA comments are included in Attachment A.

TtNUS prepared a Technical Memorandum Strategy for Environmental Investigations at the Kilgore Manufacturing Company Facility (Technical Memorandum, November 2, 2010). The Technical Memorandum presented the strategy for the investigations to be conducted at each AOC and was

intended to facilitate discussions between Otterbein and OEPA regarding the scope of the investigation. The Technical Memorandum included:

- An updated CSM
- A sampling and data use approach, and
- A generalized table of contents for the RI/FS Work Plan

OEPA responded to the Technical Memorandum on November 10, 2010 with both general and specific comments. Those comments were taken into consideration by Otterbein in the preparation of this Work Plan.

5.3 RI/FS WORK PLAN

This RI/FS Work Plan follows the guidance provided by OEPA (and specifically outlined in the USEPA Guidance for performing a RI/FS). According to the guidance the Work Plan consists of four documents:

- Work Plan
- PER and OEPA cComments (Attachment A)
- Field Sampling Plan (Attachment B)
- Quality Assurance Project Plan (Attachment C)
- Health and Safety Plan (Attachment D)

This Work Plan includes by reference the previously submitted documents: the PER [Tetra Tech, August 10, 2010 (Attachment A)] and the Technical Memorandum (Tetra Tech, November 2, 2010).

5.4 SITE CHARACTERIZATION AND DATA MANAGEMENT

5.4.1 Site Characterization

Otterbein has evaluated pre-2010 site characterization data gathered from numerous earlier site investigation and the results of this evaluation are presented in the PER (Attachment A). The PER identified a number of data gaps and the proposed RI is designed to fill those gaps and provide data sufficient to fulfill the needs of the RI/FS. The data gathered by the proposed site investigation will be combined with the existing data to update the Conceptual Site Model and to provide data of sufficient quality and quantity to support the RI/FS.

The proposed additional site characterization will consist of: a wetlands characterization; a soil investigation; a UXO avoidance investigation; a test pit investigation; and a groundwater investigation.

The various site characterization investigations are briefly described below, and are described in detail in the FSP (Attachment B).

5.4.1.1 Wetlands Characterization

The wetlands characterization will consist of four tasks and multiple subtasks:

- Water Resources Investigation
  - Wetland delineation and survey
  - Wetland functional assessment
  - Watercourse investigation and survey
  - Watercourse functional assessment
  - Impact Analysis and Delineation Report
  - Delineation field review
  - Mitigation planning

- Cultural Resources Investigation
  - Literature review
  - On-site review
  - Test pit sampling

- Threatened and Endangered Species Investigation
  - Coordination with U.S. Fish and Wildlife Service and ODNR
  - Field investigations (if indicated by existing data)

- Permit Applications
  - Pre-application meeting with US Army Corps of Engineers and OEPA
  - Application for appropriate permits

The Wetlands Characterization is being conducted by CEC of Columbus, OH. CEC has subcontracted Mr. Ryan Weller of Weller & Associates, a Registered Professional Archaeologist, to complete the Cultural Resources Investigation.

The Wetlands Characterization is being performed in accordance with methodology described in the 1987 Corps of Engineers Wetlands Delineation Manual and the U.S. Fish and Wildlife Service's National List of Plant Species that Occur in Wetlands: Northeast (Region 1).CEC will also use the Ohio Rapid Assessment Method for Wetlands v. 5.0 (ORAM) to evaluate the wetlands. The watercourse Functional Assessment will be conducted in accordance with the guidance provided in Rapid Bioassessment

Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish (EPA 841-B-99-002).

As this RI/FS Work Plan is being submitted to OEPA, CEC has completed the wetland delineation field task, and the other tasks are scheduled to occur as quickly as possible (to avoid delaying any field work associated with the Remedial Investigation).

5.4.1.2 UXO Avoidance Investigation

Although the possibility of encountering MEC is remote a UXO trained technician will be onsite for all intrusive investigations. The technician will support the investigations by performing UXO anomaly avoidance procedures, designed to avoid contact with potential MEC at the Site. The technician will use a Schonstedt GA-52Cx magnetic locator or a White's spectrum XLT all metals detector to screen each boring location. The magnetometer will be used to clear the surface area in the vicinity of the boring/well, and then a down hole magnetometer will be used to screen each 2 foot depth of the boring as drilling progresses, until the desired boring depth is attained.

If the detector indicates the potential presence of subsurface UXO, the boring will be moved to a nearby area, and the location of the anomaly recorded for future evaluation. (The detection of subsurface anomalies alone is not considered evidence of MEC. If the technician uncovers actual UXO, the project will be stopped, the University will be notified, and additional UXO technicians will be mobilized to dispose of the UXO.

5.4.1.3 Soil/Sediment Investigation

Soil samples will be collected at all eight identified AOCs for site wide characterization to assist in determining remediation. After sampling, each borehole will be backfilled to within 6 inches of grade using the soil cuttings removed from the borehole. A minimum 6-inch thick grout/bentonite seal will then be placed to grade at each boring. The surface will be returned to its original condition.

A drilling subcontractor will utilize direct push technology (DPT) methods to advance the proposed soil borings to their required depths. Soil sampling will proceed continuously from the land surface to the total depth of each boring. The subcontractor will provide appropriately sized disposable acetate liners capable of containerizing each 4 (or 5) foot interval.

A soil boring log will be prepared for each boring with soil descriptions and all relevant information, observations, depth to saturated soil/water table, and photoionization detector (PID) field screening results. Soil samples will be collected from two intervals per location and analyzed for Target Analyte List

(TAL) Metals, strontium, explosives, and at some locations PAHs. Soil samples will be collected in laboratory provided jars and placed immediately in an iced cooler for shipment to a fixed base laboratory. Soil sample depths will be included on each log.

Further detail of soil and sediment sample methods are described in Section 5.2 and 5.3 of the FSP (Attachment B).

5.4.1.4 Test Pit Investigation

Two long pits will be installed in AOC 8 – the Former Burial Trench Area to determine the “lateral extent” of contamination. Test pits will be approximately 6 feet deep and extend on the north and west sides for up to 800 feet. Up to eight soil samples will be collected based on visual observations.

Further detail of soil and sediment sample methods are described in Section 5.2 and 5.3 of the FSP (Attachment B).

5.4.1.5 Groundwater Investigation

Eleven new permanent monitoring wells will be installed on site. Seven wells will be installed within the boundaries of established AOCs and four will be installed along the property boundary.

Prior to groundwater sampling, existing monitoring wells will be inspected for physical integrity. If wells are damaged or unsuitable this information will be reported in the Remedial Investigation Report.

Newly installed monitoring wells will be developed no sooner than 48 hours after well installation. Existing wells have not been sampled or developed in several years; therefore, they will be redeveloped prior to sampling.

Groundwater sampling will be collected in laboratory provided bottles from six existing monitoring wells and the 11 newly installed permanent wells. All groundwater samples will be collected for TAL metals, strontium, perchlorate, and explosives. Additionally, the three southern boundary wells down gradient of AOC 8 will be sampled for VOCs and PAHs. All samples will be sent to an OEPA approved laboratory.

Further detail of soil and sediment sample methods are described in Section 5.2 and 5.3 of the FSP (Attachment B).

5.4.1.6 Surface Water Investigation

There is one existing pond onsite; however depending on the time of year, water may accumulate in low lying areas in and around the wetlands. The surface water sample in the existing pond will be sampled and if other ponds are present during the time of the field event, samples may also be collected there. One surface water sample will also be collected form an off-site pond. Surface water samples collected from these locations will be sampled for TAL metals, strontium, explosives, and PAHs

Further detail of soil and sediment sample methods are described in Section 5.2 and 5.3 of the FSP (Attachment B).

5.4.2 Data Management

Newly-collected data will be compiled, along with existing data, in spreadsheets and maps in order to evaluate the potential environmental impairment of the site. Products of the data management will include:

- Groundwater potentiometric maps
- Contaminant distribution maps
- Wetlands delineation maps
- Updated AOC location maps
- Analytical results tables
  - Contaminant exceedance tables and tag map
  - Contaminant hits table
  - Occurrence and distribution of contaminants in soil and groundwater
  - Positive detections table for soil and groundwater

All new and previously existing data will be compared to RSLs to facilitate decisions about the site.

5.5 HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS

A Human Health Risk Assessment (HHRA) will be conducted to evaluate current and potential future threats to human health in the absence of any remedial action. The assessment will be done in a manner consistent with the US EPA Risk Assessment Guidance for Superfund (RAGs), EPA/540/1-82/002 (RAGS, Part A, 1989) and other relevant federal and Ohio guidance as appropriate. The HHRA is described in detail in Section 6.0 of this Work Plan. An Ecological Risk Assessment (ERA) will be prepared to evaluate current or potential future adverse effects (in the absence of any remedial action) to the flora and fauna at the Site. The ERA is more fully described in Section 7.0 of this Work Plan

5.6 REMEDIAL INVESTIGATION REPORT

Following completion of confirmatory sampling activities and sample analysis data validation, TtNUS will submit a Remedial Investigation Report. The report will include:

- A description of sampling methodology, tabular summary of soil and groundwater analytical data, tag maps, laboratory analytical data, monitoring well location data, boring logs, sample log sheets, test pit drawings, and potentiometric surface maps.

- A description of field activities, any deviations from the work plan, summary of geology and hydrogeology of the site, discussion of current site conditions and site history, current site use and historical use, and analytical data identifying areas of contamination.

- Recommendations for future work at the site.

The Remedial Investigation Report will be written in accordance with the Draft RI Format, as outlined in Appendix J of the OEPA Generic Scope of Work for Conducting Remedial Investigations and Feasibility Studies (OEPA, 2006).

5.7 REMEDIAL ALTERNATIVE DEVELOPMENT

Otterbein will further develop the preliminary Remedial Action Objectives (RAOs) identified in the PER and prepare an alternatives Array Document. These tasks are described in the more detail in Section 8.0 Feasibility Study.

5.8 FEASIBILITY STUDY REPORT

A Feasibility Study Report will be prepared to present a detailed analysis of the remedial alternatives. This task is described in more detail in the Section 8.0 Feasibility Study.

5.9 MONTHLY PROJECT REPORTS

Otterbein has been preparing monthly progress reports in accordance with provisions of the proposed Consent Agreement since July 2012 and these will continue until the end of the project. The items included in the monthly reports include:

- Status of the Work
- Difficulties Encountered
- Activities Planned for the Upcoming Month
- Key Personnel Changes
- Target Completion Dates for Activities
- Deviation From the Schedule
- Analytical Data Received
- Soil/Waste/Water Treated or Removed

6.0 HUMAN HEALTH RISK ASSESSMENT

This section presents the methodology that will be used to prepare an HHRA of chemicals detected in soil, groundwater, surface water, and sediment at the former Kilgore Manufacturing Site, Westerville, Ohio. The HHRA will evaluate whether detected concentrations of chemicals in the study area media pose a significant threat to potential human receptors under current and/or future land uses. Potential risks to human receptors will be estimated based on the assumption that no actions will be taken to control contaminant releases. Primary sources of guidance will include the OEPA Generic Statement of Work for Conducting Remedial Investigations and Feasibility Studies (OEPA, September 1, 2006). Current guidance and reports published by the USEPA were also considered in preparing this protocol and will be considered during the preparation of the HHRA:

- Soil Screening Guidance: Technical Background Document. Office of Solid Waste and Emergency Response (OSWER), Washington, D.C. EPA/540/R 95/128 (USEPA, 1996a).

- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. Office of Solid Waste and Emergency Response Washington, D.C., OSWER 9355.4 24 (USEPA, 2002a).

- Exposure Factors Handbook. Office of Health and Environmental Assessment, Washington, D.C. EPA/600/P 95/002Fa (USEPA, 1997a).

- Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure-Factors. OSWER Directive 9285.6 03, OSWER, Washington, D.C. (USEPA, 1991).

- Distribution of Preliminary Review Draft: Superfund's Standard Default Exposure-Factors for Central Tendency and Reasonable Maximum Exposure. OSWER, Washington, D.C. (USEPA, 1993a).

- Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. Office of Emergency and Remedial Response, Washington, D.C. OSWER 9285.6 10 (USEPA, 2002b).

- RAGS, Volume I: Human Health Evaluation Manual (Part A) (USEPA, 1989).

- RAGs, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final. Office of Superfund Remediation and Technology Innovation, Washington, D.C. 20460 EPA/540/R/99/005, OSWER 9285.7 02EP; PB99 963312 (USEPA, 2004a).

- Guidelines for Carcinogen Risk Assessment. EPA/630/P 03/001B. March 2005 (USEPA 2005a).

- Supplemental Guidance for Assessing Susceptibility from Early Life Exposure to Carcinogens. EPA/630/R 03/003F (USEPA, 2005b).

- RAGS, Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment), Final. Office of Superfund Remediation and Technology Innovation, Washington, D.C. 20460 EPA 540 R 070 002, OSWER 9285.7 82 (USEPA, 2009a).

The HHRA for the former Kilgore Manufacturing Site will be structured and reported according to the guidelines of the RAGS, Human Health Evaluation Manual, Part D: Standardized Planning, Reporting, and Review of Superfund Risk Assessments (RAGS Part D) (USEPA, 2001). The HHRA will consist of six components (see sections 1 through 6 for a more complete discussion):

- Data evaluation
- Toxicity assessment
- Uncertainty analysis
- Exposure assessment
- Risk characterization
- Development of remedial goal options

6.1 DATA EVALUATION METHODOLOGY

Data evaluation, the first component of a baseline HHRA, is a medium specific task that begins with compilation of relevant analytical data and concludes with selection of chemicals of potential concern (COPC) to be evaluated in the assessment. First, the data available for the relevant study area(s) are reviewed in terms of data quality; typically only validated data is used in a HHRA. However, historical data that has been subjected to a quality assurance review (if not fully validated) will be included in the HHRA, and the uncertainty associated with the use of historical data (e.g., due to differences in validation procedures) will be noted. Environmental samples selected for HHRA are summarized in tables. Second, a medium specific list of COPCs (used to quantitatively and/or qualitatively determine potential human health risks) are selected based on a toxicity screen (i.e., a comparison of site contaminant concentrations to conservative toxicity-screening values).

6.1.1 Data to be Evaluated HHRA

Validated data collected during the following primary environmental investigations will be used to assess risks to potential human receptors:

- October/November 1996 Soil and Groundwater Samples
- July 1997 Soil Samples
- February/March 2000 Soil Samples
- December 2000 Soil and Groundwater Samples
- January 2001 Soil Samples
- April 2004 Soil and Groundwater Samples
- June 2005 Groundwater Samples
- Proposed Soil, Groundwater, Surface Water, and Sediment Samples recommended in this Work Plan

Fixed base analytical results (i.e., results from a fixed base laboratory and not from field analytical results) from field investigations for lists of target analytes will be used in the quantitative risk evaluation. F ield measurements and data regarded as rejected (i.e., that were qualified as “R” during data validation) will not be used in the quantitative risk assessment. If a chemical was not detected in an environmental medium, but its reported detection limits [sample quantitation limits (SQLs)] for the environmental samples exceeds the COPC toxicity screening-levels, that chemical will be qualitatively discussed in the uncertainty analysis section.

6.2 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Selecting COPCs is a qualitative screening process to limit the number of chemicals quantitatively evaluated in the baseline HHRA to those site related constituents that dominate overall potential risks. Screening by risk based concentrations focuses the risk assessment on meaningful chemicals and exposure routes. In general, a chemical will be selected as a COPC and retained for further quantitative risk evaluation if the maximum detection in an environmental data set exceeds the lowest risk based screening concentration. Chemicals eliminated from further evaluation are assumed to present minimal risks to potential human receptors.

6.2.1 Derivation of Screening Criteria

The primary COPC screening criteria for all media within the study area will be derived from USEPA RSLs developed by the U.S. Department of Energy’s Oak Ridge National Laboratory (ORNL) (USEPA, 2010a). These risk based concentrations are based on exposure pathways for which generally accepted methods, models, and assumptions have been developed (i.e., ingestion, dermal contact, inhalation) and for specific land use conditions (residential, industrial). They do not consider effects on groundwater or ecological receptors. The COPC screening levels used to evaluate soil data are defined in the following narrative.

Soil/Sediment Screening Levels for all Parameters Except Lead — Screening levels to select COPC for direct human contact exposures to surface and subsurface soil will be based on the following criteria:

- RSLs for Residential Soil (USEPA, 2010a).
- Generic Soil Screening Levels for Transfers from Soil to Air ($SSLs_{air}$) (published on the USEPA Website: http://rais.ornl.gov/epa/ssl1.shtml).
- Federal Soil Screening Levels (SSLs) for Groundwater Protection (USEPA, 2010a).

COPC screening levels based on the USEPA RSLs correspond to a systemic hazard quotient (HQ) of 0.1 for noncarcinogens or an incremental lifetime cancer risk of 1×10^{-6} for carcinogens. In contrast, USEPA RSLs for noncarcinogens are based on an HQ of 1. The COPC screening levels derived for soil are based on an HQ of 0.1 to account for the potential cumulative effects of several chemicals affecting the same target organ or producing the same adverse noncarcinogenic effect. USEPA RSLs for residential soil will conservatively be used for soil COPC selection. Because risk-based sediment screening levels are not available and because sediment may be periodically exposed rather than continually submerged (i.e., in some cases the study area sediment samples are more soil-like than sediment-like), USEPA RSLs for residential soil will also conservatively be used for sediment COPC selection.

The SSL_{air} values for chemical migration from soil to outside air (published online at http://rais.ornl.gov/epa/ssl1.shtml) will be used to select COPC for surface and subsurface soil. These values are more recent than those in the 1996 and 2002 soil screening level SSL guidance documents (USEPA, 1996a and USEPA, 2002a). The SSLsair are based on an HQ of 1; however, the COPC screening values will be adjusted to be based on an HQ of 0.1. The SSLair values do not apply to sediment because sediment is typically submerged and not subject to volatilization or particulate emissions.

Maximum chemical concentrations in soil will be compared to federal SSLs for groundwater protection, which were designed to protect groundwater at most sites (as published in the USEPA RSL table). These groundwater protection SSLs allow an initial qualitative evaluation of the potential for chemical migration from soil to groundwater. Chemicals with concentrations exceeding the SSL criteria may potentially migrate from soil to groundwater in sufficient quantities to pose groundwater quality problems. Chemicals detected at concentrations exceeding the federal SSL for groundwater protection, but at concentrations less than COPC screening levels for direct contact risk will not be evaluated quantitatively in the HHRA. However, these chemicals will be further evaluated qualitatively using the approach presented in Section 4.3.

Groundwater/Surface Water Screening Levels for all Parameters Except Lead — Screening levels to select COPC for direct human contact exposures to groundwater will be based on the following criteria:

- RSLs for Tap Water (USEPA, 2010a).
- Federal Safe Drinking Water Act (SDWA) MCLs (USEPA, 2009d).
- Generic Screening Levels for Groundwater for Evaluating Vapor Intrusion to Indoor Air (GSL_{vapor}) (USEPA, 2002a).

COPC screening levels based on the USEPA RSLs correspond to a systemic HQ of 0.1 for noncarcinogens or an incremental lifetime cancer risk of 1×10^{-6} for carcinogens. In contrast, USEPA RSLs for noncarcinogens are based on an HQ of 1. The COPC screening levels derived for tap water are based on an HQ of 0.1 to account for the potential cumulative effects of several chemicals affecting the same target organ or producing the same adverse noncarcinogenic effect. Criteria based on USEPA RSLs for tap water will conservatively be used for COPC selection for groundwater. For surface water, the screening levels used for groundwater will be adjusted upward by a factor of 10 (i.e., multiplied by 10) to account for anticipated reduced exposure to surface water (i.e., the surface water within the study area is not a potential domestic water supply source).

Federal SDWA MCLs for public drinking water supplies are enforceable standards designed to protect human health, promulgated under the federal SDWA. Primary MCLs are based on laboratory or epidemiological studies and apply to public water systems. A public water system is defined as a system providing water to the public for human consumption that either has at least 15 service connections or regularly serves an average of 25 individuals daily for at least 60 days per year. Primary MCLs are designed to prevent adverse human health effects but also reflect the technical feasibility of removing a contaminant from water. Primary (i.e., health based) and secondary (i.e., aesthetic based) MCLs are promulgated under the SDWA. Secondary MCLs are provided for reference purposes only and are not used in COPC selection. The SDWA MCLs are not relevant to the selection of COPC for surface water because surface water bodies are not potential drinking water sources.

The GSL_{vapor} are published in Table 2C of the USEPA's Evaluating Vapor Intrusion into Indoor Air [EPA530 F 02 052 (USEPA 2002a)], and in updates to that table. The values correspond to a target cancer risk level of 1×10^{-6} or a hazard index of 1 for carcinogens and noncarcinogens, respectively. The GSL_{vapor} were derived to identify chemical concentrations in groundwater that may adversely affect the indoor air quality of a building overlying subsurface VOC contamination. The GSL_{vapor} assume a subsurface attenuation factor of 0.001 for groundwater to indoor air concentrations. Consistent with USEPA guidance, the COPC screening levels are based on an HQ of 1. GSL_{vapor} are not relevant to the

selection of COPC for the surface water because buildings would not be constructed atop surface water bodies.

Screening Levels for Lead — Guidance from the USEPA Office of Prevention, Pesticides, and Toxic Substances and the OSWER recommends 400 milligram per kilogram (mg/kg) as the lowest screening level for lead contaminated soil in a residential setting where children are frequently present (USEPA, 1994). To be conservative, 400 mg/kg will be used as the screening level for COPC selection for soil and sediment. However, guidance from the USEPA Technical Review Workgroup for Lead indicates that "a reasonable screening level for soil lead at commercial/industrial (i.e., non residential) sites is 750 mg/kg" for a typical non contact intensive worker (1999); 800 mg/kg is the current USEPA RSL for soil, assuming an industrial land use scenario. The SDWA action level of 15 micrograms per liter (µg/L) will be used as the screening level for lead in groundwater and surface water.

6.2.2 Decision Rules for Establishing COPC

The following decision rules will be used to select COPC:

- A chemical detected in study area media will be selected as a COPC for the HHRA if the maximum detected chemical concentration exceeds its respective screening level.

- Essential nutrients will not be selected as COPCs. USEPA guidance (USEPA, 1989) states that "Chemicals that are (1) essential human nutrients, (2) present at low concentrations (i.e., only slightly elevated above natural occurring levels), and (3) toxic at very high doses (i.e., much higher than those that could be associated with contact at the site) need not be considered further in the quantitative risk assessment." Examples of such chemicals are magnesium, calcium, potassium, and sodium. Historical information available for the study area indicates that no unusual use or disposal of these constituents occurred there. The recommended daily allowance (RDA) and recommended daily intake (RDI) values indicate that soil concentrations greater than 1,000,000 mg/kg (i.e., pure mineral intake) would be required before receptor intake would exceed RDA and RDI values. A review of current analytical data for the study area indicates that such concentrations have not been detected in study area media.

- Surrogate COPC screening levels will be used for some chemicals. For example, risk based COPC screening levels are not currently available for some chemicals [e.g., acenaphthylene, benzo(g,h,i)perylene, phenanthrene] detected in the study area media due to lack of toxicity criteria. In the COPC screening, acenaphthene will be used as a surrogate for acenaphthylene; pyrene will be used as a surrogate for benzo(g,h,i)perylene and phenanthrene.

Chemicals without COPC screening levels or appropriate surrogate-chemical COPC screening levels will be evaluated qualitatively in the COPC selection section and/or in the uncertainty section of the HHRA. The evaluation will consider the number of times the chemical was detected and the magnitudes of the observed concentrations.

6.3 EXPOSURE ASSESSMENT METHODOLOGY

The exposure assessment component of an HHRA defines and evaluates, either quantitatively or qualitatively, the type and magnitude of human exposure to the chemicals present at or migrating from a site. It is designed to depict the physical setting of the site, to identify potentially exposed populations and applicable exposure pathways, to calculate concentrations of COPC to which receptors might be exposed, and to estimate chemical intakes under the identified exposure scenarios. Actual or potential exposures at a site are dependent upon the most likely pathways of contaminant release and transport as well as on patterns of human activity. A complete exposure pathway has four components: a source of chemicals that can be released to the environment, a route of contaminant transport through an environmental medium, an exposure or contact point for a human receptor, and an exposure route.

6.3.1 Conceptual Site Model

The HHRA will include an update to the CSM provided in this Work Plan. The updated CSM will identify the exposure pathways by which human receptors may come in contact with environmental media within the study areas (or contaminated off-site environmental media). The CSM will depict the relationships among the following elements of a complete exposure pathway (i.e., a pathway that potentially results in human exposure and is evaluated [qualitatively or quantitatively] in an HHRA):

- Site sources of contamination
- Contaminant release mechanisms and transport/migration pathways
- Exposure routes
- Potential receptors

These CSM elements establish the manner and degree to which a potential receptor may be exposed to chemicals present at a site. The degree of risk incurred by a potential receptor varies according to the means of exposure, the duration of exposure, and the specific chemical to which the receptor is exposed. An exposure does not necessarily result in an “unacceptable” health or environmental risk, although risks generally increase with increased frequency and/or duration of exposure.

The CSM will identify the sources of possible contamination and discuss contaminant release mechanisms and transport and migration pathways relevant to the study area soil. The CSM is the basis of the exposure pathways evaluated in the HHRA. The CSM analysis will be comprehensive and will

consider both current and plausible future land use. Consequently, while the current/anticipated future land use at the former Kilgore Manufacturing Site is recreational/educational, the HHRA will also present risks assuming a residential land use. These risk estimates are included in the assessment to support risk management decisions. Risks to the following potential receptors will be evaluated:

- Construction workers — Construction workers are plausible on site adult receptors under future land uses. Construction workers could be exposed to chemicals in surface and subsurface soil (0–2 feet bgs and 2–10 feet bgs or to the zone of saturation, respectively) through incidental ingestion and dermal contact and through inhalation of airborne contaminants emanating from soil. It is assumed that direct contact with the deeper [saturated zone] soil is limited and, thus, direct contact with soil greater than approximately 10 feet bgs (or greater the saturated zone if determined to be within 10 feet bgs) will not be evaluated quantitatively. Such soil (i.e., the saturated zone soil) will be evaluated qualitatively in the uncertainty analysis. Construction workers could also be exposed to chemicals in groundwater through dermal contact and through inhalation of airborne contaminants; however, construction workers are not expected to ingest groundwater. Additionally, construction workers could be exposed to chemicals in surface water and sediment through ingestion and dermal contact.

- Industrial workers — Industrial workers are plausible on site adult receptors under future land uses. These receptors could be directly exposed to chemicals in surface soil (0–2 feet bgs) through incidental ingestion, dermal contact, and inhalation of airborne particulates and vapors emitted from the soil. Industrial worker exposure to subsurface soil (2–10 feet bgs) is unlikely. However, because future construction could potentially bring subsurface soil to the surface, exposure to subsurface soil via incidental ingestion, dermal contact, and inhalation will be evaluated for this receptor to aid in risk management decisions. This receptor is expected to be exposed to soil equally as often (but less intensely) than the construction worker. Industrial workers could also be exposed to chemicals in groundwater that have volatilized into indoor air; however, industrial workers are not expected to have direct contact with groundwater. Additionally, industrial workers could be exposed to chemicals in surface water and sediment through ingestion and dermal contact.

- Adolescent trespassers — Adolescent trespassers are plausible on-site receptors under current land use. These receptors may be exposed to potentially contaminated surface soil (0–2 feet bgs) through incidental ingestion, dermal contact, and inhalation of chemicals emitted from soil to the air. Adolescent trespassers do not have contact with subsurface soil while at the site. Additionally, adolescent trespassers may be exposed to chemicals in surface water and sediment through ingestion and dermal contact.

- Child, adolescent, and adult recreational users — Recreational users are potential receptors for study area contaminants under future land use. A recreational user may be exposed to potentially contaminated surface soil (0–2 feet bgs) through incidental ingestion, dermal contact, and inhalation of chemicals emitted from soil to the air. Because future construction activities could redistribute subsurface soil at the surface, recreational users will be evaluated for risks to subsurface soil (2-10 feet bgs) to aid in risk management decisions. Recreational users could also be exposed to chemicals in surface water and sediment through ingestion and dermal contact. Recreational users are not expected to have contact with groundwater.

- Current child, adolescent, and adult off-site residents — The off-site resident is a plausible receptor under current land use. Off-site residents are not expected to have exposure to chemicals in surface soil (0–2 feet bgs) through ingestion and dermal contact except as trespassers, which are evaluated separately. Off-site residents may be exposed to chemicals in surface soil through fugitive dust and volatile emissions from the site. Current off-site residents are not exposed to on-site subsurface soil (2–10 feet bgs). Based on currently available information, off-site residents do not have contact with on-site groundwater through ingestion and dermal contact; however, this conclusion is pending the results of the RI. However, off-site residents may be exposed to chemicals in groundwater volatilizing into indoor air (vapor intrusion). Current off-site residents are not expected to be exposed to on-site surface water and sediment except as trespassers, which are evaluated separately. However, if the wetlands investigation determines that the on-site wetlands are connected to the off-site wetlands, then off-site residents will be evaluated to exposures to chemicals in surface water and sediment via ingestion and dermal contact.

- Future child, adolescent, and adult on-site residents— The hypothetical future residential scenario is typically evaluated in a risk assessment to facilitate risk management decisions. However, this scenario is extremely conservative for the study area because on-site residential land use will be prohibited by deed restriction. We assume that a hypothetical resident may be exposed to chemicals in surface soil (0–2 feet bgs) through ingestion, dermal contact, and inhalation of chemicals emitted from soil to air. To aid in risk management decisions, hypothetical residents will also be evaluated for risks posed by exposure to subsurface soil (2–10 feet bgs), since future construction could potentially redistribute subsurface soil to the surface. Additionally, future on-site residents could be exposed to chemicals in groundwater through ingestion (i.e., drinking water), dermal contact (e.g., showering/bathing), and inhalation of chemicals that have volatilized into indoor air. Future on-site residents may also be exposed to surface water and sediment through ingestion and dermal contact.

6.3.2 Central Tendency Exposure versus Reasonable Maximum Exposure

Traditionally, exposures evaluated in an HHRA were based on the concept of a "reasonable maximum exposure" (RME) only, defined as "the maximum exposure that is reasonably expected to occur at a site" (USEPA, 1989). Subsequent risk assessment guidance (USEPA, 1992) stipulates the need address an average case, or central tendency, exposure (CTE). However, in this HHRA, only the RME scenario will be evaluated, since the RME scenario is designed to provide the reasonable maximum exposure likely to occur, it is more conservative than the CTE scenario, and is typically the basis of risk management decision making.

6.3.3 Exposure Point Concentration

Exposure point concentration (EPC), calculated for COPCs only (both site related and naturally occurring), is an estimate of chemical concentrations in an exposure unit (EU); EPCs estimate exposure intakes. An EU is the area over which receptor activity is expected. The following paragraphs discuss the EU that will be evaluated in the HHRA and the guidelines for calculating EPCs.

Each Area of Concern (AOC) within the site will be evaluated as a single EU. The following guidelines will be used to calculate EPCs for COPC concentrations in each AOC:

- For soil, groundwater, surface water, and sediment data sets containing at least five samples, the 95 percent upper confidence limit (UCL) on the arithmetic mean, which is based on the distribution of the data set, will be selected as the EPC unless the UCL value exceeds the maximum detected concentration. In this case, the maximum detected concentration will be used as the EPC. The maximum concentration will also be used as the EPC in the event of an insufficient number of detections to calculate a 95% UCL (i.e., less than four positive detections in a data set) in accordance with USEPA guidance (USEPA, 2010c). EPCs will be calculated following USEPA's Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (USEPA, 2002b) and using USEPA's ProUCL software (USEPA, 2010c).

- The sample quantitation limit will be used as an input for non detects in the USEPA's ProUCL software to calculate the 95percent UCL in accordance with ProUCL guidance (USEPA, 2010c). Duplicates will be averaged to calculate the EPCs for COPC in all media within the study area.

In accordance with the USEPA's Integrated Exposure Uptake Biokinetic Model (IEUBK) Model (USEPA, 1994, 2009b) and their Technical Review Workgroup (TRW) Adult Lead Model (USEPA, 2003b), average lead concentrations will be used to estimate blood lead levels from exposure to lead. This is because the

first step in the model calculations is the development of a central estimate of blood lead concentrations, which requires an “appropriate average concentration” for an individual.

6.3.4 Chemical Intake Estimation

Intakes for the identified potential receptor groups will be calculated using current USEPA risk assessment guidance (as recommended by OEPA September 1, 2006, guidance) and presented in the risk assessment spreadsheets. Risk assessment results will be presented using the USEPA RAGS Part D Table format. Exposure assumptions to be used in the calculations will be compiled and submitted to OEPA as a preliminary deliverable prior to calculating risks (this interim risk assessment deliverable will likely be submitted while the field investigation is being conducted).

Noncarcinogenic intakes are typically estimated using the concept of an average annual exposure. Carcinogenic intakes are calculated as an incremental lifetime exposure, which assumes a life expectancy of 70 years. Several USEPA guidance documents (e.g., 1989, 1991, 1993a, 1997a, 2004a) will be consulted for exposure assumptions. The exposure assumptions will reflect the current primary guidance used for exposure assumption development.

Standard chemical-intake equations presented in USEPA guidance (e.g., 1989, 2004a, 2009a) will be used to calculate chemical intakes for soil (ingestion, dermal contact, and inhalation), groundwater (ingestion and dermal contact), surface water (ingestion and dermal contact), and sediment (ingestion and dermal contact). Inhalation of chemicals in groundwater that have volatilized during construction activities will be evaluated for construction worker using guidance for the Virginia Department of Environmental Quality (VDEQ) (2004). Inhalation of chemicals that have volatilized from groundwater into indoor air will be evaluated for residents using the Johnson and Ettinger Volatilization Model (USEPA, 2004a). The model assumes that volatile chemical vapors emitted from groundwater migrate through subsurface soil and cracks in building foundations to accumulate in the air inside a building.

6.3.4.1 Assessing Cancer Risks from Early Life Exposures

The USEPA’s Supplemental Guidance for Assessing Susceptibility from Early Life Exposure to Carcinogens (USEPA, 2005b) recommends adjusting the toxicity of carcinogenic chemicals that act mutagenically when evaluating early life exposures to contaminants. The guidance recommends using age dependent adjustment factors (ADAFs) in concert with age specific exposure estimates when assessing cancer risks. Absent chemical specific data, the supplemental guidance recommends the following default adjustments, which reflect that cancer risks are generally higher from early life exposures than from similar exposures later in life:

- For exposures before two years of age (i.e., spanning a two year interval from the first day of birth until a child's second birthday), a 10 fold adjustment.

- For exposures between two and less than 16 years of age (i.e., spanning a 14 year time interval from a child's second birthday until their sixteenth birthday), a three fold adjustment.

- For exposures after reaching 16 years of age, no adjustment.

These adjustments will be applied using the same method as that used by USEPA to develop the RSLs. Children will be evaluated in two age groups, ages 0–2 and 2–6 years old. Adolescents will be evaluated as one age group, 6–16 years old. Adults will be evaluated as one age group (16–30 years old). Using this approach, the intakes for adolescent trespassers, recreational users, and residents are calculated as follows:

$$\text{Intake}_{\text{Child}} = \text{Intake}_{(\text{ages } 0\text{— } 2 \text{ years})} \times 10 + \text{Intake}_{(\text{ages } 2\text{— } 6 \text{ years})} \times 3$$

$$\text{Intake}_{\text{Adolescent}} = \text{Intake}_{(\text{age } 6\text{— } 16 \text{ years})} \times 3$$

$$\text{Intake}_{\text{Adult}} = \text{Intake}_{(\text{ages } 16\text{— } 30 \text{ years})} \times 1$$

This approach will be used only for chemicals identified as mutagenic in the USEPA RSL screening table [e.g., carcinogenic polycyclic aromatic hydrocarbons (cPAHs), hexavalent chromium].

Risks to receptors involving different age groups are sums of the cancer risks calculated for individual children, adolescents, and adult receptors. Therefore, lifelong cancer risks from chemicals that act via the mutagenic pathway are assessed through the lifelong off-site resident, lifelong recreational user, and lifelong on-site resident receptor scenarios.

6.3.4.2 Exposure to Lead

The equations and methodology presented in the previous section cannot be used to evaluate exposure to lead because of the absence of published dose response parameters. Thus, exposure to lead will be assessed using the following models:

- The latest version of USEPA's IEUBK Model for Lead, (USEPA, 2009b). This model is typically used to evaluate lead exposure assuming a residential land use scenario.

- USEPA's TRW Model for Lead (USEPA, January 2003b; model version date: 06/21/2009). This model is typically used to evaluate lead exposure assuming a non residential land use scenario.

The IEUBK model for lead (USEPA, 1994, 2009b) is designed to estimate blood levels of lead in children under seven, based on either default or site specific input values for air, drinking water, diet, dust, and soil exposure. Studies indicate that infants and young children are extremely susceptible to adverse effects from exposure to lead. Considerable behavioral and developmental impairments have been noted in children with elevated blood lead levels. The threshold for toxic effects from this chemical is believed to be in the range of 10–15 micrograms per deciliter (µg/dL). Blood lead levels greater than 10 µg/dL are considered a "concern."

For the study area, the IEUBK model for lead will be used to address exposure to lead in children when detected soil concentrations exceed the OSWER soil screening level of 400 mg/kg for residential land use (USEPA, 1994). Average chemical concentrations, as well as default parameters for some input parameters, will be used in the evaluation. Estimated blood lead levels and probability density histograms will be presented to support this analysis, and will be appended to the HHRA. Site-specific average groundwater concentrations will be used as an input to the model if available. The SDWA action level of 15 µg/L will be used as the screening level for lead in groundwater.

Non residential adult exposure to lead in soil will be evaluated using USEPA's TRW model for lead (USEPA, 2003a, 2009c). In this model, adult exposure to lead in soil is addressed evaluating the relationship between lead concentration in site soil and the blood lead concentration in the developing fetuses of adult women. The adult lead model generates a spreadsheet for each exposure scenario evaluated (i.e., construction, industrial, recreational). The spreadsheet output is the probability that blood lead concentrations in the fetus will exceed 10 µg/L. That probability is calculated in accordance with the following USEPA guidelines:

- Use of the TRW Interim Adult Lead Methodology in Risk Assessment (USEPA, 1999)
- Frequently Asked Questions (FAQs) on the Adult Lead Model (USEPA, 2010b)

No models are currently available to evaluate periodic exposure of adolescent receptors to lead. Therefore, the results of the IEUBK model for children will be used to qualitatively assess this receptor's exposure risk. The qualitative discussion will assert that potential adverse effects from exposure to lead are expected to be of lesser magnitude for adolescent receptors than for young children.

6.4 TOXICITY ASSESSMENT

The toxicity assessment seeks to identify potential adverse health effects in exposed populations. Quantitative estimates of the relationship between the magnitude and type of exposures and the severity or probability of human health effects are defined for the identified COCs. Quantitative toxicity values

determined during this component of the risk assessment are integrated with exposure assessment outputs to characterize the potential occurrence of adverse health effects for each receptor group.

The reference dose (RfD) is the toxicity value used to evaluate noncarcinogenic health effects for ingestion and dermal exposures. The reference concentration (RfC) is used to evaluate noncarcinogenic health effects for inhalation exposures. The RfD and RfC estimate a daily exposure level for a human population that is unlikely to pose an appreciable risk during a portion of or for all of a human lifetime. It is based on a review of animal and/or human toxicity data, with adjustments for various data uncertainties. Carcinogenic effects are quantified using the cancer slope factor (CSF) for ingestion and dermal exposures and using inhalation unit risks (IUR) for inhalation exposure that are plausible upper bound estimates of the probability of the development of cancer per unit intake of the chemical over a lifetime. These are typically based on dose response data from human and/or animal studies.

6.4.1 Toxicity Criteria for Oral and Inhalation Exposures

Oral RfDs and CSFs and inhalation RfCs and IURs used in the risk assessment will be obtained from the following primary USEPA literature sources (USEPA, 2003c):

- IRIS — USEPA's "Integrated Risk Information System" online database.

- USEPA's Provisional Peer Reviewed Toxicity Values (PPRTVs) — USEPA's Office of Research and Development/National Center for Environmental Assessment (NCEA) Superfund Health Risk Technical Support Center develops chemical specific PPRTVs when requested by USEPA's Superfund program.

- Other toxicity values — These sources include, but are not limited to, California Environmental Protection Agency (Cal/EPA) toxicity values, Federal Agency for Toxic Substances and Disease Registry (ATSDR) values, and the Annual Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997b).

Although toxicity criteria can be found in several toxicological sources, USEPA's IRIS online database is the preferred source of toxicity values. This database is continuously updated, and its values are verified by USEPA.

6.4.2 Toxicity Criteria for Dermal Exposure

RfDs and CSFs in the scientific literature are typically expressed as "administered" (i.e., not absorbed) doses. Therefore, these values are considered inappropriate for estimating risks associated with dermal

exposures. Oral dose response parameters based on administered doses must be adjusted to absorbed doses before they can be compared to estimated dermal exposure intakes.

When oral absorption is essentially complete (i.e., 100 percent), an absorbed dose is equivalent to the administered dose; therefore no toxicity adjustment is necessary. Conversely, when the gastrointestinal absorption of a chemical is poor (e.g., 1 percent), the absorbed dose is smaller than the administered dose; thus, toxicity factors based on the absorbed dose should be adjusted to account for the difference in the absorbed dose relative to the administered dose. USEPA (2004a) recommends a 50 percent absorption cut off to reflect the intrinsic variability in analyzing absorption studies. Therefore, the adjustment from administered to absorbed dose was only performed when the chemical specific gastrointestinal absorption efficiency was less than 50 percent. The adjustment from administered to absorbed dose was made using chemical specific gastrointestinal absorption efficiencies published in numerous sources of guidance [e.g., USEPA 2004a (the primary reference), IRIS, ATSDR toxicological profiles, etc.], using the following equations:

$$RfD_{dermal} = (RfD_{oral})(ABS_{GI})$$

$$CSF_{dermal} = (CSF_{oral}) \ / \ (ABS_{GI})$$

where:

ABS_{GI}	=	absorption efficiency in the gastrointestinal tract
RfD_{dermal}	=	reference dose for dermal exposures
RfD_{oral}	=	reference dose for oral exposures
CSF_{dermal}	=	cancer slope factor for dermal exposures
CSF_{oral}	=	cancer slope factor of oral exposures

As noted, the preceding adjustment of the oral toxicity criteria (i.e., reference doses, cancer slope-factors) is necessary so that the dermal route of exposure may be quantitatively evaluated in the baseline risk assessment. Further explanation of this procedure and its necessity are presented in Appendix A of the USEPA RAGS Part A.

6.4.3 Chromium Toxicity

Toxicity criteria are available for different forms of chromium, which is considered more toxic in the hexavalent state. In the USEPA's most recent RSL table, hexavalent chromium is listed as a carcinogen that has been determined to act "mutagenically" and the corresponding RSL for residential soil is less than 1 mg/kg. The USEPA Guidelines for Carcinogen Risk Assessment (USEPA, 2005a) and Supplemental Guidance of Assessing Susceptibility from Early Life Exposure to Carcinogens (USEPA,

2005b) specify the use of ADAFs for carcinogens, such as chromium, that act mutagenically. In contrast, the RSL for residential soil for trivalent chromium (not listed as a carcinogen/mutagen) is 120,000 mg/kg. The site history information, conceptual site model, and available analytical data for the study area (total chromium, hexavalent chromium) will be reviewed to determine what percentage (if any) of the chromium in soil is present/likely to be present in the hexavalent form. The HHRA will evaluate chromium assuming it is present in the trivalent state unless analytical data or site history indicates hexavalent chromium is present in the soil. No chemical specific ADAFs have been derived for hexavalent chromium; therefore, default ADAFs will be used to evaluate exposures to hexavalent chromium as discussed in Section 2.4.4.

6.4.4 Toxicity Criteria for the Carcinogenic Effects of cPAHs

Limited toxicity values are available to evaluate the carcinogenic effects from exposure to cPAHs. The most extensively studied cPAH is benzo(a)pyrene, which is classified by USEPA as a probable human carcinogen. Although CSFs are available for benzo(a)pyrene, insufficient data are available to calculate CSFs for other cPAHs. The toxic effects of these chemicals will be evaluated using toxicity equivalency factors (TEFs) based on the potency of each compound relative to that of benzo(a)pyrene, as presented in current USEPA guidance (USEPA, 1993b). TEFs are used to convert each individual cPAH concentration into an equivalent concentration of benzo(a)pyrene.

As discussed above, the USEPA's Guidelines for Carcinogen Risk Assessment (USEPA, 2005a) and Supplemental Guidance of Assessing Susceptibility from Early Life Exposure to Carcinogens (USEPA, 2005b) specify the use of ADAFs for carcinogens that act mutagenically. The cPAHs are included in the group of chemicals determined to act mutagenically. No chemical specific ADAFs have been derived for cPAHs; therefore, the default ADAFs will be used as discussed in Section 2.4.4.

6.5 RISK CHARACTERIZATION

This section of the HHRA will characterize the potential human health risks associated with exposures to study area media. Potential risks (noncarcinogenic and carcinogenic) for human receptors from exposures as outlined in the exposure assessment will be quantitatively determined. Sections 4.1 and 4.2 outline the methods used to quantitatively estimate the type and magnitude of potential risks to human receptors.

6.5.1 Quantitative Analysis of Constituents Other Than Lead

Quantitative estimates of risk for chemicals other than lead will be calculated according to risk assessment methods outlined in USEPA guidance (USEPA, 1989). Lifetime cancer risks are expressed in the form of dimensionless probabilities referred to as incremental lifetime cancer risks (ILCRs), based

on CSFs and IURs. Noncarcinogenic risk estimates are presented in the form of HQs, which are determined by comparing intakes against published RfDs and RfCs. ILCR estimates for ingestion and dermal exposures will be generated for each COPC using estimated exposure intakes and published CSFs, as follows:

ILCR = (Estimated Exposure Intake)(CSF)

If the equation above produces an ILCR greater than 0.01, the following equation is used:

ILCR = 1 [exp(Estimated Exposure Intake)(CSF)]

ILCR estimates of inhalation exposures are generated for each COPC using estimated exposure concentrations and published IURs, as follows:

An ILCR of 1×10^{-6} indicates that the exposed receptor has a one in one million chance of developing cancer under the defined exposure scenario. Alternatively, such a risk may be interpreted as representing one additional case of cancer in an exposed population of one million persons.

Noncarcinogenic risks will be assessed using the concept of HQs and hazard indices (HIs). The HQ for a COPC is the ratio of the estimated intake to the RfD and is calculated for ingestion and dermal exposures as follows:

HQ = (Estimated Exposure Intake)/(RfD)

For inhalation exposures, the HQ is calculated as follows:

$$HQ = (\text{Exposure Concentration})/(\text{RfC})$$

An HI will be generated by summing the individual HQs for all COPC. The HI is not a mathematical prediction of the severity of toxic effects; therefore, it is not a true probabilistic “risk;” it is simply a numerical indicator of the possibility of the occurrence of noncarcinogenic (threshold) effects.

6.5.2 Interpretation of Risk Assessment Results

To interpret the quantitative risk estimates and aid risk managers in determining the need for remediation, quantitative risk estimates are compared to typical OEPA and USEPA risk benchmarks. Calculated ILCRs are interpreted using the OEPA risk benchmark (1×10^{-5}) for cumulative risk and the USEPA target

cancer risk range (1×10^{-4} to 1×10^{-6}); HIs are evaluated using a value of 1.0. Current USEPA policy regarding lead exposures is to limit the childhood risk of exceeding a 10 µg/dL blood lead level to 5 percent.

USEPA defines the range of 1×10^{-4} to 1×10^{-6} as the ILCR target range for hazardous waste facilities addressed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA). Individual or cumulative ILCRs greater than 1×10^{-4} are generally considered "unacceptable" by the USEPA. Risk management decisions are necessary when the ILCR is within 1×10^{-4} to 1×10^{-6}. USEPA typically does not require remediation when the cumulative ILCR is less than 1×10^{-6}. Similarly, cumulative ILCRs greater than 1×10^{-5} are generally considered "unacceptable" by OEPA; remediation may or may not be necessary when the cumulative ILCR exceeds 1×10^{-5}.

An HI exceeding unity (1.0) indicates that noncarcinogenic health risks may be associated with exposure. If an HI exceeds unity, target organ effects associated with exposure to COPC are considered. Only those HQs for chemicals affecting the same target organ(s) or exhibiting similar critical effect(s) are regarded as truly additive. Consequently, the cumulative HI could exceed 1.0, but no adverse health effects would be anticipated unless the COPC affected the same target organ or exhibited the same critical effect (i.e., unless target organ /critical effect specific HIs exceeded 1).

As a general guideline, a "no further action" recommendation will be forwarded to OEPA whenever the cancer risk estimates and total HIs (estimated on a target organ/target effect basis) for receptors of concern are less than 1×10^{-5} and 1, respectively; and when risks associated with lead exposure are below the USEPA risk benchmark. Otherwise, in most cases, the need for remedial action (including institutional controls) will be evaluated in an FS. However, the 1×10^{-5} risk benchmark should not be viewed as a discrete limit. Risks slightly greater than 1×10^{-5} may be considered "acceptable" (i.e., protective) if justified by site specific conditions, including any uncertainties about the nature and extent of contamination and associated risks. Consequently, a "no further action" recommendation may be forwarded to OEPA risk managers for review and discussion when the 1×10^{-5} risk benchmark is exceeded. Those reviews and discussions may affect the analyses presented in the FS. The following factors will be considered in this determination:

- The magnitude of the media specific risk estimates.
- Significant uncertainties in the baseline HHRA that would overestimate baseline risk assessment results.
- Significant uncertainties in EPC estimates that would overestimate baseline risk assessment results.

6.5.3 Refined Evaluation of Chemical Migration from Soil to Groundwater

Chemicals of potential concern for migration from soil to groundwater will be selected, as detailed in Section 2. However, a more refined evaluation of the potential for such migration will be included in the risk characterization component of the HHRA and will be based on the following considerations:

- Does the maximum detected soil concentration exceed the SSL at a dilution attenuation factor of 20 (DAF_{20})?
- Does the mean of positive detections in soil exceed the SSL at a DAF_{20}?
- What is the frequency of detections exceeding the SSL at a DAF_{20}?
- Was the chemical selected as a COPC in groundwater?
- Does the maximum concentration in groundwater exceed the SDWA MCL?
- What is the frequency of detections in groundwater exceeding the USEPA RSL for tap water (based on an ILCR of $1x10^{-6}$ or an HI of 1)?
- What is the frequency of detections in groundwater exceeding 10 times the USEPA RSL for tap water (based on an ILCR of $1x10^{-6}$ or an HI of 1)?

These factors will be considered when selecting COC for groundwater protection. Constituents selected as COPC for migration from soil to groundwater in the initial screening will not be retained as COC if any of the following is true:

- The maximum soil concentration is less than the groundwater protection SSL, based on a DAF_{20}.
  Rationale: A dilution attenuation factor of 1 (DAF_1) is conservative; a DAF_{20} is assumed to be more accurate at most sites (USEPA, 1996a).
- The frequency of detections greater than the SSL at a DAF_{20} is less than 5 percent (when at least 20 samples are included in the data set and no contamination “hot spot” is present). A “hot spot” is defined as a concentration that exceeds twice the SSL at a DAF_{20}.
  Rationale: Chemicals are unlikely to pose risks to water quality through leaching from soil to groundwater if they are detected infrequently (i.e., less than 5 percent) in soil.

- The chemical was not selected as a COPC in groundwater.
  Rationale: If a chemical was not detected in site groundwater, the data do not indicate that water quality has been adversely affected. This is an important consideration because the contamination events within the study area occurred more than 40 years ago. Thus, given the passage of time, groundwater concentrations likely reflect the potential for chemical migration from soil to groundwater.

- The maximum concentration in groundwater is less than the SDWA MCL.
  Rationale: SDWA MCLs are federally enforceable drinking water standards. Concentrations of chemicals in groundwater that are less than corresponding SDWA MCLs indicate that groundwater has not been adversely affected.

- The frequency of detections greater than the USEPA tap water RSL is less than 5 percent (when at least 20 samples are included in the data set and no contamination "hot spot" is present). A "hot spot" is defined as a concentration twice the tap water RSL.
  Rationale: Chemicals are unlikely to pose risks to water quality through leaching from soil to groundwater if they are detected infrequently (i.e., less than 5 percent) in groundwater.

6.6 UNCERTAINTY ANALYSIS

The uncertainty analysis component of the HHRA will provide a summary of uncertainties inherent in the risk assessment and will include a discussion of how they may affect the quantitative risk estimates and conclusions of the risk analysis. The baseline HHRA for the study area will be performed in accordance with current USEPA guidance. However, varying degrees of uncertainty are associated with any baseline HHRA. A brief discussion of uncertainty issues generally considered in an HHRA is provided in the following narrative.

Uncertainty in COPC selection is related to the status of the available databases, the grouping of samples, the numbers, types, and distributions of samples, data quality, and the procedures used to include or exclude constituents as COPC. Uncertainty associated with the exposure assessment includes the values used as input variables for a given intake route or scenario, the assumptions made to determine EPCs, and the predictions regarding future land uses and population characteristics. Uncertainty in the toxicity assessment includes the quality of the existing toxicity data needed to support dose response relationships and the weight of evidence used to determine the carcinogenicity of COPC. Uncertainty in risk characterization is associated with exposure to multiple chemicals and the cumulative uncertainty from combining conservative assumptions made in earlier steps of the risk assessment.

Whereas various sources of random uncertainty and bias exist, the magnitude of bias and uncertainty and the direction of bias are influenced by the assumptions made throughout the risk assessment,

including selection of COPC and selection of values for dose response relationships. Throughout the risk assessment, assumptions that consider safety factors will be made to overestimate the final calculated risks. Generally, risk assessments carry two types of uncertainty: measurement and informational uncertainty.

Measurement uncertainty refers to the usual variance that accompanies scientific measurements. For example, this type of uncertainty is associated with the analytical data collected for each site. The risk assessment reflects the accumulated variances of the individual values used.

Informational uncertainty stems from inadequate availability of information needed to complete the toxicity and exposure assessments. This gap is often significant, such as the absence of information on the effects of human exposure to low doses of a chemical, the biological mechanism of chemical action, or the behavior of a chemical in soil.

After the risk assessment is complete, the results must be reviewed and evaluated to identify the type and magnitude of uncertainty involved. Relying on risk assessment results without considering the uncertainties, limitations, and assumptions inherent in the process can be misleading. For example, to account for uncertainties in developing exposure assumptions, conservative estimates will be made to ensure that the particular assumptions protect sensitive subpopulations or maximally exposed individuals.

If a number of conservative assumptions are combined in an exposure model, the resulting calculations can propagate the uncertainties associated with those assumptions, thereby producing much larger uncertainty in the results. This uncertainty is biased toward over predicting both carcinogenic and noncarcinogenic risks. Thus, both the results of the risk assessment and the uncertainties associated with them must be considered when making risk management decisions.

This interpretation of uncertainty is especially relevant when the risks exceed the point of departure for defining “acceptable” risk. For example, when risks calculated using a high degree of uncertainty are less than an “acceptable” risk level (i.e., 10 6), the interpretation of “no significant risk” is typically straightforward. However, when risks calculated with a high degree of uncertainty exceed an acceptable risk level (i.e., $1x10^{-4}$), a conclusion can be difficult unless uncertainty is considered. The draft HHRA will be conducted using the most recent USEPA RSLs available at the time of preparation. However, the RSLs are “evergreen” screening values and are subject to change as new toxicity information becomes available and is evaluated by the USEPA. Consequently, the COPC could change if the RSLs change.

6.7 REMEDIAL GOAL OPTIONS

Cleanup goals will be developed for those study areas with ILCRs greater than 1×10^{-5} and a total HI greater than 1.0. Cleanup goals will be derived for those COCs that contribute significantly to the cancer risk and/or HI for each exposure pathway in a given land-use scenario for a receptor group. Chemicals that are not considered to be significant contributors to risk will not be included as COCs if their individual carcinogenic risk contribution is less than 1×10^{-6} and their non carcinogenic HQ is less than 0.1. Cleanup goals will be calculated using the following equation:

$$\text{Cleanup Goal [chemical i]} = \text{EPC[chemical i]} \times \text{Target Risk/Calculated Risk[chemical i]}$$

where:

Cleanup goal [chemical i]	=	chemical specific cleanup goal
EPC [chemical i]	=	exposure point concentration used in risk assessment calculations
Target risk	=	target risk for carcinogens or the target hazard quotients for noncarcinogens
Calculated risk [chemical i]	=	total risk calculated for a specific chemical in the risk assessment

7.0 ECOLOGICAL RISK ASSESSMENT

7.1 INTRODUCTION

The goal of the ERA will be to determine whether adverse ecological impacts are present as a result of exposure to chemicals released to the environment through historical activities at the Former Kilgore Manufacturing Site, Westerville, Ohio. The ERA will contain information that enables risk managers to conclude that either ecological risk at the site is negligible or that further information is necessary to evaluate the potential ecological risk.

The ERA methodology will be in accordance with guidance presented in the following documents:

- Guidance for Conducting ERAs, DERR-00-RR-031 (State of Ohio, EPA, Division of Emergency and Remedial Response, October 2006, Revised April 2008).
- Final Guidelines for ERA (USEPA, 1998).
- ERA Guidance for Superfund: Process for Designing and Conducting ERA (USEPA, 1997).

This ERA will consist of Levels I, II, and III of the Ohio Environmental Protection Agency (OEPA) ERA Guidelines which generally follow Steps 1, 2, and the first part of Step 3 (often referred to as Step 3a) of the eight step USEPA ERA process. The Level III baseline assessment will only be conducted if warranted based on the results of the Level II ERA. Also, in the event that a Level III baseline assessment is conducted, no tissue samples or toxicity testing is planned at this time. Collection of that data would require additional planning and coordination with OEPA, which cannot be done until the initial ERA is prepared.

The following narrative briefly outlines the components of the ERA to be prepared for the study areas within the former Kilgore Manufacturing Site. Details (e.g., exposure assumptions) will be compiled and submitted to OEPA as a preliminary deliverable prior to formal preparation of the ERA (this interim risk assessment deliverable will likely be submitted while the field investigation is being conducted).

7.2 LEVEL 1 SCOPING

The Level 1 scoping is similar to the screening-level problem formulation step in the USEPA ERA process. It includes general descriptions of the study area with emphasis on the habitats and ecological receptors present. This phase also involves characterization of site-related chemicals, chemical sources, migration routes, and an evaluation of routes of chemical exposure.

7.3 LEVEL 2 -SCREENING

The Level 2 screening will be conducted to determine the need for further ecological evaluation of a site (i.e., whether a Level III baseline assessment is needed). This screening will consist of comparison of site analytical data to background levels and the screening levels described in the OEPA ERA Guidelines.

The media screening will be conducted for soil, sediment, and surface water because samples from these media will be collected. Although groundwater data will also be collected, it will not be evaluated in the Level 2 screening because surface water samples will be collected and that will be the exposure point for groundwater.

A detailed site survey as part of the Level II ERA is not needed and will not be conducted because a wetland delineation has already been conducted in the area.

After the screening is conducted, a decision will be made as to whether the Level III baseline assessment is needed.

7.4 LEVEL III BASELINE ASSESSMENT

In the event that a Level III baseline assessment is needed, the following describe some of the general steps that would be conducted and receptors that may be evaluated.

7.4.1 Environmental Setting

The objectives of this step are to 1) initially identify and characterize the habitats and ecological resources throughout the site, and, 2) describe the likely chemical sources, release mechanisms, migration pathways, and the fate of chemicals resulting from site-related activities, as well as ecological receptors that could be adversely affected by chemicals.

7.4.2 Potential Receptors

A site visit was completed to evaluate the quality of the wetlands present at the site. Several forested, scrub/shrub, and emergent wetland areas covering half of the 40-acre site were identified. The remaining 20 acres consist of dense grasses and brush. Based on the habitat at the site, soil invertebrates, birds and mammals are likely present at the site and are potential ecological receptors of concern. An aquatic bed was identified in one of the wetland areas creating habitat for amphibians.

7.4.3 Endpoints

7.4.3.1 Assessment Endpoints

An assessment endpoint is an explicit expression of the environmental value that is to be protected (USEPA, 1997). The selection of these endpoints is based on the habitats present, the migration pathways of chemicals, and the routes that chemicals may take to enter receptors.

For this ERA, the assessment endpoints will include the protection of the following groups of receptors from a reduction in growth, survival, and/or reproduction caused by site-related chemicals:

- Soil invertebrates
- Terrestrial vegetation
- Benthic invertebrates
- Terrestrial invertivorous birds and mammals
- Terrestrial herbivorous birds and mammals
- Wetland invertivorous birds and mammals

The following paragraphs discuss why the above assessment endpoints exemplify those important for this ERA.

Soil Invertebrates: Soil invertebrates present within the study area aid in the formation of soil, as well as in the redistribution and decomposition of organic matter in the soil, and serve as a food source for higher trophic-level organisms. They can also accumulate some contaminants, which can then be transferred to the higher trophic-level organisms that consume invertebrates.

Terrestrial Vegetation: Terrestrial vegetation within the study area consists of grasses, shrubs, and trees. These plant types serve as a food source, provide shade and cover for many organisms, and help prevent soil erosion, among other important functions. They can also accumulate some contaminants, which can then be transferred to the higher trophic-level organisms that consume plants.

Benthic Invertebrates: Benthic invertebrates serve as a food source for higher trophic-level organisms (i.e., fish, amphibians, birds, mammals). They can also accumulate contaminants, which can be transferred to higher trophic-level organisms that consume invertebrates.

Terrestrial Herbivorous Birds and Mammals: Herbivorous birds and mammals (i.e., animals that consume only plant tissue) are present within the study area. Their role in the community is essential because

without them, higher trophic levels could not exist (Smith, 1966). They may be exposed to and accumulate contaminants that are present in the plants they consume, and soil they incidentally ingest.

Terrestrial Invertivorous Birds and Mammals: Birds and mammals that consume primarily invertebrates are considered first-level carnivores. They serve as a food source for higher trophic level carnivores and may be exposed to and accumulate chemicals present in the food items they consume, and soil they incidentally ingest.

Wetland Invertivorous Birds and Mammals: Birds that consume primarily invertebrates are considered first-level carnivores. They serve as a food source for higher trophic level carnivores and may be exposed to and accumulate chemicals present in the food items they consume, and sediment they incidentally ingest.

As indicated in USEPA (1997), "it is not practical or possible to directly evaluate risks to all of the individual components of the ecosystem at a site. Instead, assessment endpoints focus the risk assessment on particular components of the ecosystem that could be adversely affected by contaminants from the site." Therefore, the ERA will focus on the endpoints that tend to yield the highest risks, which will account for endpoints that have lower risks.

Carnivorous birds and mammals generally have large home ranges. The study area covers approximately 40 acres of land. When the size of the study area is compared to the home range of top carnivores, such as the red-tailed hawk and the red fox, carnivores would receive only a very small portion of their diet from the study area; therefore, they will not be included as receptors in the ERA. Threshold oral toxicity values for reptiles and amphibians are not available for most chemicals, so risks to reptiles and amphibians will not be quantitatively evaluated. With the above factors in mind, amphibians, reptiles, and carnivores will not be selected as assessment endpoints for the ERA.

7.4.3.2 Measurement Endpoints

Measures of effects are estimates of biological impacts (i.e., survival, growth and/or reproduction) that are used to evaluate the assessment endpoints. The following measures of effects are examples of those that will be used to evaluate the assessment endpoints in this ERA.

- Decreases in survival, growth, and/or reproduction of plants, terrestrial invertebrates, and benthic invertebrates will be evaluated by comparing measured concentrations of chemicals in surface soil and sediment to screening values designed to be protective of ecological receptors.

- Decreases in survival, reproduction, and/or developmental effects of birds and mammals will be evaluated by comparing the estimated ingested dose of contaminants in surface soil and sediment to no-observed-adverse-effects levels (NOAELs) and lowest-observed-adverse-effects levels (LOAELs) for surrogate wildlife species.

7.5 CONCEPTUAL SITE MODEL

A CSM in ERA problem formulation is a written description of predicted relationships between ecological entities and the stressors to which they may be exposed (USEPA, 1998). The CSM will consist of two primary components: predicted relationships among stressor, exposure, and assessment endpoint response, and a diagram that illustrates the relationships (USEPA, 1998).

7.6 ECOLOGICAL EFFECTS EVALUATION

The ecological effects assessment is an investigation of the relationship between the exposure to a chemical and the potential for adverse effects resulting from exposure. In this step, screening levels for toxicity of the chemicals to ecological receptors are compiled. Screening levels recommended by the Ohio EPA will be considered in the evaluation and will be forwarded to the Ohio EPA for review and comment prior to incorporation into the ERA.

7.7 CHARACTERIZATION OF EXPOSURE

This portion of the ERA will include identification of contaminant concentration data used as the EPCs to represent ecological exposure in various media. The total exposure dose for terrestrial wildlife hypothetically exposed to chemicals in soil, sediment, and associated food items such as plants and invertebrates will be estimated using food chain models. Selection of a particular species will be required so that intake through ingestion can be estimated. The availability of exposure parameters (i.e., body mass, and ingestion rates) will be factors in selecting surrogate receptor species.

The equations used to determine contaminant intake will be provided in the interim risk assessment deliverable referenced in the preceding narrative.

7.8 RISK CHARACTERIZATION

The risk characterization is the final phase of an ERA, and compares exposure to ecological effects. It is at this phase that the likelihood of adverse effects occurring as a result of exposure to a stressor is evaluated. An ecological effects quotient (EEQ) approach will be used to characterize the potential risk to ecological receptors by comparing exposure concentrations and doses to effects data. When EEQ values exceed 1.0, it is an indication that ecological receptors are potentially at risk; additional evaluation

or data may be necessary to confirm with greater certainty whether ecological receptors are actually at risk, especially since most benchmarks are developed using conservative exposure assumptions and/or studies. The EEQ value should not be construed as being probabilistic; rather, it is a numerical indicator of the extent to which an EPC exceeds or is less than a benchmark. The equations used to calculate the EEQs will be provided in the interim risk assessment deliverable referenced in the preceding narrative.

The final part of the screening evaluation is selection of COPCs. Chemicals that are not selected as COPCs are assumed to present negligible risk to ecological receptors and are not further evaluated in the ERA for those receptors. Chemicals that are initially selected as COPCs in the Level II screening will be evaluated further in Level III. As part of the risk characterization, a refinement of the conservative exposure assumptions and concentrations will be conducted to evaluate the potential risks to ecological receptors (e.g., plants, invertebrates, and wildlife receptors). The objective of the evaluation is to further refine the number of chemicals that are retained as COPCs in order to focus additional efforts (if necessary) on chemicals that are of significant ecological concern. The following describes the process that will be used to further evaluate chemicals initially selected as COPCs in soil and sediment.

The following factors will be evaluated, as appropriate, to determine if the risks are great enough to warrant additional evaluations. Note that all of these factors might not be applicable for each chemical and/or receptor group.

- Magnitude of criterion exceedance: Although the magnitude of the risks may not relate directly to the magnitude of a criterion exceedance, the magnitude of the criterion exceedance may be one item used in a lines-of-evidence approach to determine the need for further site evaluation. The greater the criterion exceedance, the greater the probability and concern that an unacceptable risk exists.

- Frequency of chemical detection and spatial distribution: A chemical detected at a low frequency typically is of less concern than a chemical detected at higher frequency if toxicity and concentrations and spatial areas represented by the data are similar. All else being equal, chemicals detected frequently will be given greater consideration than those detected relatively infrequently. In addition, the spatial distribution of a chemical may be evaluated to determine the area that a sample represents.

- Contaminant bioavailability: Many contaminants (especially inorganics) are present in the environment in forms that are typically not bioavailable, and the limited bioavailability will be considered when evaluating the exposures of receptors to site contaminants. Contaminants with generally less bioavailability will be considered to be less toxic than the more bioavailable contaminants, all other factors being equal.

- More Appropriate Benchmarks: More appropriate benchmarks will be used to further evaluate risks to specific groups of ecological receptors (e.g., plants and invertebrates) because while screening levels are useful for initial screening, they might not be appropriate for evaluating all of the assessment endpoints.

8.0 FEASIBILITY STUDY

The Feasibility Study (FS) will be conducted in accordance with USEPA RI/FS Guidance, Chapter 4. Otterbein developed and evaluated a range of remedial alternatives during the RI/FS scoping presented in the PER. Otterbein will continue to develop and evaluate the remedial alternatives initially developed during project scoping as the RI data becomes available.

8.1 REFINE REMEDIAL ACTION OBJECTIVES (USEPA RI/FS GUIDANCE SECTION 4.2.1)

Otterbein will further refine the preliminary RAOs identified during project scoping.

RAOs for protection of human health should specify a site-specific PRG, an exposure pathway and receptor, and preliminary points of compliance. An ITM will be prepared and submitted identifying the refined RAOs for protection of human health and the environment and detailing the methods and procedures used to refine them. Otterbein will revise the refined RAOs per Ohio EPA's comments, if any, and include the refined RAOs in the Alternatives Array Document described in 8.2 below.

8.2 ALTERNATIVES ARRAY DOCUMENT (USEPA RI/FS GUIDANCE CHAPTER 4)

Otterbein will prepare an Alternatives Array Document (MD) which documents the methods, rationale, and results of the technology, process option, and alternatives development and the screening process. Respondent shall include an evaluation of whether the amount and type of data existing for the Site will support the subsequent detailed analysis of the alternatives. Respondent shall modify the alternatives based on Ohio EPA's comments, if any, to assure identification of an appropriate range of viable alternatives for consideration in the detailed analysis. The MD, as revised by Respondent to incorporate Ohio EPA comments, shall be combined with the detailed analysis of alternatives to form the FS Report described in Section 9 and Appendix M of this SOW.

8.3 TREATABILITY STUDIES

At this time there is no plan to conduct a treatability study at the Site. Should the data collected in the RI suggest the need to change the potential remedial alternatives, and a treatability study be indicated, Otterbein would submit a plan to OEPA detailing the proposed treatability study.

8.4 DETAILED ANALYSIS OF ALTERNATIVES

Once it has been determined that sufficient data exist to proceed, Otterbein will conduct a detailed analysis of the alternatives surviving the screening process to provide Ohio EPA with the information

needed for selection of a site remedy. The detailed analysis shall consist of an individual analysis of each alternative against eight evaluation criteria followed by a comparative analysis of the alternatives using the same evaluation criteria as the basis for comparison.

8.5 FEASIBILITY STUDY REPORT (USEPA RI/FS GUIDANCE SECTION 6.5)

Otterbein will prepare and submit a FS Report for review and approval. The AAD, revised based on comments received from Ohio EPA, shall be incorporated into the FS as it is prepared. Otterbein will refer to Table 6-5 of the USEPA RI/FS Guidance for an outline of the FS Report format and required report content.

9.0 KEY ASSUMPTIONS

There are several key assumptions concerning the status of the Site which have been considered in the preparation of this RI/FS. These assumptions are presented below:

- The site has been investigated on at least eight occasions and data from those investigations will be used in the RI/FS to the extent possible.

- Since 1962, remediation has been conducted at the site on at least six separate occasions.

- The majority of the remedial activities undertaken in the past involved the removal of UXO materials.

- UXO materials remaining on the site (if any) are expected to be below the ground surface.

- The Remedial Investigation will therefore be conducted under the supervision of trained UXO personnel providing UXO support.

- The intrusive portions of the RI will be conducted using UXO avoidance practices.

- In the event that potentially dangerous UXO materials are discovered, the location of the material will be marked, the findings reported to Otterbein, and appropriate measures will be undertaken to remove the UXO safely, and in accordance with standard protocols.

- Otterbein University intends to act conservatively regarding residual contamination remaining at the eight AOCs. It is anticipated that, for most AOCs, residual contamination detected or assumed to be present (e.g., munitions and explosives of concern [MEC]) will likely be excavated and disposed off-site

- The site is immediately adjacent to a residential neighborhood and facilities of the Westerville School District. Because of the high public visibility for this project, citizen involvement and communication will be a key requirement for all future site activities.

- The United States Department of Justice and the Department of Defense are funding a portion of the RI/FS and it is expected that the representatives of the Federal government will monitor ongoing site activities.

- Otterbein has not finalized plans for future property use and no firm decisions on future use are expected in the near-term.

- Otterbein has indicated a strong preference to conduct conservative remedial measures in order to eliminate all future environmental liabilities and concerns to the public.

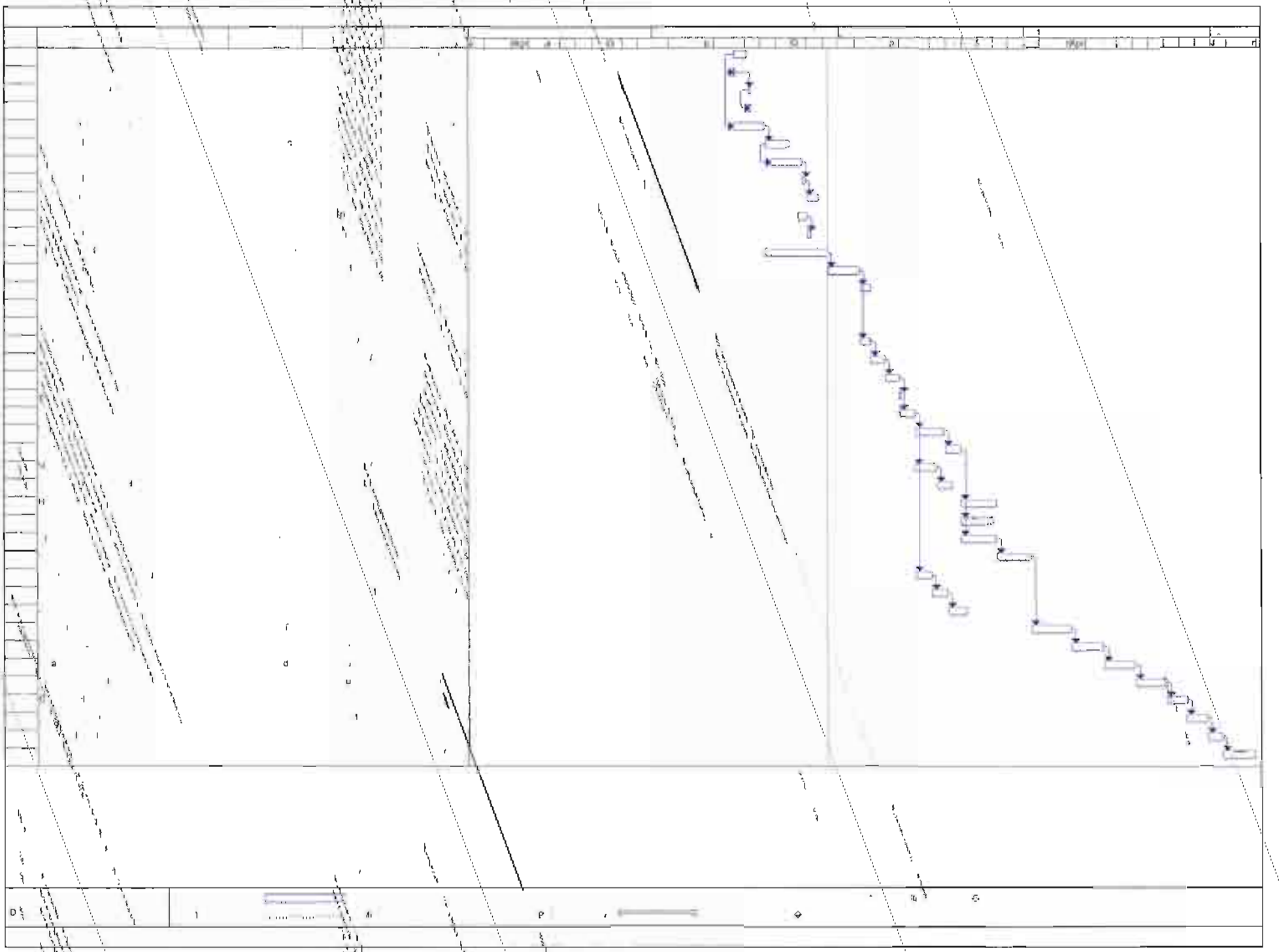
- It is understood by Otterbein that the proposed scope of work may not be sufficient to support a No Action alternative at some of the AOCs.

10.0 SCHEDULE

Although the draft Consent Order had not been signed as of the date of this Work Plan, Otterbein and OEPA mutually agreed to proceed with the RI/FS process in June 2010. The work began with a Site Investigation on July 12, 2010, and continues with the submission of this Work Plan.

As with most investigations, there are several factors which can significantly impact the schedule of a RI/FS. In the case of the Kilgore RI/FS, the most significant factor appears to be the presence of wetlands on a large portion of the Site. Work has begun on the wetlands delineation project and a report will be submitted to the Corps of Engineers in the very near future; however, the report may initiate a permit process which could delay the start of field investigations. The wetlands could also impact the schedule by dictating the time of year in which the site is accessible to drilling and excavation equipment.

The anticipated schedule for the Kilgore RI/FS is presented as a Gantt chart on Figure 10-1. Because of the many uncertainties related to the wetlands issue the Gantt chart does not include the wetlands tasks. Delays in obtaining wetland-related permits may delay many of the dates shown in the chart.



11.0 PROJECT MANAGEMENT

The RI/FS project is being conducted in accordance with the draft consent decree between Otterbein, OEPA and the US Department of Justice. Otterbein retained TtNUS Pittsburgh, PA to conduct the RI/FS on behalf of the university.

In accordance with the draft consent decree OPA and Otterbein have named Site Coordinators who will serve as points of contact for the respective groups. OEPA named Mr. Robin Roth of the OEPA Division of Emergency and Remedial Response Central Division as the OEPA Site Coordinator. Otterbein named Mr. Al Quagliotti of TtNUS as the Site Coordinator for the university.

Ms Jennifer Pearce of Otterbein will serve as the Public Relations Officer for the project and will serve as the liaison with the public regarding activities and conditions at the Site. TtNUS has assigned several professionals specific roles in the RI/FS. Mr. Al Quagliotti P.G. will serve as the Project Manager of the project. Ms Shannon Hill will serve as the Field Operations Leader (FOL) for activities conducted at the Site. A variety of other personnel are named to specific positions in the Health and Safety Plan (HASP).

Mr. Bill Acton of Civil and Environmental Consultants (CEC) will serve as manager of the wetlands delineation project and wetland permitting activities.

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PRE-INVESTIGATION EVALUATION REPORT

OF THE

FORMER KILGORE MANUFACTURING COMPANY FACILITY

WESTERVILLE, OH

Performed for:

OTTERBEIN COLLEGE

Westerville, OH

August 10, 2010

PREPARED UNDER THE DIRECTION OF:

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1.0 INTRODUCTION

Tetra Tech NUS, Inc. has prepared this Pre-investigation Evaluation Report (PER) dated August 10, 2010, to aid in better understanding the Site's current condition and future investigation. The Kilgore Farm Site (Site) is located at 400 North Spring Road, Westerville, Ohio (Figure 1-1). The facility closed operations in 1962, and the property was donated to Otterbein College. Otterbein College has investigated the Site on numerous occasions since acquiring the property. As a result of the multiple investigations, eight areas of concern (AOC) have been identified at the Site.

Otterbein College, the United States of America and the Ohio Environmental Protection Agency (OEPA) have been negotiating a consent decree which will state the responsibilities of Otterbein in the investigation and remediation of the Site.

This report was prepared following guidance provided in the Ohio EPA "Generic Statement of Work for Conducting Remedial Investigations and Feasibility Studies", September, 2006.

The Project Initiation Meeting is described in Section 2.0, including a note on the initial Site visit and OEPA File Review. Section 3.0 presents a description of Current conditions, including Site background and history, the general environmental setting, and descriptions of the eight defined AOCs. Section 4.0 presents a compilation of existing data, previously developed for the Site, and references the numerous earlier investigations. Section 5.0 is a Conceptual Site Model (CSM) which further summarizes the pertinent issues at the Site and identifies migration pathways and receptors.

Section 6.0 presents the findings of a Level I Ecological Assessment. Section 7.0 presents the Pre-investigation Evaluation of Remedial Alternatives, and Section 8.0 identifies data needs and data usage. Section 9.0 presents the references used in the report.

2.0 PROJECT INITIATION MEETING

2.1 PROJECT INITIATION MEETING

The Project Initiation Meeting was held on July 12, 2010, at the Otterbein Equine Center, which is located on a portion of the former Kilgore Manufacturing Facility property which has already been granted a release of liability under the Ohio VAP program. The meeting was attended by Mr. Robin Roth of the Ohio Environmental Protection Agency (OEPA), who will serve as the OEPA Site Coordinator for the project. Mr. Kenneth Schultz of OEPA was also in attendance. Mr. Al Quagliotti of Tetra Tech Inc. represented Otterbein College as their designated Site Coordinator. Mr. Dave Bell represented Otterbein College along with Mr. Ron Kuis, Otterbein's outside Counsel.

The meeting followed the agenda prepared by Mr. Roth. Mr. Kuis provided a review of the historical background of the Site. Mr. Quagliotti presented a conceptual model of the Site using a series of figures which illustrated eight defined areas of concern and led a discussion of potential receptors. Mr. Roth reviewed the technical requirements of the draft orders and the preliminary statement of work. The first deliverable (this PER) was discussed in some detail. Mr. Roth and Mr. Schultz provided guidance on the performance of the RI/FS and informed the Otterbein representatives of several local issues which might impact the performance of the work.

2.2 INITIAL SITE VISIT

Following the Project Initiation Meeting, the group toured the Site. Mr. Kuis left the group to attend other meetings at the college. The remaining group walked the Site, observing the general locations of the areas of concern, existing monitoring wells, remnant features and adjoining residential properties. The group encountered soggy conditions over a large portion of the Site, presumably due to heavy rains the days before, and morning of the meeting.

2.3 OEPA FILE REVIEW

Following the initial Site visit, Mr. Kuis and Mr. Quagliotti visited the office of the OEPA Central District to conduct a search of the OEPA files pertaining to the Site. The files were reviewed and most were found to be copies of files already in the possession of Otterbein. Mr. Quagliotti designated 39 pages of files to be copied and the OEPA provided the copies on July 13, 2010.

3.0 DESCRIPTION OF CURRENT CONDITIONS

The property is currently vacant and partially wooded and overgrown with dense grasses and brush. Remnants of gravel roads are still visible but all above ground structures have been destroyed.

3.1 SITE BACKGROUND AND HISTORY

The Kilgore Farm Property is located in the City of Westerville, in Delaware County in central Ohio (Figure 1-1). In 1941, in response to the needs of the Army Chemical Warfare Service for World War II, Kilgore Manufacturing purchased the 111 acre former farm Site for conversion to a pyrotechnics and ordnance manufacturing facility. The facility consisted of a network of small magazines, concrete buildings (including a boiler house), Quonset huts, a water tower, and other ancillary support facilities. OnSite activities conducted by Kilgore Manufacturing included experimental work and the manufacture and assembly of some explosives and incendiary items and detonation devices. Over the course of operations, various types of flares were manufactured including parachute, floating, photoflash, battlefield, trip, high altitude, 3-minute and highway emergency flares for military and civilian uses. Incendiary bombs included thermite and magnesium “X” type explosive bomb clusters and for a short period of time, the facility experimented with the production of shaped charges (Kuis, 2003). Other specific products built or stored included 155 mm illuminating shells, hand and smoke grenade fuses and primers, M1 Flame Throwers, rocket line launchers, phosphorous float lights, and M112 photoflash cartridges (Kuis, 2003). Pelletization of black powder also occurred. Typical types/descriptions of Munitions and Explosives of Concern (MEC) that may be present are described below (UXB, Jan. and Mar., 2000). Earlier indications that land mines may have been produced (Lawhon & Associates, 1996) were later discredited.

After World War II, Kilgore Manufacturing made toy cap guns and pyrotechnics for public use and illuminating flares for civilian and military use until 1961 when the facility closed. Figure 3-1 shows an aerial photograph of the Site in 1958 before it was closed. Otterbein College has owned the 111-acre former Kilgore Farm Property since it was donated to the college in 1962 by the Commercial Credit Corporation (who owned Kilgore at the time) after operations ceased. Farming, notably of beans and corn, resumed after 1967 and finally ceased in 1986. In 2007, Otterbein successfully obtained a zoning change from rural residential to planned Neighborhood District for the entire 111 acres to allow the Site to be used for college expansion. Phase I of Site development included a 69.145 parcel adjacent to the Site that is the location of Otterbein’s equine science field operations. Phase II Site development is associated with the 39.818 acres Site parcel and the intended future use of the property is yet to be determined.

Wastes generated during operations included burning/disposal of produced wastes, such as material from settling sumps in the manufacturing area, and those items not meeting military standards of acceptability. Concerning waste disposal, records are incomplete. Most information is a result of a series of cleanups and investigations that spanned from 1962 to 2007, including removal of foundations and building structures in 1996. Eight specific areas of concern (AOCs) have been identified as well as two general areas (Figure 3-2). Environmental investigations included geophysical surveys, an ordnance survey, on-Site testing to determine if the materials found were shock sensitive, friction sensitive, or flammable, trenching to visually identify the edges of waste and to assess buried geophysical anomalies, and chemical sampling of soil, groundwater and surface water.

The AOC locations have been well researched and established. However, poor waste handling/disposal procedures were evident during cleanups and investigations based on unrecorded disposal, both containerized and uncontainerized materials, materials disposed in various forms, and various disposal practices including surface placement, shallow burial and burning of materials. In spite of the age of the Site at more than 40 years, objects brought to the surface by plowing have developed the characteristic of ignitability and so time did not have an effect on materials degradation. The overall UXO threat assessment has been characterized as “medium” with a “potential hazard to local population if not cleared.” Moreover, elevated concentrations of metals, sulfate, perchlorate, and phosphorus are present in soil samples. Some soil samples had a pH low enough to be classified as corrosive and at least one sample exceed the TCLP regulatory level for chromium. Outside of the AOC areas, flares and miscellaneous objects were visible throughout the Site at the surface and, during excavation, at the shallow subsurface. Plowing for farming purposes and/or frost heave could be responsible for subsurface findings.

Potential chemicals of concern associated with the operations of the Kilgore Manufacturing Facility are presented in Table 3-1 (extracted from Metcalf & Eddy, 2005).

3.2 ENVIRONMENTAL SETTING

The property is currently vacant. The property is partially wooded and overgrown with dense grasses and brush. The majority of the Site is covered with mature woodland. Remnants of gravel roads are still visible but all above-ground structures have been razed.

The property is located in a residential area of Westerville and is surrounded by a mix of residential and school properties (Figures 3-3. The Site is surrounded by the following:

North: Vacant field and wooded land
East: Vacant field and wooded land vacant wooded land, domestic housing

South: Westerville North High School and Heritage Middle Schools
West: The Otterbein College Equine Science Facility

The area is cold in the winter and warm to hot in the summer. The average winter temperature is 31 degrees F while the average summer temperature is 72 degrees F. The prevailing wind is from the south-southwest with an average wind speed of 11 miles per hour. The total annual precipitation is approximately 38 inches of which 60 percent usually falls from April through September. The average annual snowfall is 28 inches, which occurs from late November until early March.

Site topography is generally level with relief less than 10 feet (898 to 890 feet above mean sea level) from west to east across the Site.

3.2.1 Hydrology

There are no permanently flowing rivers or streams on the Site, but there is a drainage ditch on the northern portion of the property (AOC 2) which has some flow, northwest to southeast, after precipitation events. There is no sediment on the property; the material in the drainage ditch (AOC 2) becomes saturated during wet periods, but is most properly characterized as soil as it consists mainly of topsoil and not material transported by moving water. Ponded surface water on the southern portion of the property and small wetland areas have been identified in two areas along the southern and western property lines, 1.3 acres just west of the former burial trench area (AOC 8) and 4.0 acres just south of the former Manufacturing Area (AOC 5), respectively. Hoover Reservoir, located about 2,000 feet east of the Site is the nearest surface water body; there are no direct drainage ways that connect the property to Hoover Reservoir.

A portion of the Site is considered to be wetlands.

3.2.2 Geology

Site surface soils are brown weathered silty clay with varying amounts of sand and gravel/shale fragments. The weathered soil horizon extends to approximately 10 feet below ground surface. Beneath the weathered soils, the unweathered soils are of the same composition but are gray in color. There is approximately 50 feet of glacial drift above the bedrock. Figure 3-4 displays the location of geologic cross-sections at the Site and Figures 3-5 through 3-8 show cross-sections A-A', B-B', C-C', and D-D'.

3.2.3 Hydrogeology

The Site is in an area that contains thin lenses of sand and gravel interbedded in thick layers of clay and silt. Domestic and farm supplies are generally 100 feet or less in glacial overburden. The Site is adjacent to an area with meager, often inadequate supplies of groundwater. Previous Site investigations have noted the presence of discontinuous sand seams in several different groundwater flow zones in the glacial till and none of the identified sand seams were found to be extensive. Site groundwater flow was to the east-southeast, consistent with regional flow direction.

3.2.4 Wetlands

A large portion of the Site is covered by wetlands. A preliminary Jurisdictional Opinion (PJO) was conducted by Civil and Environmental Consultants, Inc. (CEC) in 2005 for the entire 111 acre former Kilgore Manufacturing property owned by Otterbein College. This report (included as Appendix G) designates three areas of the current study Site as wetlands. Wetland A was described as a forested/scrub/shrub/emergent wetland covering approximately 14 acres in the forested, eastern portion of the Site. Wetland B was described as a forested/scrub/shrub wetland covering 2 acres in the southwestern corner of the current study Site. The final wetland was Wetland C, described as an aquatic bed/scrub/shrub wetland located in the southeastern corner of the current study Site.

A full wetland delineation study was conducted on the 70 acre parcel of the Former Kilgore property, just west of the current Site prior to construction of the current Otterbein Equine Center. This study conducted by MAD, Scientist & Associates LLC is also located in Appendix H.

3.3 DESCRIPTION OF THE AREAS OF CONCERN

3.3.1 AOC 1 Unidentified Rectangular Feature

AOC 1 is located in the northeast portion of the Site, south of the former Manufacturing Area (AOC 5), and is defined by two unknown rectangular features of unknown past use (Metcalf & Eddy, 2005). No evidence remains of the horizontal structures. Green silt-like material and orange sand were observed in this area.

(Brown & Caldwell, July 2007), using visual identification of the "green material encountered in borings and trenches", estimated the size of AOC 1 to be:

Dimensions, ft			Volume, cu yd*	Tonnage
Length	Width	Depth		
75	125	3	1,094	1,860

* Includes 5% contingency

3.3.2 AOC 2 Drainage Ditch Near Former Manufacturing Area

AOC 2 is a drainage ditch located in northeast portion of the Site between the former Manufacturing (AOC 5) and Experimental (AOC 6) Areas where wastes were reportedly buried. The burial reportedly consisted of off-spec material that was buried parallel and within 8 to 10 feet of either side of the ditch The ditch has some flow, northwest to southeast, after precipitation events. There is no sediment on the property; the material in the drainage ditch becomes saturated during wet periods, but is most properly characterized as soil as it consists mainly of topsoil and not material transported by moving water (Metcalf & Eddy, 2005).

The AOC 2 size was estimated by Brown & Caldwell (July 2007) based on the observed limits of waste in trenches and the boring results and the depth of the deepest waste in a given trench.

Dimensions, ft			Volume, cu yd*	Tonnage
Length	Width	Depth		
400	30	3	1,400	2,380

* Includes 5% contingency

3.3.3 AOC 3 Burial Area

AOC 3 is a former burial area, reportedly used to dispose of cinders and nonflammable materials generated at the facility. Purple powder, white crystalline material and gray and black ash were observed in this area. This AOC was reportedly excavated to a depth of 10 feet and backfilled with clean soil (Metcalf & Eddy, 2005).

Brown & Caldwell, July 2007 estimated the size of AOC 3 using observed limits of waste in trenches, the boring results and the depth was based on the depth of native material observed in the trenches.

Dimensions, ft			Volume, cu yd*	Tonnage
Length	Width	Depth		
100	100	5	1,945	3,112

* Includes 5% contingency

3.3.4 AOC 4 Burn Pit

The AOC is a burial area located east of the former Quonset Huts. According to a former employee (employed 1946 to 1961), the burn pit (AOC 4) was used once/week to burn flares, caps, and other off-spec materials and waste. Extreme care was apparently taken to ensure that all materials in the burn pit were completely destroyed during each burning event to prevent accidents from occurring during the next burn event. It was periodically excavated and resulting cinders and nonflammable material buried in trenches (AOC 8) (Metcalf & Eddy, 2005).

Reportedly, prior to 1962, contaminated soil from the burn pit was excavated to a depth of 10 feet and disposed of offSite and the excavation backfilled (Metcalf & Eddy, 1998).

Based on the project cost estimate (Brown & Caldwell, July 2007), the size is as follows:

Dimensions, ft			Volume, cu yd*	Tonnage
Length	Width	Depth		
100	75	10	2,187	3,500

* Includes 5% contingency

3.3.5 AOC 5 Manufacturing Area Former UST Location

The AOC is associated with a former underground storage tank (UST) of 2,500 gallon volume located in the northeast corner of the Site within the former manufacturing area. The tank use was presumed to be for fuel oil storage. Because it was a fuel oil tank, it was unregulated by the State. The UST was abandoned from use in 1962 (Lawhon & Associates, 1991) and removed in 1997 along with surrounding contaminated soil (Metcalf & Eddy, 2005). The tank was approximately 47 years old at the time of removal. During removal of the UST soils were stored on plastic sheeting and water and residual product were pumped from the tank and disposed of as petroleum-contaminated liquids. Visibly contaminated soils were excavated and segregated from “clean” soils and stockpiled on the plastic sheeting. Verification soil samples were collected from the tank cavity and the results led to the removal of additional soils which were hauled offSite for disposal. A total of 104 cubic yards of impacted soils were

removed from the Site. The tank Site was categorized as a Category 3 Site. The residual concentrations of petroleum constituents in the soil were determined to be below the Category 3 Action Levels and below the VAO Generic Numeric Cleanup Standards (M&E, 2003).

This AOC has been identified as a result of hydrocarbon odors detected in soils recovered from a boring performed in the location of the former tank. Brown & Caldwell (2007) did not recommend removal of soil in this area; therefore there is no estimate of the size of any impacted soil area.

3.3.6 AOC 6 Former Experimental Area

This area, located north of former Quonset Huts, was used to conduct research and testing of new products and processes. Surface waste observed at this AOC included drums, construction debris, ash, slag, cinders, and black, loose granular materials (Metcalf & Eddy, 2005).

Based on the project cost estimate (Brown & Caldwell, July 2007), the size is as follows:

Dimensions, ft			Volume, cu yd*	Tonnage
Length	**Width**	**Depth**		
50	50	2	194	311

* Includes 5% contingency

3.3.7 AOC 7 Cinder Area

The AOC is defined by cinders, coal fragments and slag found on top of native soils. The area is located near the southeast corner of the Site (Metcalf & Eddy, 2005).

Based on the project cost estimate (Brown & Caldwell, July 2007), the size is as follows:

Dimensions, ft			Volume, cu yd*	Tonnage
Length	**Width**	**Depth**		
25	25	2	48	77

* Includes 5% contingency

3.3.8 AOC 8 Former Burial Trench Area

AOC 8, located in the southeast corner of the Site, was systematically used as a burial area allocated for the disposition of produced waste and rejected materials. The area was capped at the cessation of historical Site activities in the 1950s (Metcalf & Eddy, 2005). Cap waste was buried up until the last day of operations (W.R. Grace and Company, 1961). Recorded disposition of waste and rejected materials is complete only from January, 1951 through May 1953 (Lawhon & Associates, 1991).

Wastes were generally from settling sumps and consisted of mixtures of various chemicals used in the manufacturing process, generally mixtures of red phosphorous, potassium chlorate, gum, and antimony trisulphide. Such mixtures when dry are highly explosive, and so much of the waste was packaged wet in cans, laid in open trenches and covered over with earth. The largest can used for burying was approximately 15 inches in diameter and 30 inches long.

Rejected materials, such as pyrotechnical devices, primary explosives, scrap powder, primers, detonators and liquid flares, were also placed in open trenches and covered with earth. The most dangerous of the buried materials was photoflash cartridges. For the most part, the trenches followed the same direction and were the same distance apart (Lawhon & Associates, 1991 and W.R. Grace and Company, 1961). According to a former employee (employed 1952 to 1961), the trench burial area consisted of 20 trenches, 200 ft long by 3 ft wide by 5 ft deep (Metcalf & Eddy, 1998). As new trenches were dug, excavated soil from the new trench was used to cover up the last trench.

The size of A0C 8 has been reported as small as 2.5 acres and as large as 8 acres. Impacted material was previously noted at depths of up to 10 feet bgs. (Brown & Caldwell, July 2007).

4.0 EXISTING DATA ANALYSIS

The Former Kilgore Manufacturing Site has been investigated on at least 12 occasions since 1962. The investigations and related activities are listed on Table 4. The locations of the recent sampling (M&E, 2003) are presented on Table 4-1. The laboratory analytical methods used during these investigations are summarized in Table 4-2. The results of each investigation either led to the removal of materials of concern or added to the Site knowledge. Digital copies of reports generated by the major investigations (including tables, figures and appendices) are included in the Appendix. Some of the major reports are discussed briefly in the following section.

4.1 PREVIOUS INVESTIGATIONS

Phase I Assessments were performed by S. E. A., Inc. in 1986, and by Lawhon & Associates, Inc. in 1991.

A Voluntary Action Program (VAP) Phase I was done by Metcalf & Eddy, Inc. (M&E) of the entire 111 acre property in 1988 but was not submitted to OEPA. The 1988 investigation identified 14 AOCs; however, further investigation reduced this number to 11. Four areas on the current Equine Center parcel were later determined to require no further action. The former buriarial trench area was subsequently added to the list, resulting in eight AOCs on the current 40 acre eastern parcel. In 1998 M&E conducted a Site reconnaissance and issued a Phase I Property Assessment Amendment (M&E, 1998). The 1998 report added additional historical background, but did not suggest any significant changes to the original Phase I findings concerning contamination at the Site. The 1998 report is included in this document as APPENDIX A.

In 1999 and 2000, M&E conducted field investigations which led to the completion of the Preliminary Phase II Property Assessment (M&E, 2003) for the Ohio VAP (see Figure 4-1 and Table 4-1). This report provided the bulk of the soil and groundwater assessment, and the data are included in APPENDIX B, and data for individual AOCs are provided in tables at the end of this section.

M&E also prepared a VAP Phase I Property Assessment Amendment in June, 2005; however, no new characterization data was provided in the 2005 report. This report M&E, 2005 is presented as APPENDIX C. The second and third volumes of the report are APPENDICIES D and E, and a VAP Checklist included with the report is presented as APPENDIX F.

In 2007, Brown and Caldwell prepared a Phase I Property Assessment specifically for the Equine Center property (Brown & Caldwell, 2007), just to the west of the subject Site. This report includes information pertaining to the 40 acre subject Site and is included as APPENDIX F as additional background information.

4.2 GROUNDWATER DATA ANALYSIS

Shallow groundwater on the property has been studied throughout the Site. Several temporary and permanent monitoring wells have been installed at all 8 AOCs (see Figure 4-2 and Table 4-1). While groundwater data collected to date supports the low migration potential for Site groundwater, this has not been verified by monitoring at the perimeter of the Site. There are also some unanswered questions concerning the presence of potential hot spots of localized groundwater contamination onSite that could present a threat to pending human and ecological receptors. The former trench area (AOC 8) is of particular concern because the area is at the property boundary.

4.3 SOIL DATA ANALYSIS

There are currently 8 AOCs identified on the property. The results of previous investigations at the individual AOCs are presented in the various reports in the APPENDIX, and are discussed individually in the sections below.

4.4 NATURE AND EXTENT OF CONTAMINATION

4.4.1 AOC 1 – Unidentified Rectangular Feature

In late 1999 to mid-2005, a Preliminary Phase II Property Assessment was conducted at the Site. Geophysical results showed several anomalies attributed to surface metal debris so three trenches were excavated of the potential metallic anomalies with no finding of buried items. However, a prominent green silty material with orange sand was present and it exceeded the unrestricted residential use standards under VAP for several metals and the chromium TCLP analysis exceeded the toxicity standard. Approximately 35 hand auger borings were completed within the AOC (Brown & Caldwell, 2007 and Metcalf & Eddy, 2005). Results of the most recent (and most complete) sampling at AOC 1 are presented on Table 4-3.

Surface and subsurface soil are contaminated with metals at unacceptable concentrations. It is unknown if other contaminants such as explosives are present. Also, it is unknown if the chromium is in the more toxic hexavalent form. Additionally, the amount of MEC, if any, is unknown. As a result, human and ecological receptors are at risk from exposure to contaminated soil and possibly MEC.

4.4.2 AOC 2 – Drainage Ditch Near Former Manufacturing Area

Geophysical investigations at AOC 2 revealed a few potential metallic anomalies, the most significant being at the eastern limit of the ditch; higher conductivity areas outside the main ditch line may represent disturbed soils. Seven trenches were subsequently excavated and ordnance was identified both on the surface and at depth. Additional surface debris included glass, laboratory crockery, metal, brick and concrete. Buried debris included ordnance, gray and purple silt-like material, black granular material, white crystalline material, red and orange stained soils, metal, glass, and ceramic debris. Several metals exceeded the VAP standards.

Further investigation of AOC 2 included the installation of 10 borings, collection of a surface water sample, and a sample of the saturated soil from the drainage ditch. An additional trench was completed in a round feature located west of the former Manufacturing Area, where concrete and fill dirt were encountered. No analytical testing was conducted because the materials in the feature were identified in the field as construction debris. Two intact and potentially live primers were identified south of the western edge of the ditch. Soil samples were obtained from the trenches and from 10 borings. Soil exceeded the unrestricted residential use standards under VAP for several metals. Some of the soils had a low pH such that the soils would be classified as corrosive. Results of the most recent (and most complete) sampling at AOC 2 are presented on Tables 4-4, 4-5, and 4-6.

Groundwater samples were collected from four temporary wells and samples exceeded MCLs and VAP unrestricted use standards for several metals; however, these wells had high turbidity and are not believed to be representative of actual groundwater chemistry. A surface water sample from the ditch exceeded the MCL for antimony (Brown & Caldwell, 2007 and Metcalf & Eddy, 2005).

Surface and subsurface soil are contaminated with metals at unacceptable concentrations. It is unknown if other contaminants such as explosives are present. MEC is a known risk at the surface and subsurface but the previous investigations may not have identified all items and the total amount is unknown.

4.4.3 AOC 3 – Burial Area ESE of Burn Pit

Soil exceeded the unrestricted residential use standards under VAP for several metals and perchlorate. One sample was found to be flammable and “produced copious amounts of white smoke.” Another sample was “not flammable but produced red smoke when heated” (Brown & Caldwell, 2007 and Metcalf & Eddy, 2005). Results of the most recent (and most complete) sampling at AOC 3 are presented on Tables 4-7 and 4-8.

Geophysical investigations at AOC 3 revealed a large amount of potential buried metallic objects and areas of high conductivity associated with potentially disturbed soils. Three trenches were completed in the area. Several 55-gallon drums and drum fragments were located on the surface and numerous metallic objects and debris were excavated within the limits of the waste. These included ordnance, drum fragments, metal debris, wood, glass, burned debris, a white crystalline substance, purple powder, black to gray ash, slag, cinders, black granular material, and bright red silty material. Five-gallon pails filled with unidentified residue were also observed. Ordnance was observed both on the surface and at depth, including flares, blasting caps, and canisters.

Fourteen borings (by direct push and hand auger) were installed within and around the waste. Soil exceeded the unrestricted residential use standards under VAP for several metals and perchlorate. One sample was found to be flammable and "produced copious amounts of white smoke." Another sample was "not flammable but produced red smoke when heated."

Groundwater samples were collected from a temporary well in 2000 and a permanent VAP-compliant well, MW-9, in 2005. Due to low well yield and slow recovery, this well was analyzed for only VOCs, chromium, and perchlorate with no exceedances (Brown & Caldwell, 2007 and Metcalf & Eddy, 2005).

Surface and subsurface soil are contaminated with metals at unacceptable concentrations. It is unknown if other contaminants such as explosives are present. MEC is a known risk at the surface and subsurface but the previous investigations may not have identified all items and the total amount is unknown. Considering the preferred unrestricted land use, it is difficult to address MEC without completely excavating the Site soils and so remediation would have an inherent uncertainty. As a result, human and ecological receptors are at risk from exposure to potentially contaminated soil and MEC.

4.4.4 AOC 4 – Burn Pit

Reportedly, prior to 1962, contaminated soil from the burn pit was excavated to a depth of 10 feet and disposed of offsite and the excavation backfilled (Metcalf & Eddy, 1998). Results of the most recent (and most complete) sampling at AOC 4 are presented on Tables 4-9 and 4-10.

No environmental investigations had been conducted at AOC 4 prior to 1998. The location of the burn pit was determined from aerial photographs, and a sizeable area of potentially disturbed soil was subsequently identified south of the Burn Pit in the electromagnetic survey. No metallic debris was identified by the geophysics.

Due to the reported excavation depths of the burn Pit during its operation (up to 10 feet), trenching was not conducted. Ten borings were installed in and around the Burn Pit and the associated anomaly (potentially disturbed area) to the south. Silty clay fill was encountered to depths of approximately 10.5 feet bgs, below which native fill (dense silty clay) was encountered. Three soil samples collected exceeded the VAP residential standard for arsenic, although concentrations were noted as typical of native Ohio soils.

Groundwater samples were collected from three permanent VAP-compliant wells, MW-6, MW-7 and MW-8, in 2005. Wells MW-6 and MW-8 produced enough water for a full suite of analyses (VOCs, SVOCs, inorganics, and perchlorate); however, due to low well yield and slow recovery, well MW-7 well was analyzed for only VOCs, chromium, and perchlorate. No exceedances were noted except for thallium believed to be a laboratory artifact (Brown & Caldwell, 2007 and Metcalf & Eddy, 2005).

4.4.5 AOC 5 – UST in Former Manufacturing Area

The UST was abandoned from use in 1962 (Lawhon & Associates, 1991) and removed in 1997 along with surrounding contaminated soil (Metcalf & Eddy, 2005). The tank was approximately 47 years old at the time of removal. Results of the most recent (and most complete) sampling at AOC 5 are presented on Tables 4-11 and 4-12.

In 1997, the UST was removed. Approximately 3,500 gallons of residual product and water was pumped from the UST and disposed of as petroleum-contaminated liquids. The tank was removed and visually observed to contain numerous holes. A total of 104 cubic yards of impacted contaminated soils, as determined via visual observation and verification sampling, were removed and residual concentrations of petroleum constituents in soils were determined to be below VAP cleanup standards. The excavation was backfilled with clean gravel (Metcalf & Eddy, 2005).

During the Preliminary Phase II Property Assessment, one boring installed in location of former fuel oil tank in 2000 had a strong hydrocarbon odor in soils from 19 to 24 feet below grade, however; no samples were collected from this boring. Four additional borings were installed in 2004 and soils consisted of mostly silty clay or clayey silt with some thin sand and gravel lenses. Soil samples exceeded the VAP residential standard for arsenic.

Groundwater samples were collected from one temporary well and exceeded MCLs and VAP unrestricted use standards for several metals; however, these wells had high turbidity and are not believed to be representative of actual groundwater chemistry. Three permanent VAP-compliant wells, MW-1, MW-2 and MW-3 were installed and sampled. No exceedances were noted except for thallium believed to be a laboratory artifact (Brown & Caldwell, 2007 and Metcalf & Eddy, 2005).

The source has been removed more than 12 years ago and only arsenic in soil was cited as exceeding the standard; further evaluation of the arsenic concentration indicates that the concentration is less than the background concentration established after the investigation (Brown & Caldwell, 2007).

MEC is not expected at the Site based on Site history and previous remediation effort.

Surface and subsurface soil are not perceived to be contaminated based on Site historical source removal effort and a review of data from the investigation. Also, residual groundwater contamination appears to be at acceptable levels. Therefore, there does not appear to be a problem at this AOC.

4.4.6 AOC 6 – Former Experimental Area

Lead and polycyclic aromatic hydrocarbons (PAHs) associated with the discarded containers exceeded VAP standards. To confirm whether soil would be hazardous, three borings were installed to a depth of 16 feet and only arsenic VAP standards were exceeded. Results of the most recent (and most complete) sampling at AOC 6 are presented on Tables 4-13 and 4-14.

Surficial waste was observed in the vicinity during the Phase II investigation, including drums and drum fragments, construction debris, 1-to 3-gallon metal cans, burned debris, ash, slag, cinders, and a black loose granular material. Samples were collected of black residue inside a drum, of soils under a pile of the 1-to 3-gallon containers, and of soil beneath spilled material. During excavation of burial trenches, drum fragments, construction debris, burned debris, ash, slag, cinders, and black granular material, flare casings and black caps. Scattered casings and caps are present on the ground surface. Approximately 100 black canisters were identified during a Site walk. Lead and polycyclic aromatic hydrocarbons (PAHs) associated with the discarded containers exceeding VAP standards. Three borings were installed to a depth of 16 feet and only arsenic VAP standards were exceeded.

Groundwater samples were collected from one temporary well and in 2005, a VAP-compliant well, MW-4, was installed and sampled. Groundwater exceeded MCLs and VAP unrestricted use standards for several metals and the regulatory action level for copper was also exceeded. The exceedances, except for thallium, all occurred in the temporary well; however, these wells had high turbidity and are not believed to be representative of actual groundwater chemistry. Thallium is believed to be a laboratory artifact.

Surface and subsurface soil are contaminated with metals at unacceptable concentrations. It is unknown if other contaminants such as explosives are present. MEC is a known risk at the surface and subsurface but the previous investigations may not have identified all items and the total amount is unknown and a

UXO assessment has not been conducted to date. Considering the preferred unrestricted land use, it is difficult to address MEC without completely excavating the Site soils and so remediation would have an inherent uncertainty. As a result, human and ecological receptors are at risk from exposure to potentially contaminated soil and MEC.

4.4.7 AOC 7 – Cinder Area

Although standards were not exceeded, the materials at AOC 7 are clearly not native soils. Moreover, the orange and red fragments may be associated with unknown contaminants, for example, explosives constituents that were not analyzed for previously. Results of the most recent (and most complete) sampling at AOC 7 are presented on Tables 4-15 and 4-16.

Cinders, coal fragments, and slag were found overlying the native clay loam soils in the latest investigation of AOC 7. The area was investigated using a hand auger. Coal fragments and slag were below VAP standards for SVOCs and metals, but orange and red fragments were present in the cinders and slag (Brown and Caldwell, 2007).

A VAP-compliant monitoring well, MW-10, was installed and sampled in 2005. There were no exceedances of MCLs and VAP unrestricted use standards.

MEC is not expected at the Site based on information collected to date.

4.4.8 AOC 8 – Former Burial Trench Area

Although soil standards were not exceeded it is reasonable to assume that at least some portions of the Site soils are contaminated. Moreover, there may be unknown contaminants, for example, explosive constituents that were not analyzed for previously.

The initial (1962) clean-up of the burial Site consisted of excavation of known trenches. Over 120 tons of explosives and flares were removed and destroyed, including 3500 boosters and 200,000 fuses. A cap mix (red phosphorous, potassium chlorate gum, and antimony trisulphide), black powder, magnesium flares, phosphorus sweepings, ammonium and potassium picrate, caps and primers, M1 flamethrowers, M112 photoflash cartridges, land flares, 66 waste, 155 mm illuminating shells, 3-minute flares and M6, MK5, and M501-type materials were destroyed on the property via burning and/or detonation and the trenches were refilled (Lawhon & Associates, 1991). Later, further information clarified that some materials were destroyed by burning and/or detonation and the remaining materials were relocated to an area near the easternmost Quonset hut for staging prior to shipment from the Site (Metcalf & Eddy, 2005).

In 1985, a Site visit associated with potential sale of the farm resulted in the discovery of approximately 70 flare canisters that had apparently been dug up by plow blades during farming activities. One of the canisters was detonated as a test by the Ordnance Department at Wright-Patterson AFB. In September 1985, the canisters were delivered to Wright-Patterson AFB. In 1986, an additional 80 flare canisters were encountered and removed by Wright-Patterson AFB (Lawhon & Associates, 1991).

In January 1988, S.E.A, Inc. was contracted by Westerville Schools, which was interested in purchasing a portion of the farm, to conduct an environmental study, including the burial trench area. This investigation included monitoring well installation and groundwater sampling. (Groundwater contamination was not deemed to be an issue.) One area investigated with a metal detector had many small unidentifiable metal objects. Excavation of this area occurred and encountered a variety of materials related to Kilgore operations including parachute flares (dated 1954), black plastic caps, short cylinders composed of gray/blue/purple cylindrical-shaped material, gray-white layered solid granular substance, aluminum flitter/sodium nitrate, sulfur, and many filled aluminum canisters. Trenches were dug throughout the burial Site but only a few pieces of debris were encountered. The trenches were not filled in. Examination of the excavated items by the Columbus Bomb Squad found that materials could not be exploded (Lawhon & Associates, 1991).

As part of the Phase I Environmental Audit, a magnetic survey was conducted over the property and it was determined that several “hot areas” still existed in the southeast corner of the Site where the old trenches were located (Lawhon & Associates, 1991).

In the 1996/1997 Phase I ESA 15 trenches were excavated, each 3 ft wide by 6 ft deep and of variable length, for a total of 3,330 linear footage. A pit measuring 30 ft by 40 ft by 5 ft deep was also excavated. Six drums of miscellaneous materials removed, including a 5-gallon bucket of materials which was segregated thought to be potentially energized and was detonated. Empty M112 photoflash casings, M56 projectile fuses, various pyrotechnic debris, and two 55-gallon drums of reddish material assumed to be red phosphorous were removed. Excavated materials were staged at Quonset huts near old farmhouse.

Groundwater in this area was sampled from three wells installed in the area immediately following the trenching (previous wells had been abandoned and result) and analyzed for VOCs, SVOCs, and RCRA 8 metals. Data from three previously installed wells of the 1998 Phase I Property Assessment are of minimal value considering conflicting locational information; limited analysis for EP Tox metals only; the exclusion of some primary metals of concern such as antimony, elevated detection limits; and use of a reagent kit for nitrate. Groundwater concentrations and soil samples were nondetect and/or at concentrations suspected to represent natural conditions (Brown and Caldwell, 2007 and Metcalf & Eddy, 2005).

This AOC was not included in the Preliminary Phase II Property Assessment conducted from late 1999 to mid-2005 because the area was capped and groundwater was not deemed to be contaminated (Metcalf & Eddy, 2005).

MEC is known to be associated with the AOC. Several past remediations have addressed some munitions-related materials in the area. However, it is reasonable to presume that at least some MEC remains on Site.

4.5 NATURE AND EXTENT OF CONTAMINATION

4.5.1 Groundwater

Groundwater migration potential for the Site is low considering that the water bearing zones are discontinuous, thin lenses of sand and gravel interbedded in thick layers of clay and silt so there is a limited conduit for migration. Moreover, it appears that the clay-rich nature of the glacial overburden retards the vertical movement of contaminants and therefore the potential for groundwater contaminant migration is low.

4.5.2 Soil

Contaminated soil present at AOC 1, 2, 3, 6, and 7 extends to the subsurface. Contaminants and could infiltrate further vertically into the subsurface soil and leach from the soil into the shallow groundwater. Cinders, coal fragments, and slag present on the surface AOC 7 extend to near subsurface soil.

AOC 4 migration is not applicable and AOC 5 soil migration is not a concern.

4.6 POTENTIAL RECEPTOR IDENTIFICATION

4.6.1 Groundwater

Based on historic groundwater analysis the groundwater onSite does not pose a threat to public health. The property will be placed under a groundwater use restriction and will be supplied with potable water by the City of Westerville; therefore, groundwater exposures by onSite residential receptors are not anticipated. If retention basins for stormwater management would were constructed as part of a future development of the Site, localized contaminated groundwater could migrate to the surface water in the basins. Under this scenario residential receptors as well as construction workers and ecological receptors, could be exposed to groundwater contaminants connection with surface water.

4.6.2 Soil

The Site is currently fenced. Human receptors are currently not at risk to the soil in the AOCs, except for trespassers. Ecological receptors (pets, wildlife) are at risk directly or via the food chain. Although MEC has not been encountered to date, the uncertain history of the AOCs and proximity to MEC findings at AOC 2 make the presence of MEC suspect. If MEC is present, it would be dangerous if contacted. Also, Munitions Constituents (MC) could leach from munitions items and further contaminate the soil.

5.0 CONCEPTUAL SITE MODEL

A pictorial Conceptual Site Model (CSM) is presented as Figure 5-1. The CSM depicts the general Site location, the Areas of Concern, a simplified geologic cross section, and illustrates a few of the potential receptors. The text in the remainder of Section 5 presents a more detailed CSM.

5.1 SITE LOCATION

The property is located on the east side of Spring Road, approximately 700 feet south of Maxtown Road in a residential area of Westerville, Ohio. The property is surrounded by a mix of residential and school properties. The Site is surrounded by the following:

North: Vacant field and wooded land
East: Vacant wooded land, domestic housing
South: Westerville North High School and Heritage Middle Schools
West: The Otterbein College Equine Science Facility

The property is currently vacant. The property is partially wooded and overgrown with dense grasses and brush. The majority of the Site is covered with a mature woodland. Remnants of gravel roads are still visible but all above-ground structures have been razed. Site topography is generally level with relief less than 10 feet (898 to 890 feet above mean sea level) from west to east across the Site.

5.2 HYDROGEOLOGY

There are no permanently flowing rivers or streams on the Site, but there is a drainage ditch on the northern portion of the property (AOC 2) which has some flow, northwest to southeast, after precipitation events. A large portion of the Site is considered to be wetlands.

The Site is in an area with meager, often inadequate supplies of groundwater. The Site is underlain by a clayey glacial till, which discontinuous sand seams, none of which were found to be extensive. Site groundwater flow was to the east-southeast, consistent with regional flow direction.

5.3 AREAS AND CONSTITUENTS OF CONCERN

The AOCs are described in Section 3 and are summarized on Table 5-1. This table taken from the Phase II report (M&E, 2005) does not include AOC 8 which was not thought to be an issue at the time of the report. According to the 2005 report: “The area was capped previously, at the cessation of historical Site activities, and this has been found to have effectively isolated contaminants in this area. Subsequent groundwater monitoring has also not found any evidence of contaminant migration.” Despite the findings of the 2005 report, the Burial Trench Area has been retained as an AOC in this PER.

The Constituents of Concern (COC) have been determined through numerous investigations at the Site, and are presented on Table 3-2.

5.4 POTENTIAL KNOWN SOURCES OF GROUNDWATER RELEASES

Groundwater is not perceived to be a major issue at this time based on data collected to date; however, there are questions associated with the data. Localized “hot spots” may be present considering elevated concentrations of metals in temporary wells. It is true that the temporary wells did not have a sandpack, nor were the groundwater samples filtered, and the samples had elevated turbidity, resulting in biased high concentrations of metals due to suspended sediment. However, the contaminants were only selectively elevated in some temporary wells, some metals that are typically more soluble like hexavalent chromium would not be explained by elevated turbidity, and temporary wells were not screened at the same intervals as the typically deeper permanent wells. Furthermore, some of the permanent wells do not appear to be properly located i.e., southeast/east of their associated AOC based on groundwater flow direction and so may not be representative.

Some potential contaminants that might be present have not been analyzed in earlier investigations. For example explosives such as trinitrotoluene and dinitrotoluene daughter products and tetryl were not included in the analytical programs. In addition, although perchlorate was included in groundwater analysis, the detection limit, typically 200 µg/L was well above the screening level of 15 µg/L.

Another issue to consider is that although disposal areas were carefully researched, it is possible that source area(s) were not considered. In particular, the settling sumps from the manufacturing area are not identified as a potential source area. It is possible that the wastes may have been released directly from the sumps, if cracked for example, and thus may have contributed to dispersion of contaminants to groundwater. Elevated concentrations of metals in temporary wells MEB 5-2 and MEB 6-5 are of most concern; if the concentrations are indeed elevated, the source and downgradient extent is unknown.

The existing groundwater data has been compared to Ohio VAP standards and Federal MCLs and the results are summarized on Table 5-2.

5.5 GROUNDWATER MIGRATION PATHWAYS AND RECEPTORS

Migration potential is low considering that the water bearing zones are discontinuous, thin lenses of sand and gravel interbedded in thick layers of clay and silt so there is a limited conduit for migration. Moreover, it appears that the clay-rich nature of the glacial overburden retards the vertical movement of contaminants and therefore the potential for groundwater contaminant migration is low. Of the ten wells installed for the Preliminary Phase II Assessment, only three are estimated to produce 1.5 gallons of water per 8 hours. Three wells failed to produce enough groundwater for a full suite of samples, indicating the low hydraulic conductivity of the soils and the general lack of productivity of sand stringers.

Although not necessary to protect public health, the property will also be placed under a groundwater use restriction and will be supplied with potable water by the City of Westerville; therefore, groundwater exposures by onsite receptors are not anticipated. If future development included retention basins for stormwater management, localized contaminated groundwater could migrate to the surface water in the basins and receptors such as trespassers, construction workers and ecological receptors, could be exposed to groundwater contaminants connection with surface water.

5.6 POTENTIAL KNOWN SOURCES OF SOIL RELEASES

Known sources of soil releases are discussed in the following sections, and the existing soil data has been compared to Ohio VAP standards and Federal MCLs and the results are summarized on Table 5-3.

5.6.1 AOC 1 Unidentified Rectangular Feature

The original source(s) of releases in this area are unknown. Contaminated soil present at this Site extends to the subsurface. Contaminants could infiltrate further vertically into the subsurface soil, and leach from the soil into the shallow groundwater.

5.6.2 AOC 2 Drainage Ditch

The original source(s) of releases in this area are unknown. Contaminated soil present at this Site extends to the subsurface. Contaminants could infiltrate further vertically into the subsurface soil and leach from the soil into the shallow groundwater. Also, although flow in the drainage ditch is intermittent, contaminated soil could be washed downstream during precipitation events. MEC is a known issue at the Site and would be dangerous if contacted. Also, MC could leach from munitions items and further contaminate the soil.

5.6.3 AOC 3 Burial Area

The source(s) is reportedly the burn pit (AOC 4) that used once/week to burn off-spec materials and waste. The Burial Area was periodically excavated and resulting cinders and nonflammable material buried in trenches AOC 3 and/or AOC 8 (Metcalf & Eddy, 2005). Contaminated soil present at this Site extends to the subsurface and contaminants and could infiltrate further vertically into the subsurface soil and leach from the soil into the shallow groundwater.

Trespasser receptors are currently at risk. Ecological receptors (pets, wildlife) are at risk directly or via the food chain. MEC is a known issue at the Site and would be dangerous if contacted. Also, MC could leach from munitions items and further contaminate soil.

Surface and subsurface soil are contaminated with metals at unacceptable concentrations. It is unknown if other contaminants such as explosives are present. MEC is a known risk at the surface and subsurface but the previous investigations may not have identified all items and the total amount is unknown. Considering the preferred unrestricted land use, it is difficult to address MEC without completely excavating the Site soils and so remediation would have an inherent uncertainty. As a result, human and ecological receptors are at risk from exposure to potentially contaminated soil and MEC.

5.6.4 AOC 4 Burn Pit

The source(s) was cinders and nonflammable material. However, the source was reportedly removed more than 45 years ago and so, unless contaminated fill was used in filling the excavation, no source remains.

The source was reportedly removed more than 45 years ago and only arsenic was cited as exceeding the standard; further evaluation of the arsenic concentration indicates that the concentration is less than the background concentration established after the investigation (Brown & Caldwell, 2007).
Although historically, contaminants could have leached to groundwater, groundwater concentrations in the area are acceptable, with the exception of a nominal exceedance of arsenic. MEC is not expected at the Site based on Site history and previous remediation effort.

Surface and subsurface soil are not perceived to be contaminated based on Site historical source removal effort and a review of data from the investigation. Therefore, there does not appear to be a problem at this AOC.

5.6.5 AOC 5 UST in Former Manufacturing Area

The UST source tank has been removed as well as surrounding contaminated soil. The source has been removed more than 12 years ago and only arsenic in soil was cited as exceeding the standard; further evaluation of the arsenic concentration indicates that the concentration is less than the background concentration established after the investigation (Brown & Caldwell, 2007). Because the UST and surrounding contaminated soils have been removed, only residual contaminated groundwater may remain.

Although historically, contaminants have leached to groundwater, all of the groundwater exceedances (based on MEB 5-2) are for metals and would not be associated with the fuel oil tank source. Another source of the metals exceedances is suspected especially considering the UST was located in the manufacturing area. While several fuel oil constituents were detected, such as benzene and toluene, concentrations were well below unrestricted use standards.

MEC is not expected at the Site based on Site history and previous remediation effort. Surface and subsurface soil are not perceived to be contaminated based on Site historical source removal effort and a review of data from the investigation. Also, residual groundwater contamination appears to be at acceptable levels. Therefore, there does not appear to be a problem at this AOC.

5.6.6 AOC 6 Former Experimental Area

Contaminated soil present at this Site extends to the subsurface and contaminants and could infiltrate further vertically into the subsurface soil and leach from the soil into the shallow groundwater.

Human receptors (trespassers) are at risk. Ecological receptors (pets, wildlife) are at risk directly or via the food chain. MEC is a known issue at the Site and would be dangerous if contacted. Also, MC could leach from munitions items and further contaminate the soil.

Surface and subsurface soil are contaminated with metals at unacceptable concentrations. It is unknown if other contaminants such as explosives are present. MEC is a known risk at the surface and subsurface but the previous investigations may not have identified all items and the total amount is unknown and a UXO assessment has not been conducted to date. Considering the preferred unrestricted land use, it is difficult to address MEC without completely excavating the Site soils and so remediation would have an inherent uncertainty. As a result, human and ecological receptors are at risk from exposure to potentially contaminated soil and MEC.

5.6.7 AOC 7 Cinder Area

Although standards were not exceeded, the materials are clearly not native soils. Moreover, the orange and red fragments may be associated with unknown contaminants, for example, explosives constituents that were not analyzed for previously.

MEC is not expected at the Site based on information collected to date.
Cinders, coal fragments, and slag present at this Site on the surface extends to near subsurface soil. Contaminants could infiltrate further vertically into the subsurface soil and leach from the soil into the shallow groundwater.

Human receptors are at risk in the form of trespassers. Ecological receptors (pets, wildlife) are at risk directly or via the food chain. Although MEC has not been encountered to date, the uncertain history of the AOC and proximity to MEC findings at nearby AOC 2 make the presence of MEC suspect. If MEC is present, it would be dangerous if contacted. Also, MC could leach from munitions items and further contaminate the soil.

Site materials are clearly waste material, even though analysis to date does not indicate exceedances of criteria. Furthermore, it is unknown if other contaminants such as explosives are present. The orange and red fragments are of particular concern since they remain unidentified. Also, the amount of MEC, if any, is unknown, and a UXO assessment has not been conducted to date. As a result, human and ecological receptors are at risk from exposure to contaminated soil and possibly MEC.

5.6.8 AOC 8 Burial Trench Area

Waste were generally from settling sumps and consisted of mixtures of various chemicals used in the manufacturing process, generally mixtures of red phosphorous, potassium chlorate, gum, and antimony trisulphide. Such mixtures when dry are highly explosive, and so much of the waste was packaged wet in cans, laid in open trenches and covered over with earth. The largest can used for burying was approximately 15 inches in diameter and 30 inches long. Rejected materials, such as pyrotechnical devices, primary explosives, scrap powder, primers, detonators and liquid flares, were also placed in open trenches and covered with earth. The most dangerous of the buried materials was photoflash cartridges. For the most part, the trenches followed the same direction and were the same distance apart (Lawhon & Associates, 1991 and W.R. Grace and Company, 1961). According to a former employee (employed 1952 to 1961), the trench burial area consisted of 20 trenches, 200 ft long by 3 ft wide by 5 ft deep (Metcalf & Eddy, 1998). As new trenches were dug, excavated soil from the new trench was used to cover up the last trench.

Although soil and groundwater standards were not exceeded, it can be presumed that although the selected soil samples had acceptable concentrations, it is reasonable to assume that at least some portion of the Site soils are contaminated. Moreover, there may be unknown contaminants, for example, explosives constituents that were not analyzed for previously.

MEC is known to be associated with the AOC. Several past remediations have addressed some munitions-related materials in the area. However, it is reasonable to presume that at least some MEC remains on Site. The impacted material extends to the subsurface (approximately 10 ft bgs). Any contaminants could infiltrate further vertically into the subsurface soil and leach from the soil into the shallow groundwater. Although groundwater samples collected to date have been previously evaluated as acceptable, that is questionable. Moreover, considering the age of the data (1988), conditions may have changed from that time, especially considering the disturbances that have occurred since that time that resulted in groundwater migration.

Human receptors such as trespassers are at risk. Ecological receptors (pets, wildlife) are at risk directly or via the food chain. MEC is a known issue at the Site and would be dangerous if contacted. Also, MC could leach from munitions items and contaminate/further contaminate the soil.

MC contamination in soil has not likely been fully characterized, considering that soil contamination should be present. In addition, it is unknown if other contaminants such as explosives are present in soil and groundwater. Previously made conclusions that groundwater concentrations are acceptable are questionable considering the limited analyses and unknown well construction methodology. Additionally, the data is old (1996) and may no longer be representative. Moreover the area is of extra concern since it is at the property boundary.

MEC is a known risk at the surface and subsurface but the previous investigations have not likely identified all items and the total amount is unknown. Considering the preferred unrestricted land use, it is difficult to address MEC without completely excavating the Site soils and so remediation would have an inherent uncertainty. As a result, human and ecological receptors are at risk from exposure to contaminated soil and MEC.

However, in spite of the unknowns, information collected to date, in conjunction with preference for unrestricted land use and known MEC dangers, points toward complete removal of Site soils and so may negate the need to conduct additional investigation. The outer perimeter of the Site is not clearly defined, which is an important data gap considering the large size of the AOC greatly impacting evaluation of remediation alternatives.

5.7 SOIL MIGRATION PATHWAYS

Migration of COCs from the soil could be through one of three routes. Migration could occur through the air as a result of wind action. Migration could also occur through surface runoff across impacted areas, with the surface water carrying COCs to surface discharges or infiltration to groundwater. In wetland areas, COCs could dissolve into temporary surface water and either flow offsite or infiltrate into groundwater. Migration of COCs from soil could also occur through solution into water infiltrating into the ground with discharge to the underlying groundwater.

5.8 POTENTIAL HUMAN AND ECOLOGICAL EXPOSURE PATHWAYS

The potential human exposure pathways at the Site are summarized on Table 5-4 taken from the Phase II Report (Metcalf & Eddy, 2005). The potential Ecological Exposure pathways are summarized on Table 5-5 (Metcalf & Eddy, 2005).

6.0 LEVEL I ECOLOGICAL ASSESSMENT

In accordance with Ohio EPA Ecological Risk Assessment Guidance (OEPA, April 2008), a Level I Scoping Ecological Risk Assessment was performed to determine if a 40-acre parcel of the Former Kilgore Manufacturing Site should be further evaluated for ecological risks.

The purpose of a Level I ERA is to eliminate Sites from further ecological risk evaluation that do not have the potential for current or past release of contaminants of interest (COIs) and non-chemical stressors or, do not contain important ecological resources on or in the locality of the Site (OEPA, April 2008). The following questions are to be answered at the completion of the Level I ERA:

a) Are current or past releases at the Site suspected?
b) Are important ecological resources present at or in the locality of the Site?

The presence of ecological resources and the history of releases of hazardous substances at the Site are evaluated in the following sections.

6.1 EXISTING DATA SUMMARY

The Former Kilgore Manufacturing Site located in Westerville, Ohio encompasses approximately 111 acres (see Figure 1-1 for regional Site location). The portion of the Site being evaluated in this report consists of a 40-acre parcel (see Figure 3-2). The Site is partially wooded and overgrown with dense grasses and brush. The groundwater table within the 40 acre parcel is shallow, and several temporary and permanent monitoring wells are located throughout the Site.

Section 3.1 provides details of the Site history. In summary, the Site was previously a pyrotechnic and ordnance manufacturing facility. Activities on Site included manufacturing explosives and incendiary items and denotation devices and burning and disposal of wastes. Previous investigations have identified disposed materials in soil from Site operations and findings are summarized in Section 4.

The Site is currently vacant and above ground structures have been destroyed. The 40-acre parcel, owned by Otterbein College, is intended for residential development.

Threatened and endangered species were identified as part of wetland delineation for an adjacent Site within the Former Kilgore Manufacturing Site [see Attachment X for correspondence from United States Fish and Wildlife Service (USFWS) and Ohio Department of Natural Resources (ODNR)]. It is expected that the threatened and endangered species identified as potentially present at the adjacent Site would be

potentially present at the 40-acre parcel due to proximity and similar habitat. No rare or endangered species or other significant natural features were identified by the ODNR for the Site although the Site is within the range of the Indiana Bat (Myotis sodalis), an endangered species. If trees or habitat for the Indian Bat are present at the Site, the USFWS should be contacted prior to cutting trees. The Site is within the range of the bald eagle, which is a protected species; however, due to Site location and habitat, it is not expected to be present at the Site. The clubshell mussel (Pleurobema clava) and rayed bean mussel (Villosa fabalis) are endangered and candidate species, respectively, that may be present in the area; however, given the Site location, these species are not expected to be impacted.

6.2 SITE VISIT SUMMARY

A Site visit was completed to evaluate the quality of the wetlands present at the Site (see Attachment X-prelim jurisdictional opinion). Several forested, scrub/shrub, and emergent wetland areas covering half of the 40-acre Site were identified. The remaining 20 acres consist of dense grasses and brush. Based on the habitat at the Site, (see Site photographs in Attachment X), soil invertebrates, birds and mammals are likely present at the Site. An aquatic bed was identified in one of the wetland areas creating habitat for amphibians. Threatened or endangered species are not anticipated at the Site; however, the Site may contain habitat for the Indiana Bat, an endangered species.

Based on the Site activities, hazardous substances may have be released into the soil and potentially migrated to the shallow groundwater. Chemicals of potential concern in soil and groundwater include chemicals that would have been used in the manufacture and assembly of explosives and incendiary items and denotation devices (see Table 3-2). Previous investigations have identified elevated levels of metals in soils at the Site.

6.3 RECOMMENDATIONS

A Level II Screening ecological Risk Assessment should be conducted because habitat for ecological receptors is present that the Site and ecological receptors may be impacted by chemicals of potential concern in the soil and groundwater.

7.0 PRE-INVESTIGATION EVALUATION OF REMEDIAL ALTERNATIVES

7.1 PRELIMINARY REMEDIATION GOALS

The development of Preliminary Remediation Goals (PRGs) takes into consideration Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBCs) criteria. Section 7.3 identifies the ARARs and TBCs.

7.2 REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives (RAOs) are medium-specific goals that define the objectives of conducting remedial actions to protect human health and the environment. The RAOs specify the COCs, potential exposure routes and receptors, and acceptable ranges of contaminant concentrations [i.e., PRGs] for the Site.

Site-specific RAOs specify COCs, media of interest, exposure pathways, and cleanup goals or acceptable contaminant concentrations. The RAOs for this evaluation were developed based on the future potential land use as residential property and an extension of the Otterbein College campus, with the goals of protecting the public from potential current and future health risks.

The following RAOs were developed for the Site:

RAO 1: Prevent unacceptable human health risk associated with exposure to soil containing metals, sulfates, perchlorates, phosphorus, and MEC at concentrations greater than PRGs.

RAO 2: Prevent unacceptable risk to human and ecological receptors associated with exposure to groundwater containing metals at concentrations greater than PRGs.

7.3 FEDERAL ARARS, STATE REQUIREMENTS, AND TBCS

7.3.1 Chemical-Specific ARARs and TBCs

The following federal and state chemical-specific ARARs and TBCs are considered to be potentially applicable to the Site:

ARARs

- Maximum contaminant levels (MCLs) under the Safe Drinking Water Act (SDWA), 40 C.F.R. 141. MCLs are enforceable standards for public drinking water supply systems which have at least 15 service connections or are used by at least 25 people. These requirements are not directly applicable since groundwater at the Site is not a public water supply. However, because ground water may migrate off-Site, potentially to a public drinking water source, MCLs are considered to be relevant and appropriate requirements for this Site.

- Ohio Administrative Code (OAC) Section 3745-81 relates to MCLs for organic and inorganic contaminants of concern.

TBCs

- USEPA Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites for Residential and Industrial Receptors (USEPA Oak Ridge National Laboratory, 2008).

- EPA-Region 9 preliminary remediation goals (PRGs) are risk-based tools for evaluating and cleaning up contaminated Sites.

- USEPA SSLs developed according to guidance provided in the U.S. EPA's Soil Screening Guidance and calculated on the USEPA's Soil Screening Guidance website (USEPA, 2008).

- RCRA Subtitle C – regulates the disposal of hazardous solid waste from its generation until its ultimate disposal.

7.3.2 Location-Specific ARARs and TBCs

The following presents a summary of federal and state location-specific ARARs and TBCs that are considered to be potentially applicable to the Site:

- USEPA's Groundwater Protection Strategy (USEPA 1984): Subclass IIIA includes groundwater not a potential source of drinking water and of limited beneficial use. Such groundwater units are highly intermediately interconnected to adjacent groundwater units of a higher class and/or surface waters. They may, as a result, be contributing to the degradation of the adjacent waters.

- Historic Sites, Buildings, and Antiquities Act of 1935 [16 United States Code (USC) 461 et seq.] states that it is federal policy to preserve historic and prehistoric properties of national significance. The Site is not classified as such a property, nor is it known to possess aspects of historic or prehistoric significance; however, this Act would be applicable if information was found to classify it as such a property. As such, this Act is potentially applicable.

- Section 404 of the Clean Water Act (CWA) establishes a program to regulate the discharge of dredged or fill material into waters of the United States, including wetlands. Activities in waters of the United States regulated under this program include fill for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports) and mining projects. Section 404 requires a permit before dredged or fill material may be discharged into waters of the United States, unless the activity is exempt from Section 404 regulation (e.g. certain farming and forestry activities).

7.3.3 Action-Specific ARARs

The following action-specific ARARs and TBCs are considered to be potentially applicable to the Site:

- RCRA Subtitle C requirements may be applicable when the waste is sufficiently similar to a hazardous waste and/or the on-Site remedial action constitutes treatment, storage, or disposal, and the particular RCRA requirement is well suited to the circumstances of the contaminant release and Site. RCRA Subtitle C requirements may also be applicable when the remedial action constitutes generation of a hazardous waste. On-Site activities, mandated by a federally ordered Superfund cleanup, must comply with the substantive requirements of RCRA Subtitle C, but not with the administrative requirements (i.e., permits) of RCRA. The RCRA Subtitle C requirements must be met if the cleanup is not under federal order and/or when the hazardous waste moves off Site.

- National Ambient Air Quality Standards (NAAQSs) (40 CFR 50) promulgated under the Clean Air Act (42 U.S.C. 7401) require the attainment and maintenance of primary and secondary NAAQSs to protect public health and public welfare, respectively. These standards are not source-specific, but rather are national limitations on ambient air quality. States are responsible for assuring compliance with the NAAQSs. The implementation, maintenance, and enforcement of NAAQSs are potentially applicable ARARs.

- Department of Transportation Rules for Hazardous Materials Transport (49 CFR Parts 107 and 171 179) regulate the transport of hazardous materials, including packaging, shipping equipment, and placarding. These rules are considered potentially applicable to wastes shipped off Site for laboratory analysis, treatment, or disposal.

- The Occupational Safety and Health Administration Standards (29 CFR 1910) regulate occupational safety and health requirements applicable to workers engaged in on-Site field activities.

- Soil Conservation Act (U.S.C. 5901 et seq.) provides for the application of soil conservation practices on federal lands. During remedial activities, implementation of such practices would be required.

7.4 GENERAL RESPONSE ACTIONS

GRAs are broadly defined remedial approaches that may be used (by themselves or in combination with others) to attain the RAOs. Action-specific ARARs and TBCs are those regulations, criteria, and guidance that must be complied with or taken into consideration during on-Site implementation of GRAs. The following GRAs were considered for the Site:

- No Action – no direct action to be conducted to remediate the Site
- Limited Action [i.e. Land Use Controls (LUCs)]
- Excavation and Disposal of Contaminated Soil
- Capping of Contaminated Soil

7.5 PRELIMINARY REMEDIAL ALTERNATIVES

This section identifies, screens, and evaluates the potential remediation technologies and process options that may be applicable to the Site. The primary objective of this phase of the FS is to develop an appropriate range of remediation technologies and process options that will be used for developing remedial alternatives.

7.5.1 Preliminary Screening of Remedial Technologies and Process Options

The preliminary screening of remediation technologies and process options is based on overall applicability to the medium of concern, COCs, and specific conditions present at the Site. Table 7-1 summarizes the preliminary screening of remediation technologies and process options for both GRAs.

7.5.2 Detailed Screening of Remediation Technologies and Process Options

7.5.2.1 No Action

No Action would consist of “walking away” from the Site without implementing any remedial action or performing any monitoring and/or maintenance. As required under CERCLA regulations, the No Action

alternative is carried through the FS to provide a baseline for comparison to other alternatives and their effectiveness in mitigating risks posed by Site COCs.

Effectiveness

The No Action alternative would not be effective in reducing risks or meeting the RAOs and PRGs because no exposure control or treatment would be performed. Because no monitoring or maintenance would be performed, the No Action alternative would not be effective in evaluating the potential migration of COCs, or the potential reduction of COC concentrations.

Implementability

There would be no implementability concerns because no actions would be implemented.

Cost

There would be no costs associated with the No Action alternative.

Conclusion

Although it would not be effective, the No Action alternative will be retained for comparison to other options.

7.5.2.2 LUCs

LUCs would include property and/or groundwater use restrictions. The AOCs would be restricted to non-sensitive industrial/commercial use (i.e. no daycares or schools). The installation of groundwater wells (other than for use as environmental monitoring wells) would be prohibited.

Effectiveness

LUCs alone would not effectively reduce concentrations of COCs. However, LUCs would be an effective tool to prevent future exposure to the COCs.

Implementability

LUCs could be readily implemented at this Site.

Cost

Costs to implement and maintain the LUCs would be low.

Conclusion

LUCs are retained for the development of remedial alternatives.

7.5.2.3 Removal

The only technology considered for removal is mechanical excavation. Mechanical excavation of the impacted soil would be performed using excavators. After the excavation is completed, the location would be filled and graded with clean fill material. Excavated materials would be transported offSite for disposal in a hazardous landfill.

Effectiveness

Mechanical excavation would not reduce concentrations of COCs in the impacted soil, but it would be an effective means of isolating soil with COC concentrations greater than PRGs by transporting it from the Site to an off-Site disposal facility.

Implementability

Mechanical excavation of soil would be implementable, and the necessary resources, equipment, and materials would be readily available. It is anticipated that some of the excavated material would be disposed in a hazardous waste landfill. Potential wetland issues would require the acquisition of special permits, and the schedule of excavation might have to be adjusted to coincide with the dry season of the year.

Cost

The cost of mechanical excavation would be moderate (although potential wetland issues could impact the costs significantly).

Conclusion

Mechanical excavation is retained for the development of remedial alternatives.

7.5.2.4 Containment at AOC 8

The technology considered for containment is capping. A multimedia cap would be constructed at AOC 8 using a cushion layer of soil, an impermeable, flexible membrane liner (FML), a layer of cover soil and an asphalt cap. This has received preliminary (verbal) approval from Ohio EPA according to Brown and Caldwell (2007). Mechanical excavation will be conducted at the other AOCs.

Effectiveness

Capping would not of itself remove the soil COCs or reduce their toxicities. Nonetheless, capping is a well-established and proven technology that would be effective in preventing direct exposure to the contaminated soil. A cap would also be effective in minimizing the potential for migration of soil COCs from either leaching to groundwater or off-Site erosion. Long-term maintenance of the cap and long-term monitoring would ensure the continued effectiveness of the cap.

Implementability

Capping of soil would be implementable, and the necessary resources, equipment, and materials would be readily available. Wetland issues could potentially impact the ability to a portion of AOC 8. Further identification of both the extent of AOC 8 and the extent of the wetlands are necessary to assess the implementability of capping in this area.

Cost

The cost of capping at AOC 8 would be moderate (presuming wetlands are not an issue).

Conclusion

Capping is retained for the development of remedial alternatives.

7.5.3 Development of Preliminary Remedial Alternatives

In this section, the remediation technologies retained from the components selected in Section 7.5.2 are assembled into the following preliminary remediation alternatives:

- Alternative 1: No Action
- Alternative 2: LUCs
- Alternative 3: Excavation and Off-Site Disposal of All AOCs
- Alternative 4: Capping and LUCs at AOC 8 and Excavation and Off-Site Disposal of All Other AOCs

8.0 IDENTIFICATION OF DATA NEEDS AND DATA USAGE

8.1 ANALYSIS OF RI/FS SOW TASKS

This PER is only the first step in the Remedial Investigation/Feasibility Study (RI/FS) process. Following review of this PER by OEPA Otterbein will prepare a RI/FS Workplan. The OEPA guidance requires that the PER evaluate the various Statements of Work (SOW) be evaluated to determine if they are: 1) already completed; 2) not relevant to the Site; or 3) relevant to the Site and will be addressed in the RI/FS Workplan. Otterbein has reviewed the various SOWs and has determined that all of the SOWs are relevant with the exception of treatability studies. At this time the screened alternatives do not include any which would require a treatability study.

A majority of the Site characterization has been completed; however, additional characterization is necessary and thus the SOW for characterization will be included in the process. All other SOWs listed in the OEPA guidance will be included in the RI/FS process.

The RI/FS Workplan will follow the guidance provided in the Generic Statement of Work for Conducting Remedial Investigations and Feasibility Studies (OEPA, 2006), and will be submitted to OEPA for review and approval. The purpose of the RI/FS Workplan is to present the plan for performing the investigation required to obtain the data necessary to complete the assessment of the Site, and obtain the data needed to evaluate the potential remedial alternatives which have been identified. The RI/FS Workplan will also identify the process of evaluating and ultimately identifying the final remedy for the Site.

The RI/FS Workplan will consider the groundwater and soil data needs and employ the Data Quality Objective process to specify the types of data required to make rational decisions about the remedy for the Site. Elements of the plan will include a Field Sampling Plan, a Quality Assurance Project Plan and a Health and Safety Plan.

8.2 GROUNDWATER DATA NEEDS

While groundwater data collected to date supports the low migration potential for Site groundwater, it has not been verified that this is true at the perimeter of the Site. The former trench area (AOC 8) is of particular concern because the area is at the property boundary, and any impacts would be transported offsite.

There are also unanswered questions concerning the presence of potential hot spots of localized groundwater contamination onsite that could present a threat to pending human and ecological receptors.

Much of the previous groundwater data was collected from temporary monitoring wells, and the data cannot be replicated.

The groundwater data gaps would be addressed by the following:

- Resampling of the eight existing Site monitoring wells.
- Installation and monitoring of two wells downgradient of the former UST.
- Installation and monitoring of a well downgradient of the manufacturing area.
- Installation and monitoring of a well in AOC 6 where temporary wells yielded samples exceeding VAO standards.
- Installation and monitoring of a well downgradient of AOC 6 where a temporary well yielded samples exceeding VAO standards.
- Installation and monitoring of four wells along the property boundary, potentially downgradient of various AOCs.
- Installation and monitoring of three wells on downgradient side of the former burial

8.3 SOIL DATA NEEDS

8.3.1 AOC 1 Unidentified Rectangular Features

No additional investigation needed for characterization of this AOC; however, two additional soil borings are recommended to confirm earlier analytical results. Information collected to date, in conjunction with preference for unrestricted land use and potential MEC dangers, points toward complete removal of Site soils.

8.3.2 AOC 2 Drainage Ditch Area

Additional soil borings are required to complete the characterization of AOC 2. Although information collected to date, in conjunction with preference for unrestricted land use and known MEC dangers, points toward complete removal of Site soils, additional testing is required to determine the “nature” of the MEC in this AOC. Approximately six borings will be required to complete the characterization.

8.3.3 AOC 3 Burial Area

Although information collected to date, in conjunction with preference for unrestricted land use and known MEC dangers, points toward complete removal of Site soils; additional sampling should be conducted in this area to confirm earlier findings and validate existing analytical results. Two additional soil borings should be sufficient to complete the characterization of the Burial Area (AOC 3).

8.3.4 AOC 4 Burn Pit

No further action is anticipated at the Burn Pit. Surface and subsurface soil are not perceived to be contaminated based on Site historical source removal effort and a review of data from the investigation. Therefore, there does not appear to be a problem at this AOC. Three borings are suggested to confirm existing data and additional analytical parameters will be used to determine the "nature" of the impacts in this area.

8.3.5 AOC 5 UST in Former Manufacturing Area ESE

No further action is anticipated in this AOC. Surface and subsurface soil are not perceived to be contaminated based on the UST source/soil removal effort, and a review of data from the investigation. Three additional borings are anticipated in this area in order to confirm the earlier soil sampling and determine if there are any residual effects from the former UST. Residual groundwater contamination appears to be at acceptable levels; however, several new and existing monitoring wells will be used to monitor potential releases from the former tank.

8.3.6 AOC 6 Former Experimental Area

Although AOC 6 appears to have been sufficiently characterized, three additional borings will be performed to confirm earlier results.

8.3.7 AOC 7 Cinder Area

"Red and orange materials" were observed in this area, but were not identified. Three additional borings will serve to characterize the "nature" of these materials in AOC 7.

8.3.8 AOC 8 Southeast Landfill Area

The outer perimeter of AOC 8 is not clearly defined, and estimates of the size of the area vary. Several investigations and removal actions have occurred in this area. Existing characterization data is not sufficient to fully characterize potential MEC constituents. As a result both the "nature and extent" of remaining impact are uncertain at this time. Additional characterization will consist of up to 20 borings within the interior of the area for characterization, and several hundred feet of backhoe trenching to define the boundaries of the area.

8.4 ADDITIONAL WETLANDS IDENTIFICATION

The review of the existing preliminary wetlands report (CEC, ___) indicates that wetlands exist on the Site and that further definition is required to fully characterize the Site and evaluate the ultimate remedial options.

8.5 DQOS

The process of designing the Remedial Investigation will employ a form of the Data Quality Objective Process following the seven step process:

- State the problem
- Identify the goals of the study
- Identify information inputs
- Define the boundaries of the study
- Develop the analytic approach
- Specify performance or acceptance criteria
- Develop plan for obtaining data

The DQO process will consider the various needs for data. An example of soil decisions would include decisions relating to risk of soil contamination, potential source of contamination to groundwater, and effect upon the design of the soil and/or groundwater remediation.

The plan for obtaining data will generally be made using the judgmental sampling design method.

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TABLES

TABLE 2. POTENTIAL CHEMICALS OF CONCERN

CHEMICAL NAME	USE
Aluminum	Photoflash Flares, Smoke Flare, Incendiary Bombs
Antimony	Colored Flares
Antimony Trisulfide	Igniter, Primer in Flame Throwers
Ammonium Chloride	Smoke Flares
Ammonium Perchlorate	Smoke Flares
Ammonium Picrate	Igniters, Primer
Barium Nitrate	Photoflash Flare, Parachute Flares,
Barium Rhodanide	Stab Primers
Barium Sulfate	Float Flares, Underwater Flares
Black Powder	Accelerant in flares, Black Caps
Boron Phosphide	Igniter, Primer
Calcium	Colored Flares,
Castor Oil	Binder, oxidation inhibitor for Al and Mg, and lubricant
Copper Oxide	Colored Flares
Hexachlorobenzene	Colored Flares
Hexachloroethane	Smoke Flares
Iron Oxide	Colored Flares
Laminac	Unsaturated Polyester binder
Lead Azide	Stab Primers
Lead Thiocyanate	Stab Primers
Lead Oxide	Stab Primers
Lead Styphnate	Stab Primers
Linseed Oil	Binder in Black Powder Pelletization Process, oxidation inhibitor
Magnesium	High and medium intensity Flares, Incendiary Bombs
Mercury Fulminate	Primer
Phosphorous	Combined Light and Smoke Flares
Potassium Chlorate	Flares
Potassium Nitrate	Gun Powder Formulation, Flares
Potassium Perchlorate	Photoflash Flares, High Altitude Flash Charges, Smoke Flares
Sodium Hypophosphite	Igniter
Sodium Nitrate	Gun Powder Formulation, High Intensity Flares
Sodium Oxalate	Colored Flares
Sodium Perchlorate	High Altitude Flash Charges
Strontium Nitrate	Colored Flares
Strontium Oxalate	Slow Burning Flares, Road Flares
Sulfur	Gun Powder Formulation, Accelerants
Tetryl	Primer
Trinitrotoluene (TNT)	Shaped Charges
Zinc	Smoke Flares
Zinc Oxide	Smoke Flares
Zirconium Hydroxide	Parachute Flare, Igniter

Table 4

Overview of Investigations and Related Activities

Former Kilgore Manufacturing Facility

Date	**Event**
December 1941	Property purchased by Kilmore Manufacturing from Joe and Eva Morris in response to needs of the Chemical Warfare Service
Summer 1962	Joliet Arsenal conducts evaluation and cleanup of Kilgore property
June 1985	Otterbein Board member Ernest Fritsche identified flare canisters which were removed for disposal
Summer 1986	Mr. Fritsche and US Corps of Engineers found additional canisters which were removed for disposal
February 26, 1988	S.E.A. environmental assessment of the Kilgore property (no significant problems)
Summer 1988	Otterbein hires Lama to trench property; Lama said property was "clean and safe."
January 24, 1992	Army Corps of Engineers denies Kilgore eligibility under FUDS (Formerly Used Defense Sites), Dept. of Defense environmental cleanup program
October 22, 1992	Ohio EPA preliminary assessment of the Kilgore property
1992-1997	Lawhon & Assoc. conducts environmental investigations for Keethler
November 1996	Wright-Patterson Air Force Base conducts demilitarization of ordnance at Kilgore
May 1998	Metcalf & Eddy Phase I assessment conducted for Keethler
1999 and 2000	Various field investigations including borings, wells and test pits
October 2003	Metcalf & Eddy Phase II Environmental Assessment (soil/groundwater sampling)
May 2, 2007	Ohio EPA issues draft administrative order to Otterbein to conduct Kilgore cleanup
July 12, 2007	Brown & Caldwell estimates Kilgore cleanup cost, totaling $3,751,688
October 24, 2008	Ohio AG issues draft consent decree to Otterbein and US DOJ re Kilgore cleanup

TABLE 3
PRELIMINARY PHASE II SAMPLING LOCATIONS
KILGORE FARMS

SAMPLE	AOC #	AOC Description	Depth	Matrix	Notes
T-1B-2	1	Rectangular Area	*	soil	
T-1C-1	1	Rectangular Area	*	soil	
MEB-1-4(0.5-1)	1	Rectangular Area	0.5 - 1 feet	soil	
MEB-1-7(1.5-3)	1	Rectangular Area	1.5 - 3 feet	soil	
MEB-1-23(1.5-3)	1	Rectangular Area	1.5 - 3 feet	soil	
MEB-1-24(1.5-3)	1	Rectangular Area	1.5 - 3 feet	soil	
MEB-1-33	1	Rectangular Area	surface soil	soil	
MEB-NE TRENCH	1	Rectangular Area	surface soil	soil	
HA-1 (0-2)	1	Rectangular Area	surface soil	soil	Location displayed on Figure 3 is approximate
HA-2 (0-2)	1	Rectangular Area	surface soil	soil	Location displayed on Figure 3 is approximate
T-2A-3	2	Drainage Ditch	*	soil	
T-2B-2	2	Drainage Ditch	*	soil	
T-2C-2	2	Drainage Ditch	*	soil	
T-2C-3A	2	Drainage Ditch	*	soil	
T-2C-3B	2	Drainage Ditch	*	soil	
T-2C-4	2	Drainage Ditch	*	soil	
T-2D-1	2	Drainage Ditch	*	soil	
T-2G-1	2	Drainage Ditch	*	soil	
SED-1	2	Drainage Ditch		sediment	
MEB-2-3(4-4.5)	2	Drainage Ditch	4 - 4.5 feet	soil	
SW-1	2	Drainage Ditch	--	surface water	
MEB-2-7	2	Drainage Ditch	**	groundwater	DTW: 1.28; TD: 10.92
MEB-2-8	2	Drainage Ditch	**	groundwater	DTW: 1.68; TD: 19.10
MEB-2-9	2	Drainage Ditch	**	groundwater	DTW: 2.61; TD: 11.19
MEB-2-10	2	Drainage Ditch	**	groundwater	DTW: 1.68; TD: 19.86
T-3A-1	3	Area SE of Burn Pit	*	soil	
T-3A-2	3	Area SE of Burn Pit	*	soil	
T-3B-2	3	Area SE of Burn Pit	*	soil	
T-3E-2	3	Area SE of Burn Pit	*	soil	
MEB-3-13(1-1.5)	3	Area SE of Burn Pit	1 - 1.5 feet	soil	
MEB-3-14(0-0.5)	3	Area SE of Burn Pit	0 - 0.5 feet	soil	
MEB-3-14(0.5-1)	3	Area SE of Burn Pit	0.5 - 1 feet	soil	
MEB-3-2	3	Area SE of Burn Pit	**	groundwater	DTW: 2.26; TD: 15.36
MEB-4-3(8-8.2)	4	Burn Pit	8 - 8.2 feet	soil	
MEB-4-4(8-8.5)	4	Burn Pit	8 - 8.5 feet	soil	
MEB-4-9(9.5-10)	4	Burn Pit	9.5 - 10 feet	soil	
MEB 5-2 (4-6)	5	Former Mfg. Area	4 - 6 feet	soil	Location displayed on Figure 3 is approximate
MEB 5-2	5	Former Mfg. Area		groundwater	temporary well; sample depth not available
MEB 5-3 (2-4)	5	Former Mfg. Area	2 - 4 feet	soil	Location displayed on Figure 3 is approximate
MEB 5-4 (6-8)	5	Former Mfg. Area	6 - 8 feet	soil	Location displayed on Figure 3 is approximate
MEB 5-5 (4-6)	5	Former Mfg. Area	4 - 6 feet	soil	Location displayed on Figure 3 is approximate
MEB-6-1	6	Experimental Area	drum	soil	sampled from drum
MEB-6-2	6	Experimental Area	surface	soil	sampled of soil beneath spilled drum material
MEB-6-3	6	Experimental Area	surface	soil	soil from beneath pile of paint cans
MEB 6-4 (10-12)	6	Experimental Area	10 - 12 feet	soil	
MEB 6-5 (5-10)	6	Experimental Area	5 - 10 feet	soil	
MEB 6-5	6	Experimental Area		groundwater	temporary well; sample depth not available
MEB 6-6 (4-6)	6	Experimental Area	4 - 6 feet	soil	Location displayed on Figure 3 is approximate
MEB-7-1	7	Cinder Area	0 - 0.5 feet	soil	
MW-1	5	Former Mfg. Area	15-20 feet	groundwater	DTW: 2.95; TD: 22.6
MW-2	5	Former Mfg. Area	10-15 feet	groundwater	DTW: 3.70; TD: 17.21
MW-3	5	Former Mfg. Area	16-21 feet	groundwater	DTW: 4.95; TD: 23.11
MW-4	6	Experimental Area	22-27 feet	groundwater	DTW: 7.68; TD: 30.34
MW-5	1	Rectangular Area	13-18 feet	groundwater	DTW: 13.8; TD: 20.35; VOCs, Cr and perchlorate only
MW-6	4	Burn Pit	35-40 feet	groundwater	DTW: 27.48; TD: 40.20; VOCs, Cr and perchlorate only
MW-7	4	Burn Pit	35-40 feet	groundwater	DTW: 39.2; TD: 43.1; VOCs, Cr and perchlorate only
MW-8	4	Burn Pit	21-26 feet	groundwater	DTW: 4.34; TD: 28.28
MW-9	3	Area SE of Burn Pit	22-27 feet	groundwater	DTW: 19.62; TD: 28.75
MW-10	7	Cinder Area	19-24 feet	groundwater	DTW: 6.44; TD: 30.05
Farm 1	--	Former Farm Area	surface	soil	Not an AOC: sampled for pesticides only
Farm 2	--	Former Farm Area	surface	soil	Not an AOC: sampled for pesticides only
Farm 3	--	Former Farm Area	surface	soil	Not an AOC: sampled for pesticides only

* = Indicates grab sample from backhoe bucket; trenching depth varied from approximately 3 to 4 feet

** = Groundwater was sampled from temporary piezometers screened from total boring depth to approximately 1 foot below grade

DTW = Depth to water in feet below ground surface

TD = Total depth of boring in feet below grade

Includes only samples submitted to the laboratory. 38 hand auger borings in AOC 1 were done to visually inspect the soil.

QA/QC samples not included

Soil sample 5-1 is not included because it was not analyzed.

TABLE 4. OFF-SITE LABORATORY ANALYTICAL METHODS SUMMARY
KILGORE FARMS PHASE II

Analysis	Method (1)	PQLs(2)	Holding Time (3)	Report Level (4)	Turn Around Time (5)	Matrix
Drainage Ditch -Soil						
TAL Metal	SW-6010A/ 6020/ 7000	various*	180 days, except Hg which is 28 days	II	**14 days**	Soil
Boron	SW-6020	1 mg/kg	180 days	II	**14 days**	Soil
Ortho-Phosphate	SM 4500 E-2	1mg/Kg	28 days	II	**14 days**	Soil
Nitrite	EPA-353.2	1 mg/Kg	28 days	II	**14 days**	Soil
Nitrate	EPA-353.2	1 mg/Kg	48 hours	II	**14 days**	Soil
Sulfide	EPA-376.2	10 mg/Kg	7 days	II	**14 days**	Soil
Sulfate	EPA-300.0	10 mg/Kg	28 days	II	**14 days**	Soil
Chlorate	EPA-300.0	1 mg/Kg	14 days	II	**14 days**	Soil
Perchlorate	EPA-300.0	5 mg/Kg	14 days	II	**14 days**	Soil
Ignitability	SW-846, Ch.7	NA	7 days	II	**14 days**	Soil
Reactivity	SW-846, Ch.7	10 mg/Kg - Sulfide, 1 mg/Kg- CN	7 days	II	**14 days**	Soil
Corrosivity	SW-846, Ch.7	NA	Immediately upon receipt by the lab.	II	**14 days**	Soil
VOCs w/Ketones	SW-8260A (Up.II)	1-5 ug/Kg	14 days	II	**14 days**	Soil
Drainage Ditch - Sediment						
TAL Metal	SW-6010A/ 6020/ 7000	various*	180 days, except Hg which is 28 days	II	**14 days**	Sediment
Boron	SW-6020	1 mg/kg	180 days	II	**14 days**	Sediment
Ortho-Phosphate	SM 4500 E-2	1mg/Kg	28 days	II	**14 days**	Sediment
Nitrite	EPA-353.2	1 mg/Kg	28 days	II	**14 days**	Sediment
Nitrate	EPA-353.2	1 mg/Kg	48 hours	II	**14 days**	Sediment
Sulfide	EPA-376.2	10 mg/Kg	7 days	II	**14 days**	Sediment
Sulfate	EPA-300.0	10 mg/Kg	28 days	II	**14 days**	Sediment
Chlorate	EPA 300.0	1 mg/Kg	14 days	II	**14 days**	Sediment
Perchlorate	EPA 300.0	5 mg/Kg	14 days	II	**14 days**	Sediment
Drainage Ditch - Surface Water						
TAL Metal	SW-6010A/ 6020/ 7000	various*	180 days, except Hg which is 28 days	II	**14 days**	SW
Boron	SW-6020	0.1 mg/L	180 days	II	**14 days**	SW
Ortho-Phosphate	SM 4500 E-2	0.1 mg/L	28 days	II	**14 days**	SW
Nitrite	EPA-353.2	0.1 mg/L	28 days	II	**14 days**	SW
Nitrate	EPA-353.2	0.1 mg/L	48 hours	II	**14 days**	SW
Sulfide	EPA-376.2	1 mg/L	7 days	II	**14 days**	SW
Sulfate	EPA-300.0	1 mg/L	28 days	II	**14 days**	SW
Chlorate	EPA-300.0	0.05 mg/L	14 days	II	**14 days**	SW
Perchlorate	EPA-300.0	0.5 mg/L	14 days	II	**14 days**	SW

TABLE 4. OFF-SITE LABORATORY ANALYTICAL METHODS SUMMARY
KILGORE FARMS PHASE II

Analysis	Method (1)	PQLs(2)	Holding Time (3)	Report Level (4)	Turn Around Time (5)	Matrix
Rectangular Features-Soil						
TAL Metal	SW-6010A/ 6020/ 7000	various*	180 days, except Hg which is 28 days	II	**14 days**	Soil
Boron	SW-6010 or 6020	1 mg/kg	180 days	II	**14 days**	Soil
Ortho-Phosphate	SM 4500 E-2	1mg/Kg	28 days	II	**14 days**	Soil
Nitrite	EPA-353.2	1 mg/Kg	28 days	II	**14 days**	Soil
Nitrate	EPA-353.2	1 mg/Kg	48 hours	II	**14 days**	Soil
Sulfide	EPA-376.2	10 mg/Kg	7 days	II	**14 days**	Soil
Sulfate	EPA-300.0	10 mg/Kg	28 days	II	**14 days**	Soil
Chlorate	EPA-300.0	1mg/Kg	14 days	II	**14 days**	Soil
Perchlorate	EPA-300.0	5 mg/Kg	7 days	II	**14 days**	Soil
Ignitability	SW-846, Ch.7	NA	7 days	II	**14 days**	Soil
Reactivity	SW-846, Ch.7	10 mg/Kg - Sulfide, 1 mg/Kg- CN	7 days	II	**14 days**	Soil
Corrosivity	SW-846, Ch.7	NA	Immediately upon receipt by the lab.	II	**14 days**	Soil
VOCs w/Ketones	SW-8260A (Up.II)	2-5 ug/Kg	14 days	II	**14 days**	Soil
SVOCs	SW-8270C	330-1700 ug/Kg	14 days to extraction, 40 days extract. to analysis.	II	**14 days**	Soil
Rectangular Features-Groundwater						
TAL Metal	SW-6010A/ 6020/ 7000	various*	180 days, except Hg which is 28 days	II	**14 days**	GW
Boron	SW-6010 or 6020	0.1 mg/L	180 days	II	**14 days**	GW
Ortho-Phosphate	SM 4500 E-2	0.1 mg/L	14 days	II	**14 days**	GW
Chlorate	EPA 300.0	0.05 mg/L	14 days	II	**14 days**	GW
Perchlorate	EPA 300.0	0.5 mg/L	14 days	II	**14 days**	GW
VOCs w/Ketones	SW-8260A (Up.II)	1-5 ug/L	14 days	II	**14 days**	GW
SVOCs	SW-8270C	10-50 ug/L	14 days to extraction, 40 days extract. to analysis.	II	**14 days**	GW
Area East of Burn Pit						
TAL Metal	SW-6010A/ 6020/ 7000	various*	180 days, except Hg which is 28 days	II	**14 days**	Soil
Boron	SW-6010 or 6020	1 mg/kg	180 days	II	**14 days**	Soil
Ortho-Phosphate	SM 4500 E-2	1mg/Kg	28 days	II	**14 days**	Soil
Nitrite	EPA-353.2	1 mg/Kg	28 days	II	**14 days**	Soil
Nitrate	EPA-353.2	1 mg/Kg	48 hours	II	**14 days**	Soil
Sulfide	EPA-376.2	10 mg/Kg	7 days	II	**14 days**	Soil
Sulfate	EPA-300.0	10 mg/Kg	28 days	II	**14 days**	Soil
Chlorate	EPA-300.0	1mg/Kg	I4 days	II	**14 days**	Soil
Perchlorate	EPA 300.0	5 mg/Kg	14 days	II	**14 days**	Soil
Ignitability	SW-846, Ch.7	NA	7 days	II	**14 days**	Soil
Reactivity	SW-846, Ch.7	10 mg/Kg - Sulfide, 1 mg/Kg- CN	7 days	II	**14 days**	Soil
Corrosivity	SW-846, Ch.7	NA	Immediately upon receipt by the lab.	II	**14 days**	Soil
VOCs w/Ketones	SW-8260A (Up.II)	2-5 ug/Kg	14 days	II	**14 days**	Soil
SVOCs	SW-8270C	330-1700 ug/Kg	14 days to extraction, 40 days extract. to analysis.	II	**14 days**	Soil

TABLE 4. OFF-SITE LABORATORY ANALYTICAL METHODS SUMMARY
KILGORE FARMS PHASE II

Analysis	Method (1)	PQLs(2)	Holding Time (3)	Report Level (4)	Turn Around Time (5)	Matrix
Soils 2004						
Hexavalent Chromium	SW846 7196A	1.1 mg/kg	30 Days	II	**14 days**	Soil
ICP Metals, ICP-MS, Trace ICP Metals, Mercury	SW846-6010B/ 6020/ 7470A/ 7471A	various*	180 days, except Hg which is 28 days	II	**14 days**	Soil
Hexavalent Chromium	SW846 7196A	1.1 mg/kg	30 Days	II	**14 days**	Soil
VOCs w/Ketones	SW-8260A (Up.II)	6.4-26 ug/kg	14 days	II	**14 days**	Soil
SVOCs	SW-8270C	440-2100 ug/kg	14 days to extraction, 40 days extract. to analysis.	II	**14 days**	Soil
Chlorinated Pesticides/ Organochlorine Pesticides	SW846-8151A	Varies	14 days to extraction, 40 days extract. to analysis.	II	**14 days**	Soil
Groundwater 2004						
ICP Metals, ICP-MS, Trace ICP Metals, Mercury	SW846-6010B/ 6020/ 7470A	various*	180 days, except Hg which is 28 days	II	**14 days**	GW
Hexavalent Chromium	SW846 7196A	0.02 mg/L	24 Hours	II	**14 days**	GW
Trivalent Chromium	SW846 7196A	0.02 mg/L	14 days	II	**14 days**	GW
Perchlorate	EPA 8321A	0.5 mg/L	14 days	II	**14 days**	GW
VOCs w/Ketones	SW-8260A (Up.II)	1-5 ug/L	14 days	II	**14 days**	GW
SVOCs	SW-8270C	10-50 ug/L	14 days to extraction, 40 days extract. to analysis.	II	**14 days**	GW
Site-Wide Groundwater 2005						
ICP Metals, ICP-MS, Trace ICP Metals, Mercury	SW846-6010B/ 6020/ 7470A	various*	180 days, except Hg which is 28 days	II	**14 days**	GW
Hexavalent Chromium	SW846 7196A	0.02 mg/L	24 Hours	II	**14 days**	GW
Trivalent Chromium	SW846 7196A	0.02 mg/L	14 days	II	**14 days**	GW
Perchlorate	EPA 8321A	0.5 mg/L	14 days	II	**14 days**	GW
VOCs w/Ketones	SW-8260A (Up.II)	1-5 ug/L	14 days	II	**14 days**	GW
SVOCs	SW-8270C	10-50 ug/L	14 days to extraction, 40 days extract. to analysis.	II	**14 days**	GW

1. Method - SW - Test Methods for Evaluating Solid Waste, SW-846 and its Updates I, II, IIA, IIB, and III, USEPA, Sept. 1986.
SM- Standard Methods for the Examination of Water and Wastewater, 20th ed. 1997.
EPA - Method for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, March, 1983.
2. EQL = Estimated Quantitation Limit
3. Holding Time is the maximum time allotted from the date of collection to analysis.
4. Reporting Level as defined in the M&E Approved Laboratory Agreement.
5. Turn Around Time is the time from the receipt of sample by the laboratory until reporting of the result via facsimile.
*- PQL determined as defined

TABLE 5-1
AOC 1: UNIDENTIFIED RECTANGULAR AREA
KILGORE FARM PRELIMINARY PHASE II PROPERTY ASSESSMENT
SOIL ANALYTICAL RESULTS in mg/kg

Parameter	VAP Res. Std.[1]	T-1B-2 2/29/00	T-1C-1 3/1/00	MEB 1-4 (0.5-1) 12/5/00	MEB 1-7 (1.5-3) 12/27/00	HA-1 (0-2) 4/30/04	HA-2 (0-2) 4/30/04
aluminum	75,000	12,000	9,340	10,600	12,000	NA	NA
antimony	31	15	**120**	2	8.6	NA	NA
arsenic	6.8	1.9	**15**	**9.1**	**9.1**	NA	NA
barium	5400	203	677	400	250	NA	NA
beryllium	150	1	<1.5	<1	<1	NA	NA
boron	NE	<3.2	<7.7	NA	NA	NA	NA
cadmium	35	0.4	22	1	2.3	NA	NA
calcium	NE	4960	15,300	5,030	4310	NA	NA
chromium (TOTAL)	NE	11	**111,000**	**380**	**2500**	NA	NA
chromium (III)	120,000	NA	NA	NA	NA	NA	NA
chromium (VI)	230	NA	NA	NA	NA	<1.1	<1.2
cobalt	1400	6	42	8	11	NA	NA
copper	NE	42	20,600	110	220	NA	NA
cyanide	1600	<10	<10	NA	NA	NA	NA
iron	NE	21,200	19,000	21,500	19,900	NA	NA
lead	400	13	**1080**	31	24	NA	NA
magnesium	NE	2820	6890	2700	2470	NA	NA
manganese	NE	72	726	1260	1000	NA	NA
mercury	7.8	0.11	0.29	0.1	0.11	NA	NA
nickel	1500	2.7	55	27	30	NA	NA
nitrate	NE	NA	<2	NA	NA	NA	NA
nitrite + nitrate	NE	<1	2	NA	NA	NA	NA
nitrite	NE	<0.7	<1.3	NA	NA	NA	NA
pH	NE	6.56	6.81	NA	NA	NA	NA
phosphorus	NE	<0.14	0.55	NA	NA	NA	NA
potassium	NE	652	<2010	910	1250	NA	NA
selenium	390	<1.0	<2.3	<2.5	<1.3	NA	NA
silver	390	<2	<20	<3	<1	NA	NA
sodium	NE	144	<402	454	172	NA	NA
sulfate	NE	163	605	NA	NA	NA	NA
sulfide, reactive	NE	<10	<10	NA	NA	NA	NA
thallium	6.2	<0.1	0.4	0.4	0.5	NA	NA
vanadium	700	20	80	29	29	NA	NA
zinc	23,000	80	**130,000**	729	2270	NA	NA
hexachlorobenzene	6.9	<0.5	<0.5	NA	NA	NA	NA
xylenes (total)	160	NA	NA	NA	NA	NA	NA
perchlorate	NE	0.0108	<0.00861	NA	NA	NA	NA

TLCP ANALYSES (results in mg/L)	Max. Toxicity Charac. (mg/L)	MEB 1-23 (1.5-3) (mg/L) 12/27/00	MEB 1-24 (1.5-3) (mg/L) 12/27/00	MEB 1-33 (mg/L) 12/27/00	MEB-NE TRENCH (mg/L) 12/27/00
arsenic, TCLP	5	<0.50	<0.50	<0.50	<0.50
barium, TCLP	100	1.3	1.2	4.7	1
cadmium, TCLP	1	<0.25	<0.25	<0.25	<0.25
chromium, TCLP	5	**6.53**	0.67	<0.25	<0.25
lead, TCLP	5	<0.50	<0.50	<0.50	<0.50
mercury, TCLP	0.2	<0.0020	<0.0020	<0.0020	<0.0020
selenium, TCLP	1	<0.50	<0.50	<0.50	<0.50
silver, TCLP	5	<0.50	<0.50	<0.50	<0.50

NE: No standard established.
NA: Not analyzed for this parameter.
[1] Generic Direct Contact standard for residential land use.
Figures in **bold** exceed the applicable regulatory parameter.

TABLE 5-2
AOC 2: DRAINAGE DITCH NEAR FORMER MANUFACTURING AREA
KILGORE FARM PRELIMINARY PHASE II PROPERTY ASSESSMENT
GROUNDWATER ANALYTICAL RESULTS in ug/L

Parameter	MCL[1]	VAP Unrestricted Use Standard [4]	MW-5 6/7/05
aluminum	50 - 200 [2]	NE	--
antimony	6	6	--
arsenic	10	50	--
barium	2000	2000	--
beryllium	4	4	--
cadmium	5	5	--
calcium	NE	NE	--
chromium (TOTAL)	100	100	3.0 B
chromium (III)	NE	NE	<20
chromium (VI)	NE	NE	<20
cobalt	NE	NE	--
copper	1300 [3] /1000 [2]	NE	--
iron	300 [2]	NE	--
lead	15 [3]	15	--
magnesium	NE	NE	--
manganese	50 [2]	NE	--
mercury	2	2	--
nickel	NE	100	--
potassium	NE	NE	--
selenium	50	50	--
silver	100 [2]	NE	--
sodium	NE	NE	--
thallium	2	2	--
vanadium	NE	NE	--
zinc	5000 [2]	4700 [5]	--
perchlorate	NE	NE	<0.20
acetone	NE	NE	5.2 J
2-butanone	NE	NE	0.72 J
bis(2-ethylhexyl)phthalate	NE	NE	3.1 J, B
diethyl phthalate	NE	NE	0.55 J

[1] Maximum contaminant level: maximum permissable level of a contaminant in water delivered to any user of a public water system.

[2] Secondary MCL: non-enforceable guideline for contaminants that may cause cosmetic or aesthethic effects.

[3] Regulatory action level (not an MCL).

[4] Generic unrestricted potable use standard

[5] Risk-derived generic standard.

[6] Surface water sample.

--: Due to insufficient well volume, MW-5 was analyzed only for VOCs, chromium, and

NE: No standard established.

NA: Not analyzed for this parameter.

B: Reported analyte was found in the method blank.

J: Estimate; reported result is between the method detection limit and the reporting limi

TABLE 6-1
AOC 2: DRAINAGE DITCH NEAR FORMER MANUFACTURING AREA
KILGORE FARM PRELIMINARY PHASE II PROPERTY ASSESSMENT
SOIL ANALYTICAL RESULTS in mg/kg

Parameter	VAP Res. Std.[1]	T-2A-3 3/1/00	T-2B-2 3/1/00	T-2C-2 3/1/00	T-2C-3A 3/1/00	T-2C-3B 3/1/00	T-2C-4 3/2/00	T-2D-1 3/2/00	T-2G-1 3/3/00	SED-1 3/2/00[2]
aluminum	75,000	6800	4830	5600	250	9580	5810	9620	9560	7880
antimony	31	12	**92,000**	**99,000**	**460,000**	**36,000**	**89,000**	2.4	1.5	**110**
arsenic	6.8	**41**	4.3	5	**10**	**20**	**13**	**12**	**11**	**9.1**
barium	5400	274	113	52	12	517	133	166	133	76
beryllium	150	1	<0.5	1	<0.5	1	<1	1	1	1
boron	NE	<3.9	<4.2	<5	<3.7	<4.9	<3.3	<3.9	<6.2	<6.0
cadmium	35	<0.8	**4.2**	<1	2.9	**3.4**	0.9	<0.8	<1.2	<1.2
calcium	NE	2800	2160	5580	152	16,000	1130	3140	3600	1950
chlorate	NE	<0.28	<0.27	<0.25	NA	<0.24	NA	<0.28	NA	<0.47
chromium (TOTAL)	NE	11	9	10	2	12	17	12	11	11
chromium (III)	120,000	NA	NA	NA	NA	NA	NA	NA	NA	NA
chromium (IV)	230	NA	NA	NA	NA	NA	NA	NA	NA	NA
cobalt	1400	14	3	4	<2	13	5	8	9	8
copper	NE	31	649	228	808	203	115	22	21	25
cyanide	1600	<10	<10	<10	NA	<10	NA	<100	NA	<10
iron	NE	27,100	22,000	14,000	824	51,800	22,700	23,200	21,500	18,400
lead	400	15	<9	<5	<20	**2230**	120	58	15	285
magnesium	NE	1320	344	611	49	1750	567	2360	2280	1140
manganese	NE	199	295	2610	214	10,900	160	270	358	335
mercury	7.8	0.2	0.51	0.14	0.78	0.18	0.28	0.08	0.07	0.1
nickel	1500	25	22	25	22	34	24	24	24	23
nitrate	NE	24	<1	3	NA	**4**	NA	**4**	NA	2
nitrite + nitrate	NE	24	<1	3	NA	4	NA	4	NA	2
nitrite	NE	<0.7	<0.7	<0.6	NA	<0.6	NA	<0.7	NA	<1.2
pH	NE	6.09	2.77	3.35	NA	3.89	NA	6.4	NA	5.3
phosphorus	NE	0.36	42.3	17.3	NA	9.96	NA	<0.13	0.57	0.75
potassium	NE	367	579	506	216	744	951	1050	877	1160
selenium	390	5.9	<2.5	<1.5	<2.2	<1.5	<1.0	<1.2	<2.2	<1.8
silver	390	<2	<2	<2	2	<2	<2	<2	<2	<2
sodium	NE	276	203	186	126	235	209	233	228	225
sulfate	NE	150	589	323	NA	1190	NA	95	NA	142
sulfide, reactive	NE	<10	167	<10	NA	<10	NA	<10	NA	<10
sulfide, total	NE	<14	<13	<13	NA	<12	NA	<13	NA	<22
thallium	6.2	2.4	<0.4	<0.5	<0.4	<0.5	0.1	0.4	<0.6	<0.6
vanadium	700	23	13	15	<2	21	17	24	25	20
zinc	23,000	64	186	123	353	407	241	114	75	120
hexachlorobenzene	NE	NA	NA	NA	0.53	NA	NA	<0.50	<0.50	NA
xylenes (total)	NE	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	NA	<0.010
perchlorate	NE	0.0291	<0.00623	<0.00629	<0.0326	0.00878	<0.00645	<0.00659	NA	NA

TLCP ANALYSES (results in mg/L)	Max. Toxicity Charac. (mg/L)	MEB 2-3 (4-4.5) (mg/L) 12/18/00
arsenic, TCLP	5	<0.50
barium, TCLP	100	<1.0
cadmium, TCLP	1	<0.25
chromium, TCLP	5	<0.25
lead, TCLP	5	<0.50
mercury, TCLP	0.2	<0.0020
selenium, TCLP	1	<0.50
silver, TCLP	5	<0.50

NE: No standard established.
NA: Not analyzed for this parameter.
[1] Generic Direct Contact standard for residential land use.
[2] Sediment sample collected from drainage ditch.
Figures in **bold** exceed the applicable regulatory parameter.

TABLE 6-2
AOC 2: DRAINAGE DITCH NEAR FORMER MANUFACTURING AREA
KILGORE FARM PRELIMINARY PHASE II PROPERTY ASSESSMENT
GROUNDWATER ANALYTICAL RESULTS

Parameter	MCL[1]	VAP Unrestricted Use Standard[4]	SW-1 3/2/00[6]	MEB 2-7 12/27/00 (T)	MEB 2-8 12/27/00 (T)	MEB 2-9 12/27/00 (T)	MEB 2-10 12/27/00 (T)
aluminum	50 - 200[2]	NE	*401*	*3100*	*146*	*8420*	*198*
antimony	6	6	**48**	**6**	**31**	**9.8**	**8.1**
arsenic	10	50	4	9.9	7.2	**30**	**12**
barium	2000	2000	79	130	41	186	55
beryllium	4	4	<0.5	<0.5	<0.5	0.7	<0.5
boron	NE	NE	<50	NA	NA	NA	NA
cadmium	5	5	<0.5	0.6	<0.5	0.7	<0.5
calcium	NE	NE	46,000	110,000	210,000	290,000	200,000
chlorate	NE	NE	<20	NA	NA	NA	NA
chromium (TOTAL)	100	100	<20	<20	<20	<20	<20
chromium (III)	NE	NE	NA	NA	NA	NA	NA
chromium (VI)	NE	NE	NA	NA	NA	NA	NA
cobalt	NE	NE	<20	<20	<20	<20	<20
copper	1300[3]/1000[2]	NE	<10	<10	<10	28	<10
iron	300[2]	NE	*1030*	*8810*	*593*	*32500*	*435*
lead	15[3]	15	2.7	7.3	2.7	**19**	3
magnesium	NE	NE	14,000	34,000	64,000	110,000	73,000
manganese	50[2]	NE	*301*	*220*	*240*	*384*	*315*
mercury	2	2	<0.2	<0.2	<0.2	<0.2	<0.2
nickel	NE	100	<20	<20	<20	39	<20
phosphorus	NE	NE	80	NA	NA	NA	NA
potassium	NE	NE	3500	4400	7900	3300	10,000
selenium	50	50	<3.0	<3.0	<3.0	<3.0	<3.0
silver	100[2]	NE	<10	<10	<10	<10	<10
sodium	NE	NE	15,000	7800	11,000	17,000	17,000
sulfate	250,000[2]	NE	58,000	NA	NA	NA	NA
thallium	2	2	<1.0	<1.0	<1.0	1.4	<1.0
vanadium	NE	NE	<20	<20	<20	25	<20
zinc	5000[2]	4700[5]	17	43	14	144	11
perchlorate	NE	NE	<5.0	NA	NA	NA	NA
acetone	NE	NE	NA	NA	NA	NA	NA
2-butanone	NE	NE	NA	NA	NA	NA	NA
bis(2-ethylhexyl)phthalate	NE	NE	<5.0	NA	NA	NA	NA
diethyl phthalate	NE	NE	<5.0	NA	NA	NA	NA

[1] Maximum contaminant level: maximum permissable level of a contaminant in water delivered to any user of a public water system.
[2] Secondary MCL: non-enforceable guideline for contaminants that may cause cosmetic or aesthethic effects.
[3] Regulatory action level (not an MCL).
[4] Generic unrestricted potable use standard
[5] Risk-derived generic standard.
[6] Surface water sample.
(T): Temporary well point.
NE: No standard established.
NA: Not analyzed for this parameter.
B: Reported analyte was found in the method blank.
J: Estimate; reported result is between the method detection limit and the reporting limit.
Figures in **bold** exceed the MCL or unrestricted use standard.
Figures in *italic* exceed the secondary MCL.

TABLE 7-1
AOC 3: BURIAL AREA EAST-SOUTHEAST OF BURN PIT
KILGORE FARM PRELIMINARY PHASE II PROPERTY ASSESSMENT
SOIL ANALYTICAL RESULTS in mg/kg

Parameter	VAP Res. Std.[1]	T-3A-1 3/1/00	T-3A-2 3/2/00	T-3B-2 3/3/00	T-3E-2 3/3/00
aluminum	75,000	4570	1020	9050	7390
antimony	31	**710**	**37**	**31**	**64**
arsenic	6.8	**14**	**58**	**20**	**16**
barium	5400	4,740	40	121	140
beryllium	150	<0.4	<0.4	1	1
boron	NE	18	<3.9	<5.0	<5.3
cadmium	35	**4.4**	<0.8	<1.0	<1.1
calcium	NE	20,500	221	1350	1490
chlorate	NE	<0.24	NA	<0.24	<0.23
chromium (TOTAL)	NE	14	23	11	9
chromium (III)	120,000	NA	NA	NA	NA
chromium (IV)	230	NA	NA	NA	NA
cobalt	1400	7	3	9	10
copper	NE	246	16	23	16
cyanide	1600	<10	<10	<10	<10
iron	NE	11,900	10,700	24,600	20,000
lead	400	143	14	19	16
magnesium	NE	4790	65	2790	2360
manganese	NE	461	60	361	648
mercury	7.8	0.1	NA [2]	0.05	0.06
nickel	1500	12	<2	27	18
nitrate	NE	15	<2	1	<1
nitrite + nitrate	NE	15	<2	1	<1
nitrite	NE	<0.6	1	<0.6	<0.6
pH	NE	7.43	3.11	6.95	7.12
phosphorus	NE	7.94	3150	3.92	0.85
potassium	NE	245	<155	1320	1050
selenium	390	<0.9	<1.2	<1.5	<1.6
silver	390	<2	<2	<2	<2
sodium	NE	446	397	234	243
sulfate	NE	180	2670	74	115
sulfide, reactive	NE	<10	<10	<10	<10
thallium	6.2	<0.3	<0.4	<0.5	<0.5
vanadium	700	7	2	27	24
zinc	23,000	3070	10	79	56
hexachlorobenzene	NE	3.5	1.4	<0.50	<0.50
xylenes (total)	NE	0.021	NA	NA	NA
perchlorate	NE	NA	<5	NA	NA
TLCP ANALYSES (results in mg/L)	**Max. Toxicity Charac. (mg/L)**	**MEB 3-13 (1-1.5) (mg/L) 12/19/00**	**MEB 3-14 (0-0.5) (mg/L) 12/19/00**	**MEB 3-15 (0.5-1) (mg/L) 12/19/00**	
arsenic, TCLP	5	<0.50	<0.50	<0.50	
barium, TCLP	100	12.2	14.6	4.9	
cadmium, TCLP	1	<0.25	<0.25	0.55	
chromium, TCLP	5	<0.25	<0.25	<0.25	
lead, TCLP	5	<0.50	<0.50	2.07	
mercury, TCLP	0.2	<0.0020	<0.0020	<0.0020	
selenium, TCLP	1	<0.50	<0.50	<0.50	
silver, TCLP	5	<0.50	<0.50	<0.50	

NE: No standard established.
NA: Not analyzed for this parameter.
[1] Generic Direct Contact standard for residential land use.
[2] This sample not analyzed for mercury due to potential for flammability.
Figures in **bold** exceed the applicable regulatory parameter.

TABLE 7-2
AOC 3: BURIAL AREA EAST-SOUTHEAST OF BURN PIT
KILGORE FARM PRELIMINARY PHASE II PROPERTY ASSESSMENT
GROUNDWATER ANALYTICAL RESULTS in ug/L

Parameter	MCL [1]	VAP Unrestricted Use Standard [4]	MEB 3-2 12/27/00 (T)	MW-6 6/7/05
aluminum	50 - 200 [2]	NE	*3940*	*3390 B*
antimony	6	6	3.3	3.8
arsenic	10	50	**12**	6.2 B
barium	2000	2000	78	65.9 J
beryllium	4	4	<0.5	<5
cadmium	5	5	0.7	0.41 J
calcium	NE	NE	230,000	109,000
chromium (TOTAL)	100	100	<20	16.4
chromium (III)	NE	NE	NA	16.4 J
chromium (VI)	NE	NE	NA	<20
cobalt	NE	NE	<20	4.6 J
copper	1300 [3] /1000 [2]	NE	22	19.2 J
iron	300 [2]	NE	*11,500*	*7,610*
lead	15 [3]	15	7.9	2.5 B
magnesium	NE	NE	100,000	38,000 B
manganese	50 [2]	NE	*617*	*132*
mercury	2	2	<0.2	<0.20
nickel	NE	100	28	22.1 J
potassium	NE	NE	6100	10,600 B
selenium	50	50	<3.0	<5
silver	100 [2]	NE	<10	<10
sodium	NE	NE	46,000	17,200
thallium	2	2	<1.0	<10
vanadium	NE	NE	<20	10.6 J
zinc	5000 [2]	4700 [5]	64	56.8
perchlorate	NE	NE	NA	<0.20
acetone	NE	NE	NA	2.5 J, B

[1] Maximum contaminant level: maximum permissable level of a contaminant in water delivered to any user of a public water system.
[2] Secondary MCL: non-enforceable guideline for contaminants that may cause cosmetic or aesthethic effects.
[3] Regulatory action level (not an MCL).
[4] Generic unrestricted potable use standard
[5] Risk-derived generic standard.
(T): Temporary well point.
NE: No standard established.
NA: Not analyzed for this parameter.
B: Reported analyte was found in the method blank.
J: Estimate; reported result is between the method detection limit and the reporting limit.
Figures in **bold** exceed the MCL or unrestricted use standard.
Figures in *italic* exceed the secondary MCL.

TABLE 8-1
AOC 4: BURN PIT
KILGORE FARM PRELIMINARY PHASE II PROPERTY ASSESSMENT
SOIL ANALYTICAL RESULTS in mg/kg

Parameter	VAP Res. Std.[1]	MEB 4-3 (8-8.2) 12/11/00	MEB 4-6 (8-8.5) 12/12/00	MEB 4-9 (9.5-10) 12/12/00
aluminum	75,000	5780	6270	7070
antimony	31	<0.9	<1.0	<1.8
arsenic	6.8	**24**	**25**	**21**
barium	5400	109	149	74
beryllium	150	<1	<1	<1
cadmium	35	<2.0	<1.6	<0.8
calcium	NE	38,100	27,500	34,300
chromium (TOTAL)	NE	10	10	10
chromium (III)	120,000	NA	NA	NA
chromium (IV)	230	NA	NA	NA
cobalt	1400	13	18	13
copper	NE	27	37	26
iron	NE	24,900	24,000	24,600
lead	400	16	13	13
magnesium	NE	11,600	12,700	11,000
manganese	NE	471	407	330
mercury	7.8	0.03	0.03	0.03
nickel	1500	44	44	41
potassium	NE	1750	1990	2090
selenium	390	<3.1	<2.5	<2.4
silver	390	<3	<4	<4
sodium	NE	662	732	655
thallium	6.2	1.3	1.2	1.8
vanadium	700	22	24	26
zinc	23,000	102	115	105
hexachlorobenzene	6.9	NA	NA	NA
xylenes (total)	160	NA	NA	NA
perchlorate	NE	NA	NA	NA

NE: No standard established.
NA: Not analyzed for this parameter.
[1] Generic Direct Contact standard for residential land use.
Figures in **bold** exceed the applicable regulatory parameter.

TABLE 8-2
AOC 4: BURN PIT
KILGORE FARM PRELIMINARY PHASE II PROPERTY ASSESSMENT
GROUNDWATER ANALYTICAL RESULTS in ug/L

Parameter	MCL[1]	VAP Unrestricted Use Standard[4]	MW-7 6/7/05	MW-8 6/7/05	MW-9 6/7/05
aluminum	50 - 200[2]	NE	--	*118 B, J*	--
antimony	6	6	--	0.65 J	--
arsenic	10	50	--	0.91 B, J	--
barium	2000	2000	--	15.8 J	--
beryllium	4	4	--	<5	--
cadmium	5	5	--	0.37 J	--
calcium	NE	NE	--	224,000	--
chromium (TOTAL)	100	100	11.5	<10	5.8 B
chromium (III)	NE	NE	11.5 B	<20	5.8 B
chromium (VI)	NE	NE	<20	<20	<20
cobalt	NE	NE	--	<50	--
copper	1300[3] /1000[2]	NE	--	<25	--
iron	300[2]	NE	--	*6680*	--
lead	15[3]	15	--	<3	--
magnesium	NE	NE	--	72,200 B	--
manganese	50[2]	NE	--	*143*	--
mercury	2	2	--	<0.20	--
nickel	NE	100	--	2.8 J	--
phosphorus	NE	NE	--		--
potassium	NE	NE	--	9320 B	--
selenium	50	50	--	<5	--
silver	100[2]	NE	--	<10	--
sodium	NE	NE	--	34,500	--
thallium	2	2	--	<10	--
vanadium	NE	NE	--	<50	--
zinc	5000[2]	4700[5]	--	<20	--
perchlorate	NE	NE	<0.20	<0.20	<0.20
acetone	NE	NE	3.4 J	2.3 J	1.9 J, B
benzene	5	5	0.22 J	<1.0	<1.0
bis(2-ethylhexyl)phthalate	NE	NE	--	9.9 J, B	--
di-n-butyl phthalate	NE	NE	--	0.60 J, B	--

[1] Maximum contaminant level: maximum permissable level of a contaminant in water delivered to any user of a public water system.

[2] Secondary MCL: non-enforceable guideline for contaminants that may cause cosmetic or aesthethic effects.

[3] Regulatory action level (not an MCL).

[4] Generic unrestricted potable use standard

[5] Risk-derived generic standard.

--: Due to insufficient well volume, MW-7 and MW-9 were analyzed only for VOCs, chromium, and perch

NE: No standard established.

NA: Not analyzed for this parameter.

B: Reported analyte was found in the method blank.

J: Estimate; reported result is between the method detection limit and the reporting limit.

Figures in **bold** exceed the MCL or unrestricted use standard.

Figures in *italic* exceed the secondary MCL.

TABLE 9-1
AOC 5: FORMER MANUFACTURING AREA
KILGORE FARM PRELIMINARY PHASE II PROPERTY ASSESSMENT
SOIL ANALYTICAL RESULTS in mg/kg

Parameter	VAP Res. Std.[1]	MEB 5-5 (4-6) 4/29/04	MEB 5-2 (4-6) 4/29/04	MEB 5-4 (6-8) 4/30/04	MEB 5-3 (2-4) 4/30/04
aluminum	75,000	12,600 B	11,500	7650	12,800
antimony	31	<8.1	<7.9	<7.3	<7.7
arsenic	6.8	**14.9**	**11.3**	**22.8**	**17.5**
barium	5400	124	116	69.3	154
beryllium	150	0.69	0.61 J	0.46 J	0.75
cadmium	35	0.42 J	0.48 J	1.1	1.6
calcium	NE	3500	2970 B	39,200 B	3010 B
chromium (TOTAL)	NE	16.5	15.5	12.4	17
chromium (III)	120,000	NA	NA	NA	NA
chromium (VI)	230	0.44 J	<1.1	0.27 J	0.35 J
cobalt	1400	9.1	10	11.4	18.4
copper	NE	22.8	18.2 B	36.0 B	22.3 B
iron	NE	27,700	23,900 B	27,700 B	29,700 B
lead	400	13.6	13.6	14.2	18.5
magnesium	NE	2810 B	2780	12,400	2960
manganese	NE	326	285	375	1450
mercury	7.8	0.032 J	0.036 J	0.017 J	0.050 J
nickel	1500	31.6	22.8	43	40.2
potassium	NE	1250 B	1120 B	1490 J	1220 B
selenium	390	0.99	1.2	1.4	1
silver	390	<1.3	<1.3	<1.2	<1.3
sodium	NE	<672	<658	<610	<640
thallium	6.2	<1.3	<1.3	0.72 B,J	<1.3
vanadium	700	29	23	30.4	29.3
zinc	23,000	117	95.2 B	107 B	107 B
benzene	9.8	0.00039 J	<0.0062	<0.0052	<0.0057
bromomethane	NE	<0.0064	<0.0062	0.00094 J	<0.0057
carbon disulfide	350	0.0014 J,B	0.0023 J,B	0.00082 J,B	0.0013 J,B
xylenes (total)	160	<0.013	<0.012	<0.010	<0.011
acetone	7300	<0.026	<0.025	0.013 J	0.0095 J
benzo (b) fluoranthene	11	<0.44	<0.430	0.017 J	<0.420
benzo (ghi) perylene	NE	<0.44	<0.430	0.036 J	<0.420
bis (2-ethylhexyl) phthalate	230	0.052 J	0.050 J	0.043 J	<0.420
2-butanone	NE	0.0033 J,B	0.0027 J,B	0.006 J,B	0.0034 J,B
di-n-octyl phthalate	100	<0.44	<0.430	<0.400	0.035 J,B
hexachlorobenzene	6.9	<0.44	<0.430	<0.400	<0.420
perchlorate	NE	NA	NA	NA	NA

NE: No standard established.
NA: Not analyzed for this parameter.
[1] Generic Direct Contact standard for residential land use.
J: Estimate; reported result is between the method detection limit and the reporting limit.
B: Reported analyte was found in the method blank.
Figures in **bold** exceed the applicable regulatory parameter.

TABLE 9-2
AOC 5: FORMER MANUFACTURING AREA
KILGORE FARM PRELIMINARY PHASE II PROPERTY ASSESSMENT
GROUNDWATER ANALYTICAL RESULTS in ug/L

Parameter	MCL[1]	VAP Unrestricted Use Standard [4]	MEB 5-2 4/29/04 (T)	MW-1 6/7/05	MW-2 6/7/05	MW-3 6/7/05
aluminum	50 - 200 [2]	NE	*595,000 B*	*411 B*	*7370 B*	*86.8 B, J*
antimony	6	6	**<300 G**	0.35 J	0.59 J	0.29 J
arsenic	10	50	**910**	0.49 B, J	9.0 B	1.5 B, J
barium	2000	2000	**6300**	20.1 J	126 J	37.9 J
beryllium	4	4	**33**	<5	<5.0	<5
cadmium	5	5	**37 B**	<1	0.56 J	0.097 J
calcium	NE	NE	910,000	358,000	141,000	153,000
chromium (TOTAL)	100	100	**1000**	<10	11.3	<10
chromium (III)	NE	NE	NA	<20	11.3 J	<20
chromium (VI)	NE	NE	NA	<20	<40 G	<20
cobalt	NE	NE	560	<50	6.7 J	<50
copper	1300 [3] /1000 [2]	NE	1700	<25	15.7 J	<25
iron	300 [2]	NE	*1,480,000*	*10,300*	*13,900*	*4610*
lead	15 [3]	15	**1900**	<3	5.1	<3
magnesium	NE	NE	478,000	111,000 B	42,800 B	49,200 B
manganese	50 [2]	NE	*16,700*	*406*	*451*	*147*
mercury	2	2	**7.9**	<0.20	<0.20	<0.20
nickel	NE	100	**2000**	<40	24.6 J	<40
phosphorus	NE	NE	NA	NA	NA	NA
potassium	NE	NE	75,800	4740 B, J	5380 B	3880 B, J
selenium	50	50	38	<5	3.8 J	<5
silver	100 [2]	NE	<50 G	<10	<10	<10
sodium	NE	NE	38,600	13,300	44,400	8570
thallium	2	2	**28.6**	**7.3 J**	**5.1 J**	<10
vanadium	NE	NE	1300	<50	24.4 J	<50
zinc	5000 [2]	4700 [5]	***10,800***	<20	61.4	<20
perchlorate	NE	NE	NA	<0.20	<0.20	<0.20
acetone	NE	NE	2.7 J,B	4.7 J, B	1.6 J, B	2.7 J, B
benzene	5	5	0.26 J	<1.0	<1.0	<1.0
2-butanone	NE	NE	<10	0.58 J	<10	<10
xylenes (total)	10,000	10,000	<0.002	<2.0	<2.0	<2.0
benzo (ghi) perylene	NE	NE	0.50 J	<10	<10	<10
bis (2-ethylhexyl) phthalate	NE	NE	4.4 J,B	2.6 J, B	9.9 J	5.1 J, B
dibenz (a,h) anthracene	NE	NE	0.42 J	<10	<10	<10
di-n-butyl phthalate	NE	NE	<10	0.53 J, B	<10	0.57 J, B
indeno (1,2,3-cd) pyrene	NE	NE	0.41 J	<10	<10	<10
toluene	1000	1000	0.31 J	<1.0	<1.0	<1.0
diethyl phthalate	NE	NE	<10	<10	<10	<10

[1] Maximum contaminant level: maximum permissable level of a contaminant in water delivered to any user of a public water syste
[2] Secondary MCL: non-enforceable guideline for contaminants that may cause cosmetic or aesthethic effects.
[3] Regulatory action level (not an MCL).
[4] Generic unrestricted potable use standard
[5] Risk-derived generic standard.
(T): Temporary well point.
NE: No standard established.
NA: Not analyzed for this parameter.
B: Reported analyte was found in the method blank.
G: Elevated reporting limit due to matrix interference.
J: Estimate; reported result is between the method detection limit and the reporting limit.
Figures in **bold** exceed the MCL or unrestricted use standard.
Figures in *italic* exceed the secondary MCL.

TABLE 10-1
AOC 6: FORMER EXPERIMENTAL AREA
KILGORE FARM PRELIMINARY PHASE II PROPERTY ASSESSMENT
SOIL ANALYTICAL RESULTS in mg/kg

Parameter	VAP Res. Std.[1]	MEB 6-1 1/11/01	MEB 6-2 1/11/01	MEB 6-3 1/11/01	MEB 6-4 (10-12) 4/29/04	MEB 6-5 (5-10) 4/29/04	MEB 6-6 (4-6) 4/29/043
aluminum	75,000	919	1630	2500	5580	6760	9040
antimony	31	<0.5	<0.5	2.5	<6.7	<7.5	<7.4
arsenic	6.8	1.2	2.5	4.5	**15.4**	**15.7**	**22.7**
barium	5400	9	108	4300	76.3	89.5	89.4
beryllium	150	<1	1	<1	0.30 J	0.37 J	0.60 J
cadmium	35	<0.6	0.8	2.6	0.78	0.92	0.53 J
calcium	NE	436	31,700	12,700	40,700 B	35,800 B	2460 B
chromium (TOTAL)	NE	4	5	11	9.7	10.7	13.7
chromium (III)	120,000	NA	NA	NA	NA	NA	NA
chromium (VI)	230	NA	NA	NA	<0.90	0.71 J	<0.99
cobalt	1400	<2	<2	21	9.7	11.7	12.2
copper	NE	5	24	82	26.1 B	28.2 B	36.0 B
iron	NE	307	5390	112,000	19,700 B	24,100 B	30,600 B
lead	400	18	24	**487**	10.7	12.8	17.1
magnesium	NE	189	2110	1310	15,200	16,300	2760
manganese	NE	4	90	628	266	197	141
mercury	7.8	<0.08	<0.08	1.74	0.042	0.018 J	0.035 J
nickel	1500	<2	12	57	34.6	37.3	41.8
potassium	NE	<213	595	573	1760 B	1540 B	1460 B
selenium	390	<1.8	<1.5	<3.1	<1.7	1.9	1.5
silver	390	<2	<2	<2	<1.1	<1.2	<1.2
sodium	NE	637	458	395	83.8 J	92.1 J	<619
thallium	6.2	0.4	0.3	<0.4	0.65 B, J	0.61 B, J	<1.2
vanadium	700	10	10	16	18.8	20.1	32.7
zinc	23,000	19	313	568	95.3 B	97.9 B	124 B
perchlorate	NE	NA	NA	NA	NA	NA	NA
n-Hexane	71	NA	NA	NA	0.0014 J	2.8 J, B	<0.0053
acetone	7300	<0.10	<0.10	<0.10	<0.017	<0.021	0.0046 J
2-butanone	6700	<0.050	<0.050	<0.050	<0.017	4.0 J, B	0.0031 J, B
carbon disulfide	350	<0.005	<0.005	<0.005	0.0013 J, B	<0.0053	0.0017 J, B
benzene	9.8	<0.005	<0.005	<0.005	0.00062 J	0.51 J, B	0.00059 J
toluene	520	<0.005	<0.005	<0.005	0.0015 J	0.90 J, B	<0.0053
xylenes (total)	160	<0.010	<0.010	<0.010	<0.0085	<0.011	<0.011
acenapthene	4600	**7000**	69	<0.5	<1.5	<0.820	<0.410
anthracene	23,000	**8300**	<2.6	<0.5	<1.5	<0.820	<0.410
benzo(a)anthracene	11	**9900**	**160**	<0.75	<1.5	<0.820	<0.410
benzo(a)pyrene	1.1	**7200**	**120**	<1.0	<1.5	<0.820	<0.410
benzo(b)fluoranthene	11	**9500**	**140**	<1.0	<1.5	<0.820	<0.410
benzo(ghi)perylene	NE	2900	45	<1.2	0.130 J	<0.820	<0.410
benzo(k)fluoranthene	110	**3000**	60	<1.0	<1.5	<0.820	<0.410
bis(2-ethylhexyl)phthalate	230	<260	<2.6	<0.50	0.170 J	0.098 J	0.070 J
chrysene	1100	**9200**	140	<0.75	<1.5	<0.820	<0.410
dibenzofuran	NE	7600	76	<0.5	<1.5	<0.820	<0.410
dibenzo(a,h)anthracene	1.1	<610	<6.2	<1.2	0.076 J	<0.820	<0.410
dimethyl phthalate	NE	2200	<1.3	<0.25	<1.5	<0.820	<0.410
fluoranthene	2300	**23,000**	360	<0.5	<1.5	<0.820	<0.410
fluorene	3100	**8400**	97	<0.75	<1.5	<0.820	<0.410
hexachlorobenzene	6.9	**<260**	<2.6	<0.5	<1.5	<0.820	<0.410
indeno(1,2,3-cd)pyrene	11	**3700**	**58**	<1.2	0.070 J	<0.820	<0.410
2-methylnaphthalene	NE	<260	<2.6	<0.50	0.260 J	<0.820	<0.410
phenanthrene	NE	29,000	400	<0.5	0.180 J	<0.820	<0.410
pyrene	1700	**17,000**	260	<0.75	<1..5	<0.820	<0.410

NE: No standard established.
NA: Not analyzed for this parameter.
[1] Generic Direct Contact standard for residential land use.
J: Estimate; reported result is between the method detection limit and the reporting limit.
B: Reported analyte was found in the method blank.
Figures in **bold** exceed the applicable regulatory parameter.

TABLE 10-2
AOC 6: FORMER EXPERIMENTAL AREA
KILGORE FARM PRELIMINARY PHASE II PROPERTY ASSESSMENT
GROUNDWATER ANALYTICAL RESULTS in ug/L

Parameter	MCL [1]	VAP Unrestricted Use Standard [4]	MEB 6-5 4/29/04 (T)	MW-4 6/7/05
aluminum	50 - 200 [2]	NE	*329,000*	*585*
antimony	6	6	**<300 G**	0.25 J
arsenic	10	50	**830**	1.5 B, J
barium	2000	2000	**3200**	18.3 J
beryllium	4	4	**18**	< 5.0
cadmium	5	5	**69**	0.13 J
calcium	NE	NE	2,190,000 B	545,000
chromium (TOTAL)	100	100	**1100 B**	2.4 J
chromium (III)	NE	NE	NA	<20
chromium (VI)	NE	NE	**1300 B,G**	<20
cobalt	NE	NE	460	1.2 J
copper	1300 [3] /1000 [2]	NE	***1300***	<25
iron	300 [2]	NE	*1,430,000*	*18,000*
lead	15 [3]	15	**710**	< 3.0
magnesium	NE	NE	476,000 B	270,000 B
manganese	50 [2]	NE	*16,900 B*	*447*
mercury	2	2	**4.1**	< 0.20
nickel	NE	100	**1500**	<40
potassium	NE	NE	56,900 B	12,200 B
selenium	50	50	<25 G	< 5.0
silver	100 [2]	NE	1.6 J	0.83 J
sodium	NE	NE	14,400	65,800
thallium	2	2	**30**	**5.6 J**
vanadium	NE	NE	920	1.1 J
zinc	5000 [2]	4700 [5]	***6400***	<20
perchlorate	NE	NE	NA	< 0.20
acetone	NE	NE	10 B	3.9 J
benzene	5	5	<1.0	<1.0
2-butanone	NE	NE	0.99 J	<10
bis (2-ethylhexyl) phthalate	NE	NE	<10	8.1 J
di-n-butyl phthalate	NE	NE	<10	0.56 J

[1] Maximum contaminant level: maximum permissable level of a contaminant in water delivered to any user of a public water system.
[2] Secondary MCL: non-enforceable guideline for contaminants that may cause cosmetic or aesthethic effects.
[3] Regulatory action level (not an MCL).
[4] Generic unrestricted potable use standard
[5] Risk-derived generic standard.
(T): Temporary well point.
NE: No standard established.
NA: Not analyzed for this parameter.
B: Reported analyte was found in the method blank.
G: Elevated reporting limit due to matrix interference.
J: Estimate; reported result is between the method detection limit and the reporting limit.
Figures in **bold** exceed the MCL or unrestricted use standard.
Figures in *italic* exceed the secondary MCL.

TABLE 11-1
AOC 7: CINDER AREA SOUTHEAST OF BURN PIT
KILGORE FARM PRELIMINARY PHASE II PROPERTY ASSESSMENT
SOIL ANALYTICAL RESULTS in mg/kg

Parameter	VAP Res. Std.[1]	MEB 7-1 1/11/01
aluminum	75,000	4560
antimony	31	1
arsenic	6.8	5.2
barium	5400	62
beryllium	150	1
cadmium	35	<0.4
calcium	NE	1350
chromium (TOTAL)	NE	5
chromium (III)	120,000	NA
chromium (VI)	230	NA
cobalt	1400	5
copper	NE	16
iron	NE	12800
lead	400	15
magnesium	NE	767
manganese	NE	248
mercury	7.8	<0.05
nickel	1500	7
potassium	NE	608
selenium	390	<1.3
silver	390	<3
sodium	NE	404
thallium	6.2	0.2
vanadium	700	15
zinc	23,000	44
hexachlorobenzene	6.9	<0.50
xylenes (total)	160	ND
perchlorate	NE	NA

NE: No standard established.
NA: Not analyzed for this parameter.
ND: not detected; detection limit not available
[1] Generic Direct Contact standard for residential land use.

TABLE 11-2
AOC 7: CINDER AREA SOUTHEAST OF BURN PIT
KILGORE FARM PRELIMINARY PHASE II PROPERTY ASSESSMENT
GROUNDWATER ANALYTICAL RESULTS in ug/L

Parameter	MCL [1]	VAP Unrestricted Use Standard [4]	MW-10 6/7/05
aluminum	50 - 200 [2]	NE	*283 B*
antimony	6	6	0.67 J
arsenic	10	50	2.8 B, J
barium	2000	2000	16.4 B
beryllium	4	4	<5.0
cadmium	5	5	0.14 J
calcium	NE	NE	302,000
chromium (TOTAL)	100	100	<10
chromium (III)	NE	NE	<20
chromium (VI)	NE	NE	<20
cobalt	NE	NE	<50
copper	1300 [3] /1000 [2]	NE	6.2 J
iron	300 [2]	NE	*6700*
lead	15 [3]	15	<3
magnesium	NE	NE	96,400 B
manganese	50 [2]	NE	*168*
mercury	2	2	<0.20
nickel	NE	100	4.3 J
potassium	NE	NE	10,600 B
selenium	50	50	<5
silver	100 [2]	NE	<10
sodium	NE	NE	23,400
thallium	2	2	<10
vanadium	NE	NE	<50
zinc	5000 [2]	4700 [5]	<20
perchlorate	NE	NE	<0.20
acetone	NE	NE	1.9 J, B
xylenes (total)	10,000	10,000	<2
bis (2-ethylhexyl) phthalate	NE	NE	7.8 J, B
di-n-butyl phthalate	NE	NE	0.61 J, B

[1] Maximum contaminant level: maximum permissable level of a contaminant in water delivered to any user of a public water system.
[2] Secondary MCL: non-enforceable guideline for contaminants that may cause cosmetic or aesthethic effects.
[3] Regulatory action level (not an MCL).
[4] Generic unrestricted potable use standard
[5] Risk-derived generic standard.
NE: No standard established.
NA: Not analyzed for this parameter.
B: Reported analyte was found in the method blank.
J: Estimate; reported result is between the method detection limit and the reporting limit.
Figures in **bold** exceed the MCL or unrestricted use standard.
Figures in *italic* exceed the secondary MCL.

TABLE 1
IDENTIFIED AREAS OF CONCERN (AOCs)

AOC Number	Area Location	Area Description	Potential Concern	Recommendation
1	NE portion of site, S of AOC 5.	Two unknown rectangular features located south of Former Manufacturing Area. Past use of area could not be established during Phase I.	Chemical impacts Energized materials	On-site testing/ Laboratory testing Ordnance identification
2	Drainage ditch in NE portion of site.	Ditch between the Manufacturing and Experimental areas in NE portion of site where wastes were reportedly buried	Chemical impacts Energized materials	On-site testing/ Laboratory testing Ordnance identification
3	Former burial area in woods in east-central portion of site.	Burial area located east of the Burn Pit. 6-8 empty drums also found in this area.	Chemical impacts Energized materials	On-site testing/ Laboratory testing Ordnance identification
4	Former burn pit E of former Quonset huts	Pit used to destroy off-spec materials.	Chemical impacts	On-site testing/ Laboratory testing
5	Former Manufacturing Area in NE corner of site.	Former UST in Manufacturing Area	Chemical impacts	Laboratory testing
6	Former Experimental Area N of former Quonset huts.	1. ~100 black canisters (not previously reported) were identified during a site walk. 2. Aerial photos showed disturbed soils of unknown nature adjacent to 2 Quonset huts. 3. During excavation of burial trenches, flare casings and black caps were reportedly staged near two of the former Quonset huts. Scattered casings and caps are present on ground surface.	Chemical impacts Energized materials	On-site testing/ Laboratory testing Ordnance identification
7	Small area near SE corner of site.	Cinders, coal fragments and slag found on top of native soils.	Chemical impacts	On-site testing/ Laboratory testing

Table 5-2 Groundwater VAP/MCL Exceedances of Regulatory Standards

AOC Number	Temp Wells (1988/1996) (AOC 8) and Ph 2 (2000)		Permanent Wells Ph 2 (2005)	
	AOC Wells (Depth to GW/ Screen Interval	**Ph 2 GW (Max conc. ug/L)**	**AOC Wells (Depth to GW/ Screen Interval**	**Ph2 GW (Max conc. ug/L)**
AOC 1 Unidentified Rectangular Features AOC 2 Drainage Ditch Near Mfg. Area	GW: MEB 2-7 (1.28/1.0-10.92) MEB 2-8 (1.68/1.0-19.10) MEB 2-9 (2.61/1.0-11.19) MEB 2-10 (1.68/1-19.86) SW: SW-1	GW: As: 30 Pb: 19 Sb: 48 SW: Sb: 48	MW-5 (13.8/13-18)	Incomplete based on well MW-5, which was only analyzed for VOCs, Cr, and perchlorate w/ no exceedances
AOC 3 Burial Area ESE of Burn Pit	MEB 3-2 (2.26/1.0-15.36)	NA	MW-9 (19.62/22-27)	None based on well MW-9
AOC 4 Burn Pit	NA	As: 12 (nominal)	MW-6 (27.48/35-40) MW-7 (39.2/35-40) MW-8 (4.34/21-26)	None based on well MW-6, MW-7, and MW-8. MW-6 and MW-7 were only analyzed for VOCs, Cr, and perchlorate
AOC 5 UST in Former Mfg. Area	MEB 5-2 (Unknown)	Sb:<300 As: 910 Pb: 1900 Zn:: 10800 Cr: 1000 Cr6: NA Ni: 2000 Th:28.6* Cd: 37 Hg: 7.9 Be: 33 Ba: 6300	MW-1 (2.95/15-20) MW-2 (3.70/10-15) MW-3 (4.95/16-21)	None based on Wells MW-1, MW-2, and MW-3; however these wells appear to be upgradient of the site
AOC 6 Former Experimental Area	MEB 6-5 (Unknown)	Sb:<300 As: 830 Pb: 710 Zn: 6400 Cr:1100 Cr6:1300 Ni: 1500 Th: 30* Cd: 69 Hg: 4.1 Be: 18 Ba: 3200	MW-4 (7.68/22-27)	VAP: Based on MW-4 Th: 5.6**
AOC 7 Cinder Area SE of Burn Pit	NA	NA	MW-10 (6.44/19-24)	None based on Wells MW-10; however this well appears to be upgradient of the site.
AOC 8 Former Burial Trench Area	N well (1988) W well (1988) S well (1988) SE well (1988) None from 1996	Pb: 1100 (1988)	NA	NA
Quonset Hut Area	NA	NA	NA	NA
Farm/Former Residence Area	NA	NA	NA	NA

Note: Groundwater samples were analyzed for metals, perchlorate, VOCs w/ketones, SVOCs, and hexavalent chromium.
* Thallium believed to be a laboratory artifact.

Table 5-3 Soil Exceedances of Regulatory Standards

AOC Number	Soil
AOC 1 Unidentified Rectangular Features	Sb: 120 As: 41 Pb: 1080 Zn: 130000 Cr: 111000 Cr6: NA
AOC 2 Drainage Ditch Near Mfg. Area	Sb:460000 As: 41 Pb: 2230
AOC 3 Burial Area ESE of Burn Pit	Sb: 710 As: As
AOC 4 Burn Pit	As: 25*
AOC 5 UST in Former Mfg. Area	As :22.8*
AOC 6 Former Experimental Area	As: 22.7* Pb: 487 PAHs
AOC 7 Cinder Area SE of Burn Pit	None
AOC 8 Former Burial Trench Area	None
Quonset Hut Area	NA
Farm/Former Residence Area	None

Note: Groundwater samples were analyzed for metals, perchlorate, VOCs w/ketones, SVOCs, and hexavalent chromium.

* Arsenic included as exceedance for Preliminary Phase 2 Sampling (Metcalf&Eddy, 2005) but. Subsequent Phase I Property Assessment Otterbein College Equine Facility (Brown and Caldwell, 2007) suggests that concentrations are indicative of background, statistically established at 25.3 mg/kg.

TABLE 13
POTENTIAL HUMAN EXPOSURE PATHWAYS
KILGORE FARM PRELIMINARY PHASE II PROPERTY ASSESSMENT

EXPOSURE/ CONTACT MEDIUM	TRANSPORTING/ SOURCE MEDIUM	EXPOSURE ROUTE	PATHWAY	PATHWAY COMPLETE? (REASON, IF NO)
Soil	Air particulates to soil	Ingestion	Airborne particulates containing COCs are deposited on soil for ingestion by on- or off-property receptors	yes
	Direct contact	Ingestion	Soil containing COCs is ingested by on- or off-property receptors	yes
	Direct contact	Dermal contact	Soil containing COCs is contacted by on-property receptors	yes
Air	Groundwater to air	Inhalation	Volatiles released from groundwater containing COCs are inhaled during bathing/showering or inhaled incidentally during other potable or process use by on- or off-property	No - no volatiles are a COC
	Soil to air	Inhalation	Volatiles released from groundwater containing COCs enter buildings through basements or foundations and are inhaled by on- or off-property receptors occupying buildings.	No - no volatiles are a COC
	Soil to air	Inhalation	Volatiles released to outdoor air from soil containing COCs are inhaled by on- or off-property receptors.	No - no volatiles are a COC
	Soil to air	Inhalation	Particulates released to outdoor air from soil containing COCs are inhaled by on or off-property receptors	yes
	Surface water to air	Inhalation	Volatiles released from surface water containing dissolved or suspended COCs are inhaled by on- or off-property receptors	No - no volatiles are a COC
Surface water	Direct contact	Ingestion	Surface water containing dissolved or suspended COCs is ingested by on- or off-property receptors from ingestion as drinking water of from other incidental ingestion	yes
	Direct contact	Dermal contact	Surface water containing dissolved or suspended COCs is contacted by on- or off-property receptors while bathing/showering, swimming or through other incidental contact related to potable, process or recreational use.	yes
	Soil to surface water	Ingestion	Surface water containing dissolved or suspended COCs from overland flow is ingested by on- or off-property receptors from ingestion as drinking water or from other incidental	yes
	Soil to surface water	Dermal contact	Surface water containing dissolved or suspended COCs from overland flow is contacted by on- or off-property receptors while bathing/showering, swimming or through other incidental contact related to potable, process or recreational	yes
	Groundwater to surface water	Ingestion	Surface water containing dissolved or suspended COCs from groundwater emanation is ingested by on- or off-property receptors from ingestion as drinking water or through other incidental ingestion	No - no volatiles are a COC
	Groundwater to surface water	Dermal contact	Surface water containing dissolved or suspended COCs from groundwater emanation is contacted by on- or off-property receptors while bathing/showering, swimming or through other incidental contact related to potable, process or	No - no volatiles are a COC
Groundwater	Direct contact	Ingestion	Groundwater containing dissolved or suspended COCs is ingested by on- or off-property receptors using groundwater.	No - connection to public water supply is required.
	Direct contact	Dermal contact	Groundwater containing dissolved or suspended COCs is used for bathing/showering or is contacted incidentally during other potable or process use by on- or off-property receptors.	No - connection to public water supply is required.
	Soil to ground water	Ingestion	Groundwater containing COCs which have leached from soil is ingested by on- or off-property receptors using groundwater as drinking water.	No - connection to public water supply is required.
	Soil to ground water	Dermal contact	Groundwater containing COCs which have leached from soil is used for bathing/showering or is contacted incidentally during other potable or process use by on- or off-property receptors using groundwater.	No - connection to public water supply is required.

TABLE 14
POTENTIAL ECOLOGICAL EXPOSURE PATHWAYS
KILGORE FARM PRELIMINARY PHASE II PROPERTY ASSESSMENT

EXPOSURE/ CONTACT MEDIUM	EXPOSURE ROUTE	PATHWAY	PATHWAY COMPLETE? (REASON, IF NO)
Soil	Ingestion	Ingestion of soil containing COCs by mammals or birds at on- or off-property locations.	Yes
	Direct contact	Direct contact with soil to plants, soil invertebrates or microorganisms at on- or off-property locations.	Yes
Surface water	Ingestion	Ingestion of surface water containing COCs by on- or off-property mammals or birds.	Yes
	Direct contact	Direct contact with surface water containing COCs by on- or off-property fish or macroinvertebrates.	Yes
Plants	Ingestion	Ingestion of plants that may have incorporated COCs from soil, surface water or sediment by on- or off-property mammals or birds.	Yes
Soil fauna	Ingestion	Ingestion of soil fauna that may have incorporated COCs from soil by on- or off-property mammals or birds.	Yes

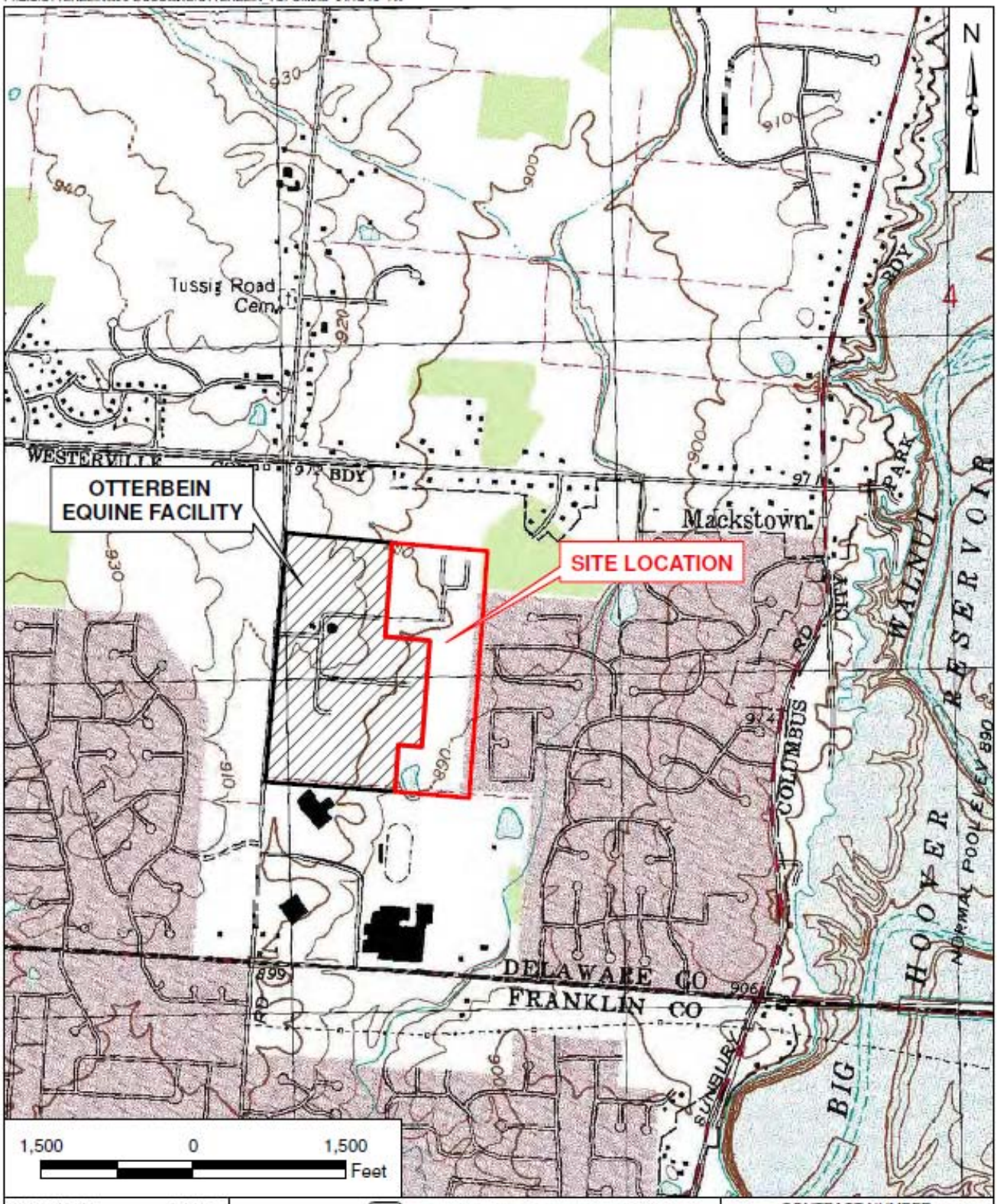
TABLE 7-1

REMEDIATION TECHNOLOGIES
KILGORE FARM SITE, WESTERVILLE, OHIO

GRA	Remediation Technology	Process Option
No Action	None	Not applicable
Limited Action	Institutional Controls	LUCs
Removal	Excavation/Disposal	Off-site landfill disposal
Containment at AOC 8	Capping	Multimedia cover

FIGURES

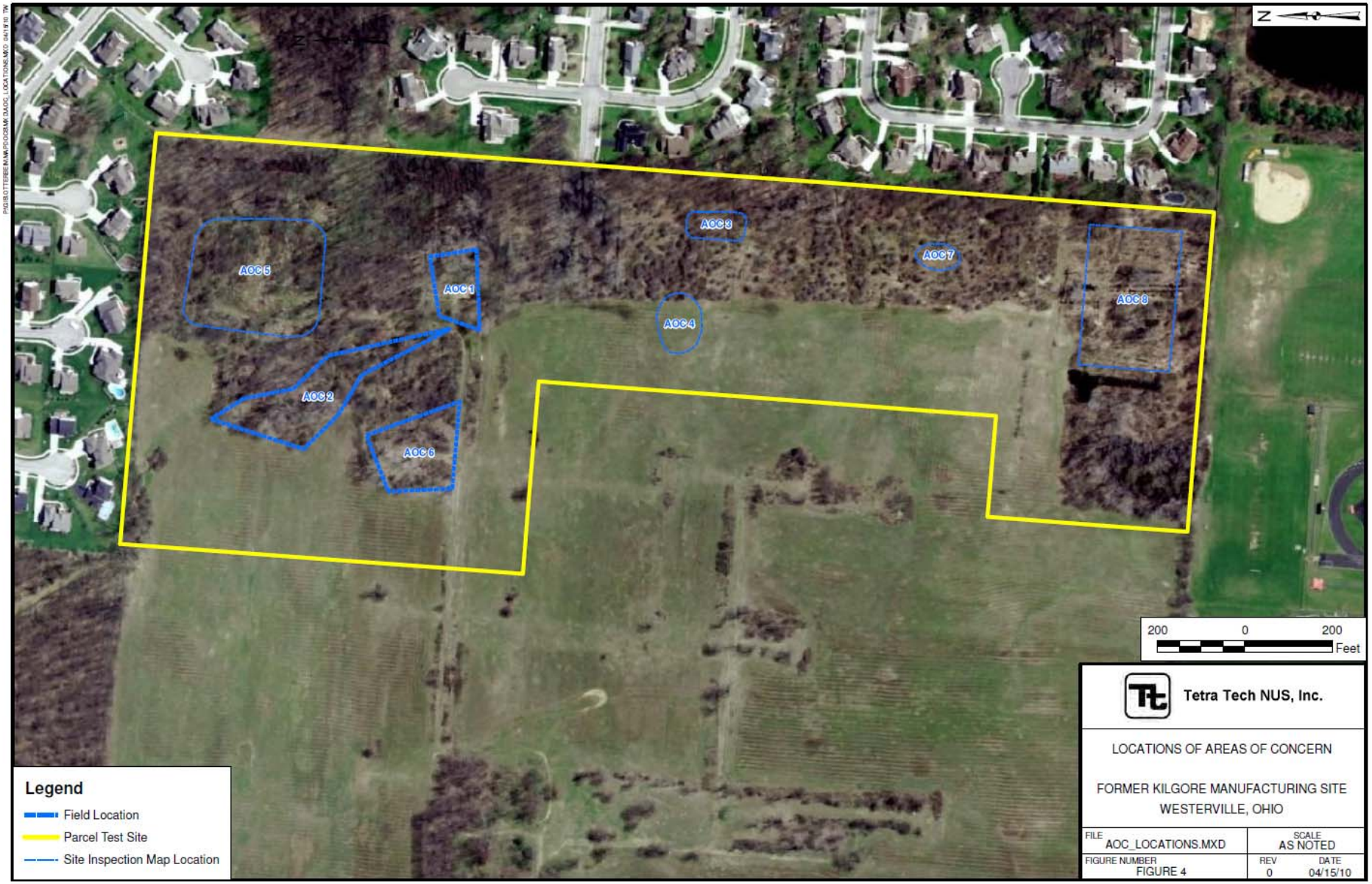
P:\GIS\OTTERBEIN\MAPDOCS\MXD\OTTERBEIN_TOPO.MXD 04/15/10 TW



DRAWN BY T. WHEATON	DATE 04/15/10	Tetra Tech NUS, Inc.	CONTRACT NUMBER
CHECKED BY S. HILL	DATE 04/15/10	USGS TOPOGRAPHIC MAP	APPROVED BY — DATE —
COST/SCHEDULE AREA		FORMER KILGORE MANUFACTURING SITE WESTERVILLE, OHIO	APPROVED BY — DATE —
SCALE AS NOTED			FIGURE NO. FIGURE 1 / REV 0

P:\GIS\OTTERBEIN\MAPDOCS\MXD\OTTERBEIN_1958.MXD 04/15/10 TW

DRAWN BY T. WHEATON	DATE 04/15/10	Tetra Tech NUS, Inc.	CONTRACT NUMBER
CHECKED BY S. HILL	DATE 04/15/10	1958 AERIAL PHOTOGRAPH	APPROVED BY ___ / DATE ___
COST/SCHEDULE AREA		FORMER KILGORE MANUFACTURING SITE WESTERVILLE, OHIO	APPROVED BY ___ / DATE ___
SCALE AS NOTED			FIGURE NO. FIGURE 2 / REV 0



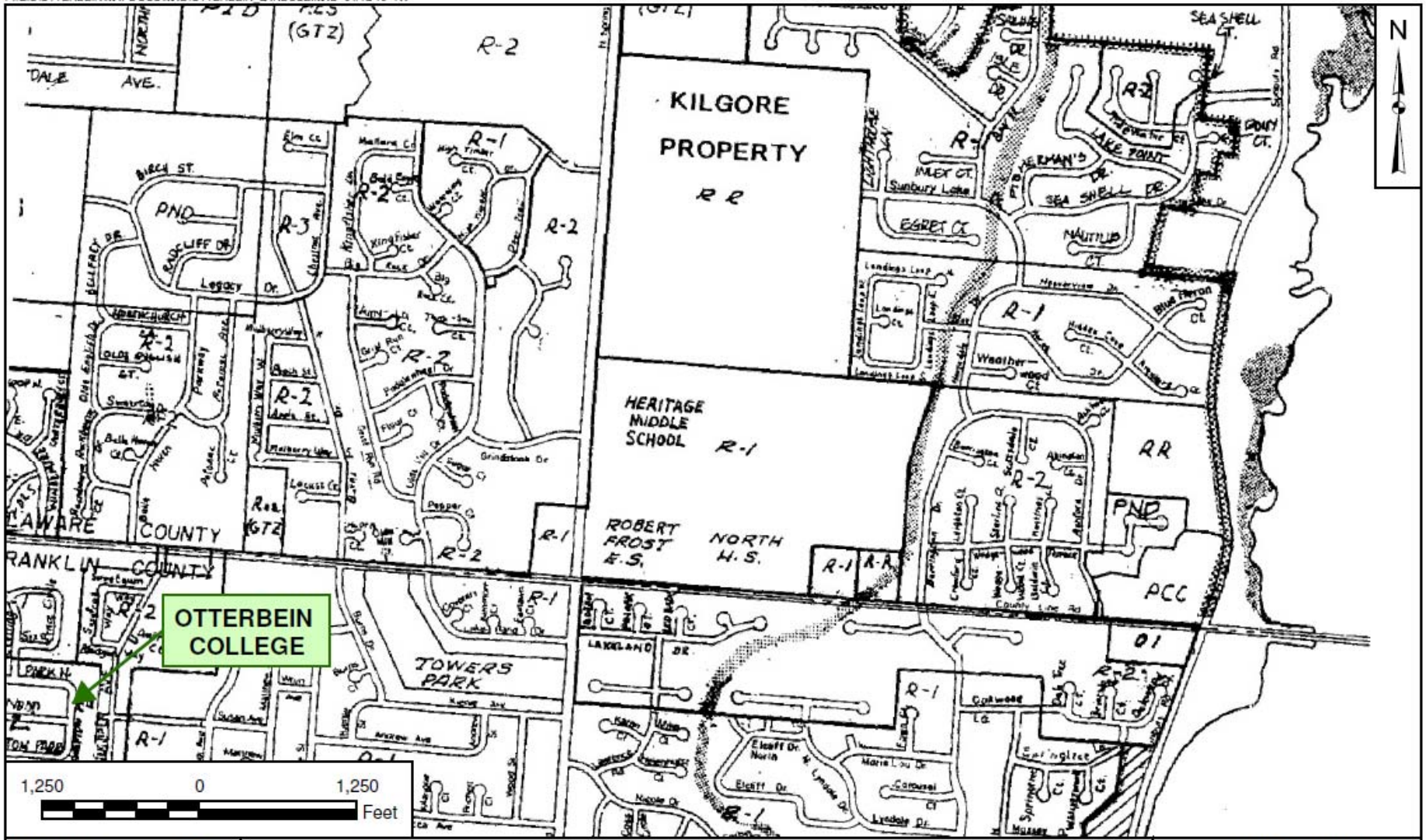
Tetra Tech NUS, Inc.

LOCATIONS OF AREAS OF CONCERN

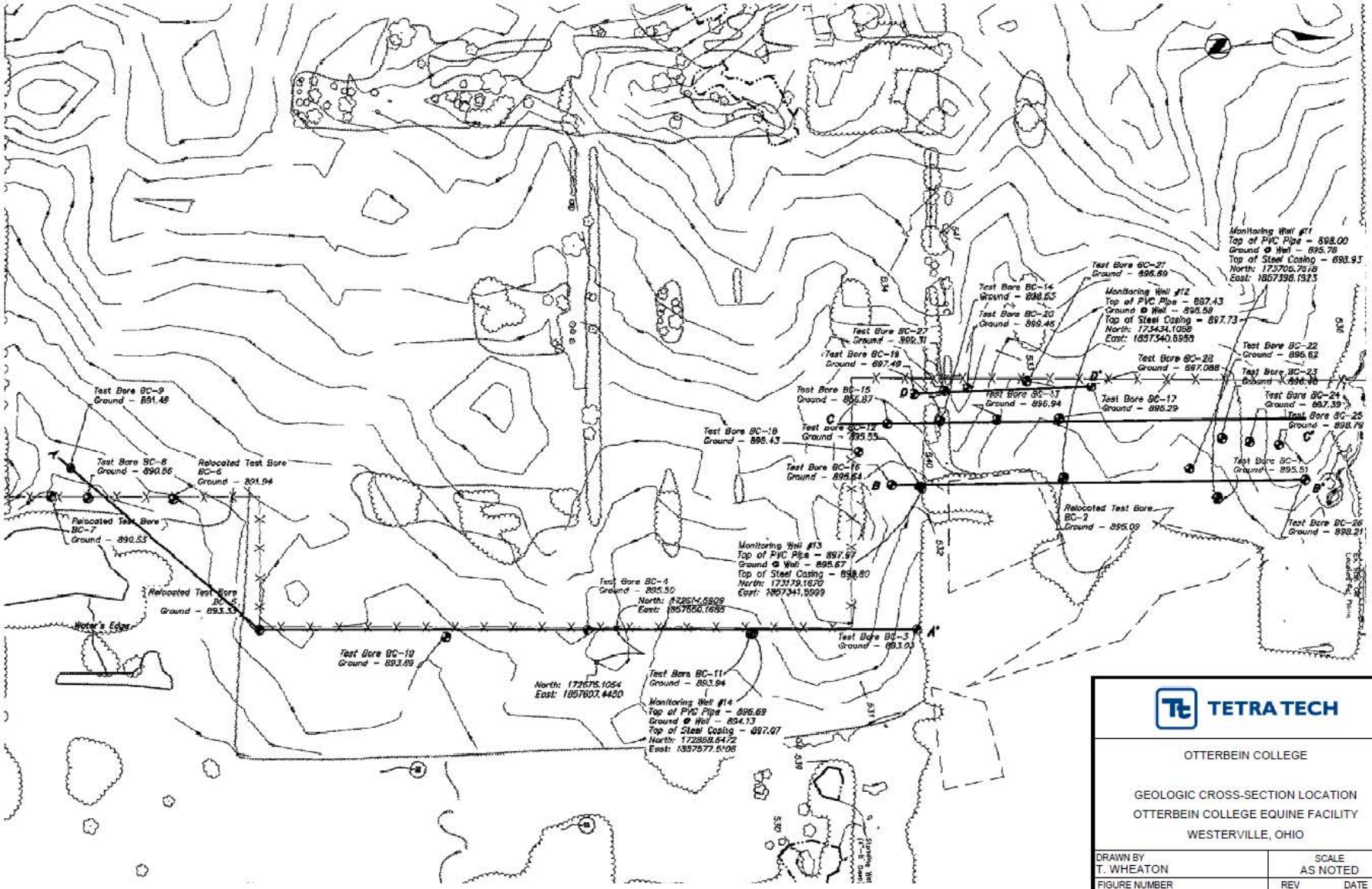
FORMER KILGORE MANUFACTURING SITE
WESTERVILLE, OHIO

FILE	SCALE
AOC_LOCATIONS.MXD	AS NOTED
FIGURE NUMBER	REV / DATE
FIGURE 4	0 / 04/15/10

P:\GIS\OTTERBEIN\MAPDOCS\MXD\OTTERBEIN_LANDUSE.MXD 04/15/10 TW



DRAWN BY T. WHEATON	DATE 04/15/10	Tetra Tech NUS, Inc.	CONTRACT NUMBER
CHECKED BY S. HILL	DATE 04/15/10	SITE LOCATION AND SURROUNDING LAND USE	APPROVED BY / DATE
COST/SCHEDULE AREA		FORMER KILGORE MANUFACTURING SITE WESTERVILLE, OHIO	APPROVED BY / DATE
SCALE AS NOTED			FIGURE NO. FIGURE 3 / REV 0

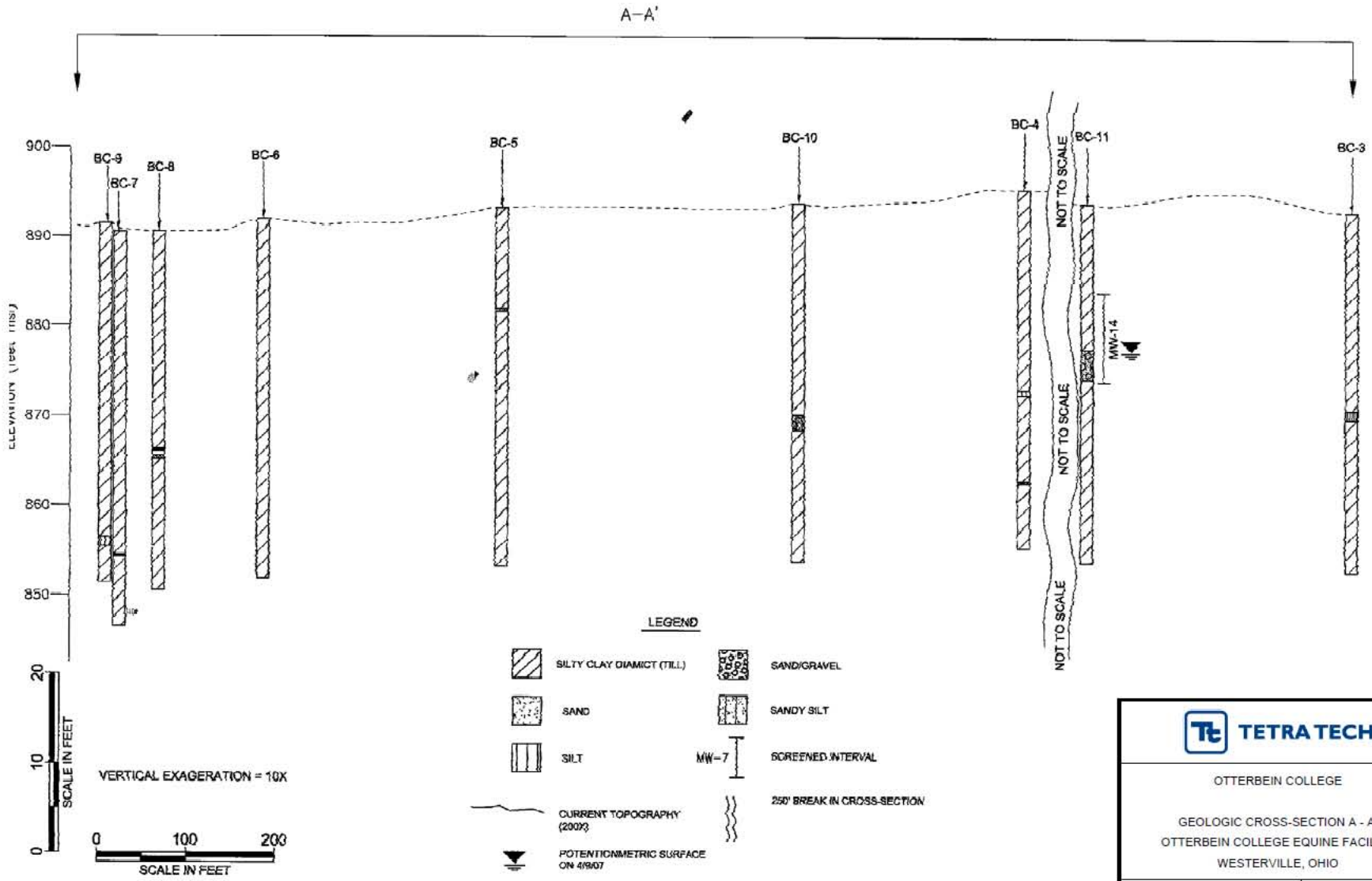


TETRA TECH

OTTERBEIN COLLEGE

GEOLOGIC CROSS-SECTION LOCATION
OTTERBEIN COLLEGE EQUINE FACILITY
WESTERVILLE, OHIO

DRAWN BY	SCALE
T. WHEATON	AS NOTED
FIGURE NUMBER	REV / DATE
FIGURE 3-4	0 / 08/06/10

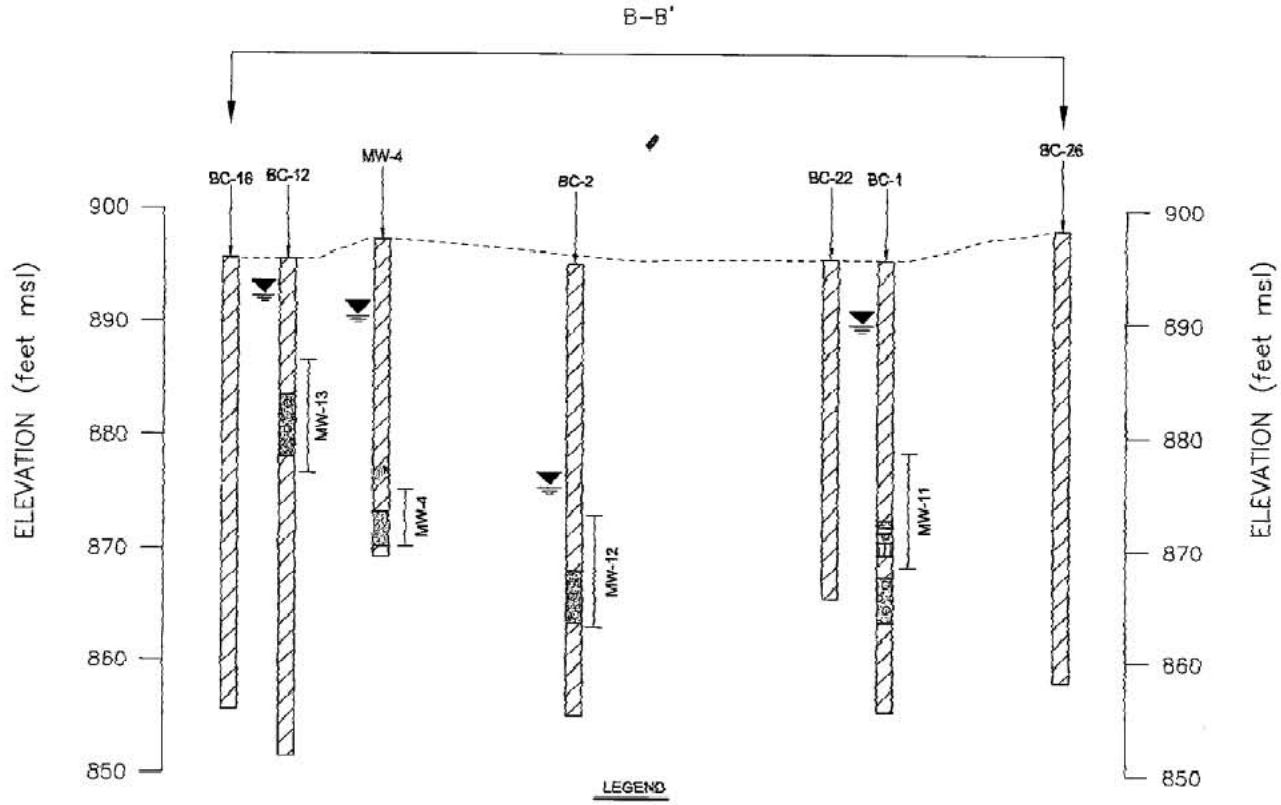


TETRA TECH

OTTERBEIN COLLEGE

GEOLOGIC CROSS-SECTION A - A'
OTTERBEIN COLLEGE EQUINE FACILITY
WESTERVILLE, OHIO

DRAWN BY	SCALE	
T. WHEATON	AS NOTED	
FIGURE NUMBER	REV	DATE
FIGURE 3-5	0	08/06/10



LEGEND

- SILTY CLAY DIAMICT (TILL)
- SAND/GRAVEL
- SAND
- SANDY SILT
- SILT
- MW-7 SCREENED INTERVAL
- CURRENT TOPOGRAPHY (200X)
- BREAKLINE SECTION 200 FEET FROM CROSS-SECTION
- POTENTIONMETRIC SURFACE ON 4/9/07

VERTICAL EXAGERATION = 10X

SCALE IN FEET: 0, 10, 20

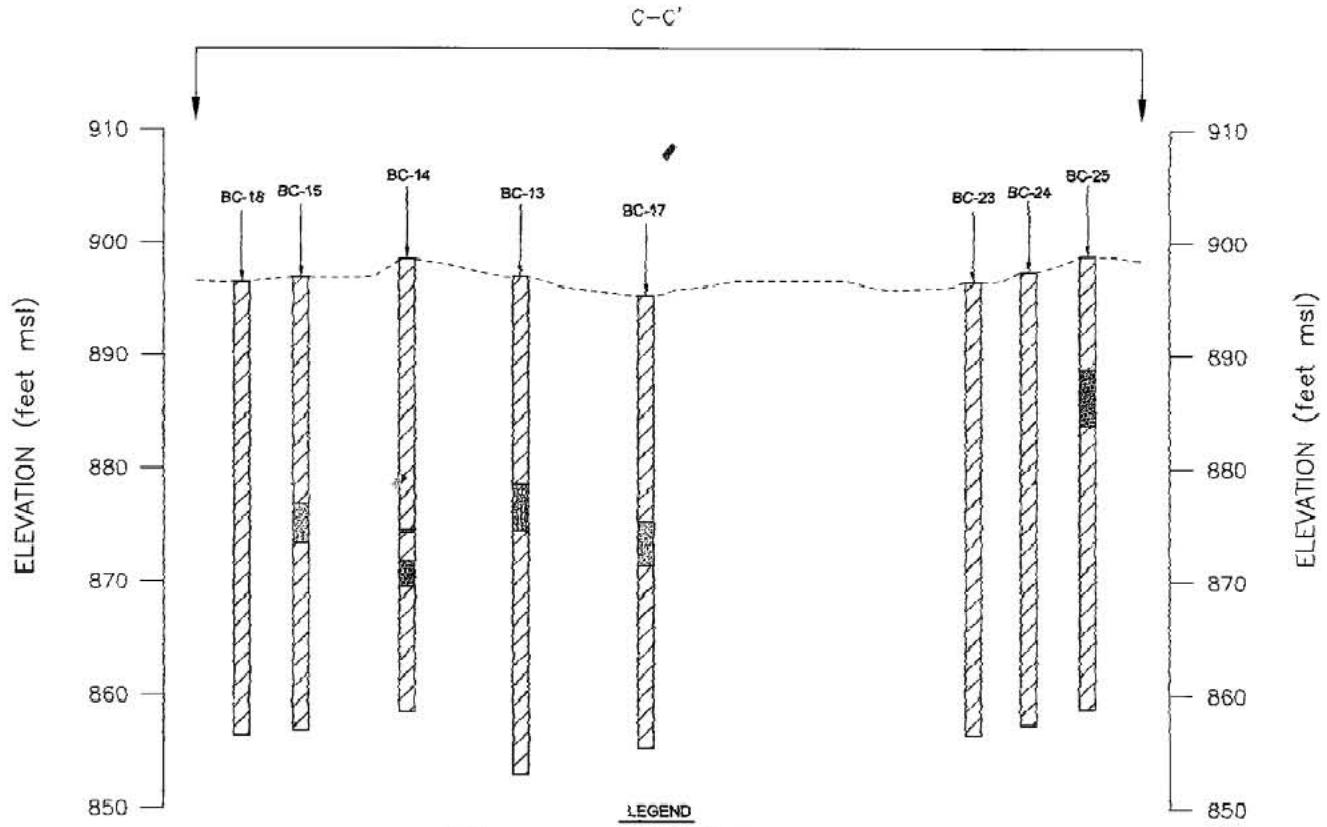
0 100 200
SCALE IN FEET

TETRA TECH

OTTERBEIN COLLEGE

GEOLOGIC CROSS-SECTION B - B'
OTTERBEIN COLLEGE EQUINE FACILITY
WESTERVILLE, OHIO

DRAWN BY	SCALE	
T. WHEATON	AS NOTED	
FIGURE NUMBER	REV	DATE
FIGURE 3-6	0	08/06/10



LEGEND

- SILTY CLAY DIAMICT (TILL)
- SAND/GRAVEL
- SAND
- SANDY SILT
- SILT
- MW–7 SCREENED INTERVAL
- CURRENT TOPOGRAPHY (2002X)
- BREAKLINE SECTION 200 FEET FROM CROSS-SECTION
- POTENTIONMETRIC SURFACE ON 4/9/07

VERTICAL EXAGERATION = 10X

0 10 20 SCALE IN FEET

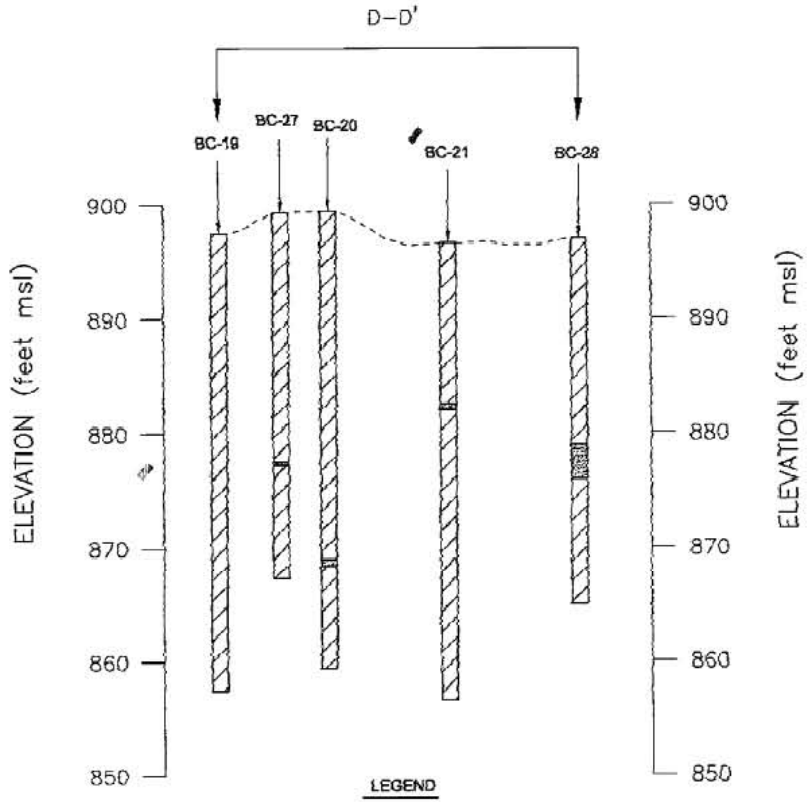
0 100 200 SCALE IN FEET

TETRA TECH

OTTERBEIN COLLEGE

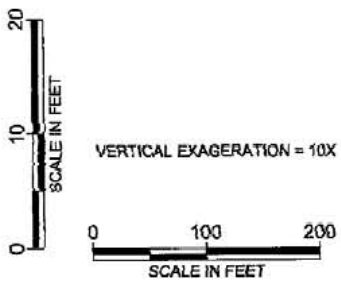
GEOLOGIC CROSS-SECTION C - C'
OTTERBEIN COLLEGE EQUINE FACILITY
WESTERVILLE, OHIO

DRAWN BY	SCALE
T. WHEATON	AS NOTED
FIGURE NUMBER	REV / DATE
FIGURE 3-7	0 / 08/06/1



LEGEND

- SILTY CLAY DIAMICT (TILL)
- SAND/GRAVEL
- SAND
- SANDY SILT
- SILT
- MW–7 SCREENED INTERVAL
- CURRENT TOPOGRAPHY (2003X)
- BREAKLINE SECTION 200 FEET FROM CROSS-SECTION
- POTENTIOMETRIC SURFACE ON 4/9/07

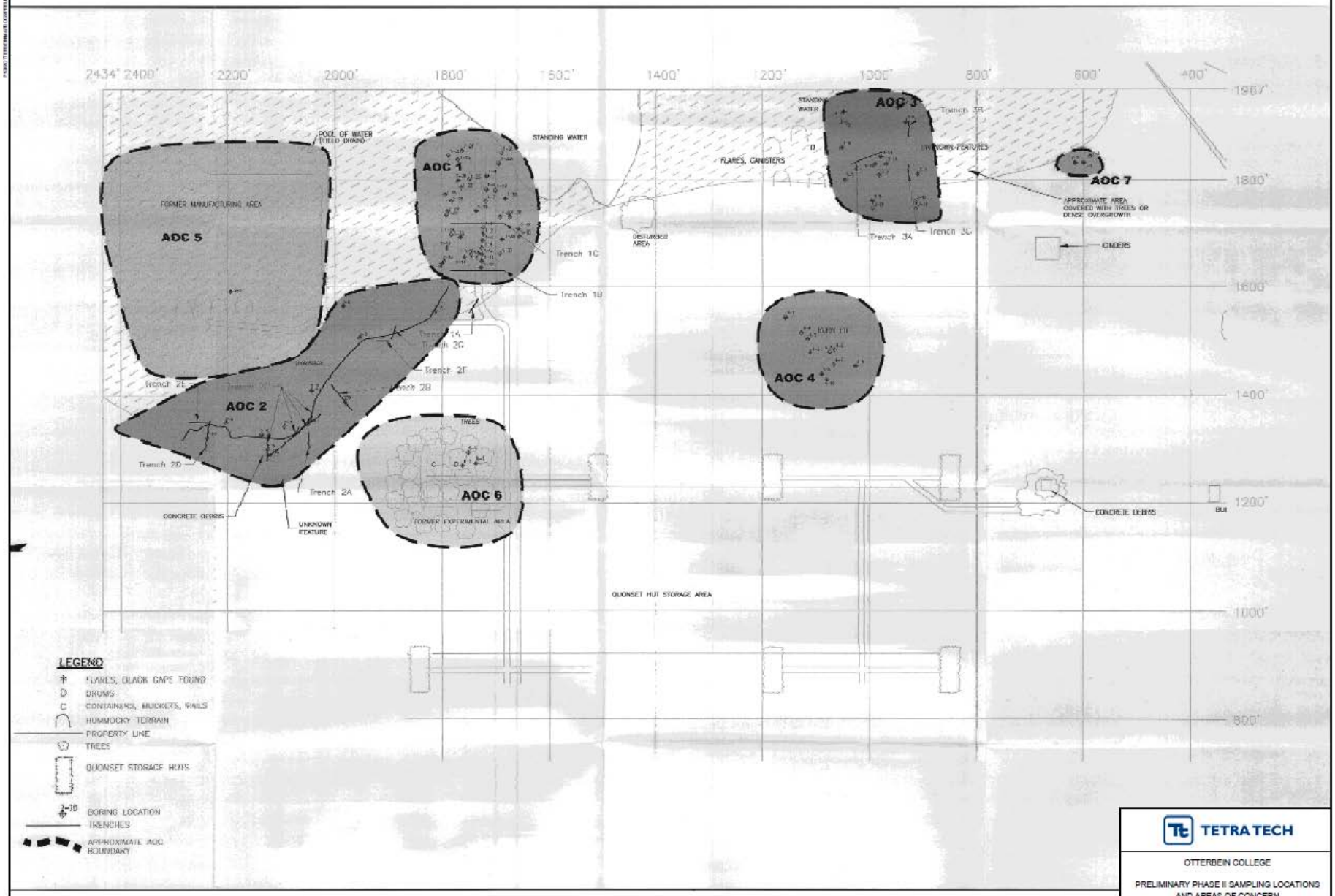


TETRA TECH

OTTERBEIN COLLEGE

GEOLOGIC CROSS-SECTION D - D'
OTTERBEIN COLLEGE EQUINE FACILITY
WESTERVILLE, OHIO

DRAWN BY	SCALE	
T. WHEATON	AS NOTED	
FIGURE NUMBER	REV	DATE
FIGURE 8	0	08/06/10

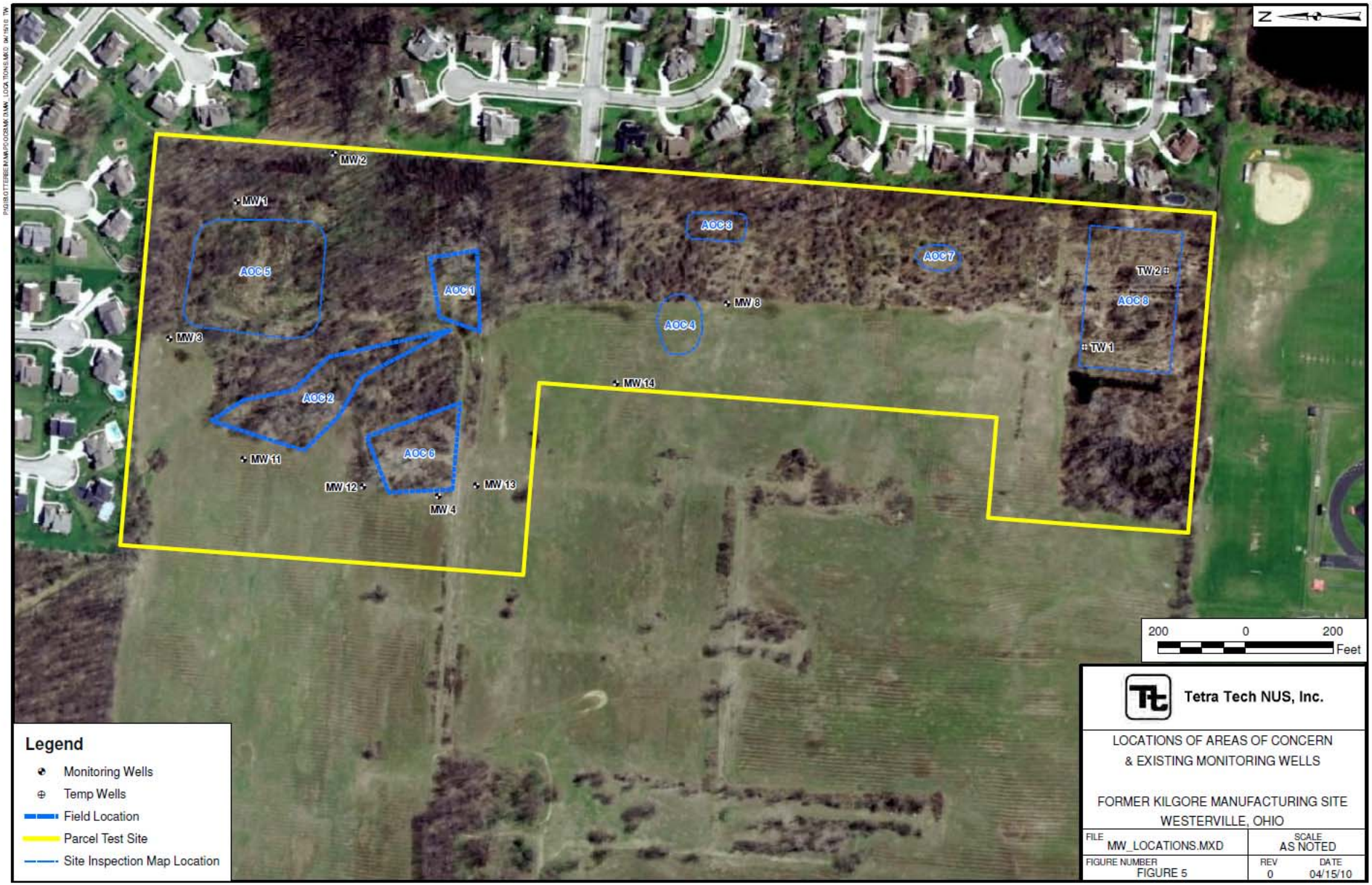


TETRA TECH

OTTERBEIN COLLEGE

PRELIMINARY PHASE II SAMPLING LOCATIONS AND AREAS OF CONCERN
OTTERBEIN COLLEGE EQUINE FACILITY
WESTERVILLE, OHIO

DRAWN BY	SCALE
T. WHEATON	AS NOTED
FIGURE NUMBER	REV / DATE
FIGURE 10	0 / 08/06/10

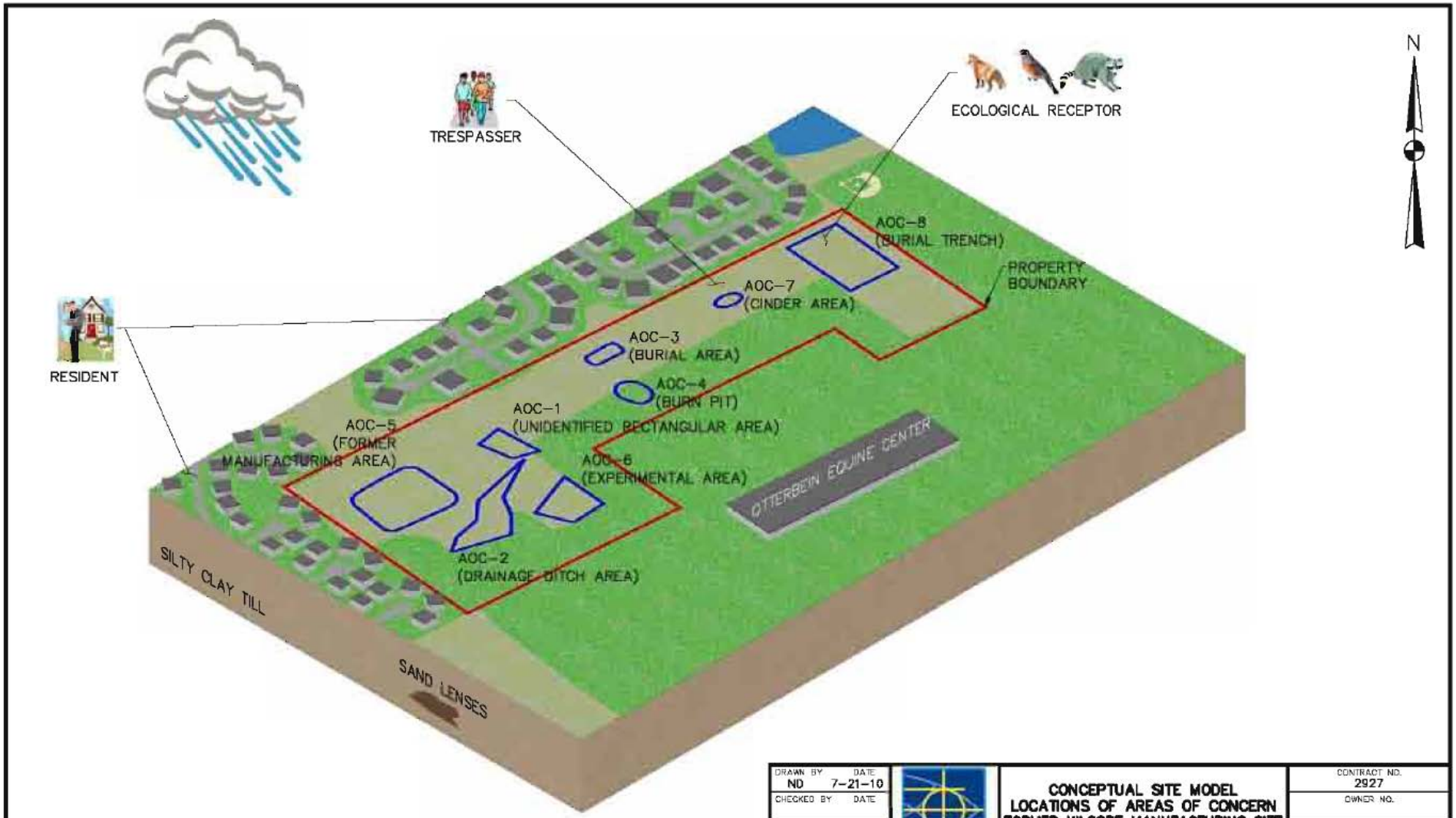


Tetra Tech NUS, Inc.

LOCATIONS OF AREAS OF CONCERN
& EXISTING MONITORING WELLS

FORMER KILGORE MANUFACTURING SITE
WESTERVILLE, OHIO

FILE	SCALE
MW_LOCATIONS.MXD	AS NOTED
FIGURE NUMBER: FIGURE 5	REV: 0 / DATE: 04/15/10



DRAWN BY ND DATE 7-21-10	NAVFAC	CONCEPTUAL SITE MODEL LOCATIONS OF AREAS OF CONCERN FORMER KILGORE MANUFACTURING SITE WESTERVILLE, OHIO	CONTRACT NO. 2927
CHECKED BY DATE			OWNER NO.
REVISED BY DATE			APPROVED BY DATE
SCALE NOT TO SCALE			DRAWING NO. FIGURE 5-1 REV. 0

R:\2927\CSM\2927CSM01.dwg PIT CARLY.KRAMER 8/5/2010 11:14:00 AM

State of Ohio Environmental Protection Agency

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www.epa.state.oh.us

P.O. Box 1049
Columbus, OH 43216-1049

CERTIFIED MAIL #91 7108 2133 3932 4449 3732

RECEIVED OCT 0 1 2010

September 28, 2010

Al Quagliotti, P.G.
Tetra Tech, NUS, Inc.
Foster Plaza 7
661 Andersen Drive
Pittsburgh, PA 15220-2745

Re: Review of Pre-Investigation Evaluation Report
Former Kilgore Manufacturing Company Property
Westerville, Delaware County, Ohio
Project ID #121001187012

Dear Mr. Quagliotti:

On August 10, 2010, the Ohio Environmental Protection Agency (Ohio EPA) received the *Pre-Investigation Evaluation Report* (PER) for the former Kilgore Manufacturing Company property located at 600 North Spring Street, Westerville, Delaware County, Ohio. The PER was prepared by Tetra Tech, NUS Inc. on behalf of Otterbein College (now Otterbein University) following Section VIII. *Remedial Investigation and Feasibility Study* (RI/FS) of draft consent decree (the most current version is August 3, 2010) for implementation of the RI/FS. (Although the consent decree remains in draft form, a revised version should not affect our comments on the PER.)

Ohio EPA has completed its review of the PER and provides the following comments to be addressed in the appropriate RI/FS work plan documents in conformance with the consent decree, the RI/FS statement of work, applicable state and federal law, and the guidance documents listed in an attachment to the consent decree.

General Comments

A. OAC 3745-27-13
Include a brief description of the Ohio Administrative Code (OAC) 3745-27-13 authorization for disturbances where hazardous or solid waste facility was operated for Areas of Concern (AOC) 3 and AOC 8.
http://www.epa.ohio.gov/portals/34/document/guidance/gd_631.pdf
http://www.epa.ohio.gov/portals/34/document/currentrule/3745-27-13_current.pdf

B. VAP Standards

Voluntary Action Program (VAP) unrestricted use standards including the generic direct contact standards for residential or unrestricted use are not applicable to remedial response sites. See General Comments G and I for further information on screening levels. For future work, plans and RI/FS documentation, consider tabulating the available data in comparison to screening levels described below, using a standardized reporting format in accordance with the *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments, Final, EPA/540/R-97/033, Publication 9285.7, NTIS PB97-963305, Office of Emergency and Remedial Response, Washington, D.C.)* (U.S. EPA, 2001). http://www.epa.gov/superfund/programs/reforms/docs/vv_RAGsD.pdf

C. ARARs

See the Ohio EPA Division of Emergency and Remedial Response (DERR) guidance titled *Use of Applicable or Relevant and Appropriate Requirements in the Ohio EPA Remedial Response Program* and the list available through the agency web site at http://www.epa.ohio.gov/portals/30/rules/RR-034LIST.pdf. See General Comment G, MCLS, and Specific Comment Section 7.3., Federal, ARARS, State Requirements, and TBCs.

D. Background

For screening purposes, the background sampling should be performed in a reference location pre-approved by Ohio EPA and in media of similar type and in a horizon as those evaluated at the site. The background level should be calculated according to the method provided in Ohio EPA DERR *Use of Background for Remedial Response Sites* (Ohio EPA DERR, 2009) as point values equal to upper quartile plus 1.5 times (interquartile range)of the data set. http://www.epa.ohio.gov/portals/30/rules/bground%20guidance.pdf

E. CSM

All potentially exposed receptors including residential, commercial, industrial and recreational should be included in the Conceptual Site Model (CSM). It may be cost-effective to determine the intended future site use prior to risk assessment, applying the process described in *Reuse Assessment: A Tool to Implement the Superfund Land Use Directive* (OSWER 9355.7-06P) (U.S. EPA, 2001). http://www.epa.gov/superfund/policy/pdfs/reusefinal.pdf

F. Ground Water Guidance

The Remedial Response Program relies on the *Technical Guidance Manual for Hydrogeologic Investigations and Ground Water Monitoring* (TGM). http://www.epa.ohio.gov/ddagw/tgmweb.aspx

G. MCLs

Ohio EPA DERR Remedial Response Program does not use the maximum contaminant levels (MCLs) for screening purposes; rather, the approach customarily followed by the Remedial Response Program is to determine a cumulative risk for the site. The cumulative risk are not to exceed our risk goal of hazard quotient (HQ) of one and lifetime cancer risk (LCR) of 1E-05. See comments on U.S. EPA's Regional Screening Levels (RSLs) in General Comment I. Comparison to RSLs or ecological screening levels is useful to identify early data needs; however, the object of the remedial investigation is to collect and evaluate data of sufficient quality to support a baseline risk assessment to determine the need for remedial action and to select feasible remedial options. MCLs may be used as Applicable or Relevant and Appropriate Requirements (ARARs) at the final phase of the RI/FS in the section of remediation goals.
http://www.epa.ohio.gov/portals/30/rules/RR-038.pdf
http://www.epa.ohio.gov/portals/30/rules/screening.pdf

H. MEC

The munitions and explosives of concern (MEC) left over at the site should be evaluated, hazard assessed and the residue should be disposed appropriately. For assessment, use the methodology described in the U.S. EPA 2008 interim guidance titled *Munitions and Explosives of Concern Hazard Assessment Methodology*, Publication Number EPA 505B08001. Interim, October 2008.
http://www.epa.gov/fedfac/documents/docs/mec_ha_methodology_interim.pdf

I. RSLs (formerly PRGs)

The screening levels used during the RI/FS should include the RSLs. The current application of RSLs replaces the older preliminary remediation goals (PRGs). The residential RSLs (and adjustments by 0.1 for non-carcinogens) are to be used for screening new and existing data. See the U.S. EPA Region 9 web site http://www.epa.gov/region9/superfund/prg/ for the most recent listing of the RSLs used by U.S. EPA Regions 3, 6 and 9. See General Comment G for a web link to Ohio EPA DERR Remedial Response Program screening level guidance.

J. Wetland

Include a brief description of the application for a Nationwide Permit or individual permit (if required) process including cultural resources investigation and endangered species survey. Ohio Administrative Code (OAC) 3745-1-54 requires "an appropriate wetland evaluation methodology acceptable to the director." In general, the Ohio Rapid Assessment Method (ORAM) has been accepted for use in Ohio.
http://www.epa.ohio.gov/dsw/wetlands/WetlandEcologySection.aspx#ORAM

K. Reference
Provide a copy of the *W.R. Grace And Compa*ny 1961 referenced report or provide its location in the PER appendix.

Specific Comments

2.1 Project Initiation Meeting
For the project initiation meeting, include a summary of the discussion and conclusions in bulleted format.

3.0 Description of Current Conditions

3.1. In Section 3.3 *Description of the Areas of Concern*, identify the basis of the conversion of volumes into tons for each of the AOCs. Provide an estimated volume of waste in AOC 8.

3.2. Characterization of the backfill used in any of the AOCs, especially AOCs 3, 4 and 5, should be addressed in the RI/FS work plan.

3.3. Include any special requirements or precautions related to the potential for encountering munitions and MEC at the site in the field sampling plan (FSP) and health and safety plan (HASP).

3.4. The stream area is identified in Figures 8 and 10, in the January 2000 UXB International, Inc. *Report of Preliminary UXO Assessment and Geophysical Investigation*, based on an EM31 data vertical, in-phase geophysical survey (see Appendix B). Add a map of AOC 2 showing the surface drainage.

3.5. The RI/FS work plan should include petroleum as chemicals of concern (COCs) in AOC 5 and an evaluation of the vapor intrusion pathway.
http://www.epa.ohio.gov/portals/30/rules/DI-033.pdf
http://www.epa.ohio.gov/portals/30/rules/VI%20guidance.pdf

3.6. Include any special requirements or precautions in the FSP and HASP related to the potential for encountering unexploded ordinance (UXO) at the site, especially in AOC 6 and AOC 8.

3.7. Explain why there is uncertainty in the acreage of AOC 8, ranging from two and one-half acres to eight acres.

3.8. Include a map for AOC 8 showing the approximate locations of the 20 exploratory trenches based on Figure 3, *Site Map*, dated December 1996 by Lawhon & Associates, Inc. (see Appendix B).

3.9. Include a figure showing the locations of underground utilities and planned utilities at the site, which may be important in identifying potential migration pathways. In addition, look for any old maps that would show field tiling.

3.10. Table 3-1, *Potential Chemicals of Concern*, is incomplete. Add the following list of potential chemicals of concern that have historically been identified at the site: arsenic, beryllium, cadmium, chromium (hexavalent), nickel, thallium, benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene, hydrocarbons, perchlorate, potassium picrate, antimony trisulfide, trinitrotoluene, and dintrotoluene. Other chemicals commonly used in the manufacture of fireworks include carbon, cesium, chlorine, lithium, rubidium, and titanium.

3.11. Clarify the size of the former underground storage tank (UST). Section 3.3.5 *AOC 5 Manufacturing Area Former UST Location*, gives the size of the UST as being 2,500 gallons; however, in Section 4.4.5, *AOC - UST in Former Manufacturing Area*, the size is listed as 3,500 gallons. In addition, state the contents of the UST and its use at the facility. Include the appropriate COCs, based on the former contents of the UST, for the planned soil and ground water sampling of AOC 5.

3.12. In Section 3.3.5 on page 3-7, explain the relevance of "*VAO*" standards.

3.13. Section 3.3.8, *AOC 8 Former Burial Trench Area*, lists the size of the 15 test trenches and pit. If possible, show the approximate locations of these test trenches and pit on a figure in map view and in cross-sectional views.

3.14. Geologic cross sections, Figures 3-5 through 3-8, should include sections parallel to the ground water flow direction and perpendicular to the ground water flow direction.

4.0 Existing Data Analysis

4.1. Section, *AOC 1 – Unidentified Rectangular Feature*, 4.4.1 states "... it is unknown if the chromium is the more toxic hexavalent form..." Under the current guidelines (U.S. EPA 1986), Chromoium VI (*e.g.,* hexavalent chromium) is classified as Group A – known human carcinogen by the inhalation route of exposure. Carcinogenicity by the oral route of exposure cannot be determined and is classified as Group D (U.S. EPA, IRIS). It may be cost-effective to request from the chemical laboratory to perform a speciation of the total chromium in soil.
http://www.epa.gov/cancerguidelines/guidelines-carcinogen-risk-assessment-1986.htm
http://www.epa.gov/ncea/iris/subst/0144.htm

4.2. In Section 4.5.2, *Soil*, the potential migration of contaminants is not taken into account for AOC 4. Explain why migration is not applicable to AOC 4. Also, add AOC 8 to this discussion.

4.3. Table 4-2, *Off-Site Laboratory Analytical Methods Summary*, is incomplete. See Specific Comment 3.10 for additional chemicals. Ensure that the practical quantitation limits are at or below the RSLs and ecological screening levels. The reporting limits (RLs) should be established early in the RI/FS process, together with the Data Quality Objectives (DQOs). The selected laboratory and analytical method should assure that the results will be generated with sensitivity adequate to the Ohio EPA DERR recommended screening levels (SLs) (U.S. EPA, 2008). Any chemical with RL greater than SL cannot be eliminated from the data set used for baseline risk assessment. Instead, it should be assumed that it is present at a concentration equal to one-half of the RL and should be processed as a COC. Please note that the adjusted SL for perchlorate in water is 0.0026 mg/L, and the SL for hexavalent chromium in soil is 0.29 mg/kg.
http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=569fa78170e3bcc5b19b8c75021eb640&rgn=div5&view=text&node=40:22.0.1.1.1&idno=40

4.4. Revise Tables 4-3, 4-4, 4-5, 4-6, 4-7, 4-8, 4-9, 4-10, 4-11, 4-12, 4-13, 4-14, 4-15 and 4-16 to include RSLs. Note that VAP unrestricted use standards, including the generic direct contact standards for residential or unrestricted use, are not applicable to remedial response sites. See General Comments B. Revise Table 5-2, *Groundwater VAP/MCL Exceedances of Regulatory Standards*, accordingly.

4.5. Re-evaluate the ground water flow direction using new data and use Figure 4-2, *Locations of Areas of Concern & existing Monitoring Wells*, as a base map for a ground water potentiometric surface map showing the direction of ground water flow at the site.

5.0 Conceptual Site Model

5.1. In Section 5.1, *Site Location*, the surrounding land use to the north should include residential development. This document states "...the CSM depicts the general Site location, the Areas of Concern, a simplified geologic cross section, and illustrates a few of the potential receptors [...] North: Vacant field and wooded land..." In the CSM described in the text and presented in Figure 5.1 (see Specific Comment 5.7), there are potentially misleading errors and inconsistencies, for example:

- The arrow which is supposed to point North, is actually pointing to the South-East.
- Instead of a "vacant field" to the North, there is already residential development.
- Neither the exposure media, nor the pathways have been identified. Only the on-site trespassers along with ecological receptors and the off-site residents have been identified as potentially exposed.
- Identify potential exposure pathways including utility corridors and transport mechanisms.
- Potential off-site receptors, including residents and nearby students, need to be identified in the CSM.

See the *Soil Screening Guidance – Attachment A: Conceptual Site Mode Summary*, EPA540/R-96/018, July 1996 (U.S. EPA, 1996) and the *Framework for Cumulative Risk* Assessment, EPA630/P-02/001F, May 2003 (U.S. EPA, 2003).
http://www.epa.gov/superfund/health/conmedia/soil/pdfs/attacha.pdf
http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=54944

5.2. In Section 5.5, *Ground Water Migration Pathways and Receptors*, explain how the hydraulic gradient was determined.

5.3. Section 5.7, *Soil Migration Pathways*, should include air, surface water and ground water media.

5.4. Add a row for AOC 8 in Table 5-1, *Identified Areas of Concern (AOCs)*.

5.5. Data gaps identified in Table 5-2, *Ground Water VAP/MCL Exceedances of Regulatory Standards*, should be addressed in the RI/FS work plan.

5.6. In Table 5-4, *Potential Human Health Exposure Pathways*, the ground water to air and soil to air exposure pathways may be complete because mercury (Hg^0) and some petroleum hydrocarbons are volatiles in terms of vapor intrusion. In addition, the pathway determination for the ground water direct contact and soil to ground water ingestion and dermal contact are deemed incomplete due to the statement that "connection to public water supply is required." Substantiate the existence of an apparent city ordinance that requires this. An environmental covenant may be required for this site to prohibit access to ground water exposure pathways. (See Ohio Revised Code (ORC) §§ 5301.80 - .92).

Section 7.2 Remedial Action Objectives

7.2.1. A baseline risk assessment must be performed to demonstrate carcinogenic and non-carcinogenic human health risk posed by the contamination at the site. See General Comment G.

7.2.2. Prepare remedial action objectives (RAOs) that are specific to both cancer and non-cancer risks using risk levels acceptable to Ohio EPA. The RAOs should address all potential COCs including petroleum and other volatile chemicals. See Specific Comment 5.6.

Section 7.3 Federal, ARARs, State Requirements, and TBCs

7.3.1 Chemical-Specific ARARs and TBCs.

- Cite OAC 3745-81-11 and 3745-81-12 that contains the MCLs for inorganic and organic chemicals.
- See the General Comment I on U.S. EPA Region 9 RSLs.
- Cite OAC 3745-1-05 (A-C) and OAC 3745-1-07 for surface water ARARs including the Antidegradation Policy for Surface Water and Water Quality Criteria.
- For petroleum UST corrective action, see the Bureau of Underground Storage Tank Regulations' rule, OAC 1301:7-9-13.

7.3.2 Location-Specific ARARs and TBCs

- For endangered plant species, see the Ohio Department of Natural Resources (ODNR) statue, ORC § 1518.02, and rule, OAC 1501:18-1, for the List of Endangered Plant Species.
- For endangered animal species, see the ODNR statute, ORC § 1531.25, and rule, OAC 1501:31-23, for the List of Endangered Animal Species.
- For wetland narrative criteria, see OAC 3745-1-51.
- For water, see Section 401 of the Clean Water Act and ORC § 6111.30.

7.3.3 Action-Specific ARARs

For "digging" where a hazardous or solid waste facility was located, see ORC § 3734.02; and for disturbances where a hazardous or solid waste facility was operated, see OAC 3745-27-13.

- For wetland antidegradation, see OAC 3745-1-54.
- For general analysis of hazardous waste, see OAC 3745-54-13.
- For the environmental covenant, see ORC §§ 5301.80 - .92.

Section 7.4 General Response Actions

7.4.1. Limited actions (*i.e.,* Land Use Controls (LUCs)) are termed institutional controls under the Remedial Response Program and require an environmental covenant per ORC §§ 5301.80 - .92. http://www.epa.ohio.gov/LinkClick.aspx?fileticket=sW9HrwpQQLs%3d&tabid=3071

7.4.2. For Table 7-1, *Remediation Technologies*, identify preliminary remedial action alternatives either as engineering controls or institutional controls. The feasibility study will likely need to include remedial action alternatives, including both engineering and institutional controls.

7.4.3. Once the remedial action alternatives are sufficiently defined, each alternative will be assessed against eight evaluation criteria, including the following:

- Threshold Criteria
  - Overall protection of human health and the environment
  - Compliance with ARARs
- Balancing Criteria
  - Long-term effectiveness and permanence
  - Reduction of toxicity, mobility, or volume through treatment
  - Short-term effectiveness
  - Implementability
  - Cost
- Modifying Criteria
  - Community Acceptance (public notice and public hearing by Ohio EPA)

8.2 Ground Water Data Needs

8.2.1. For AOC 6, explain the relevance of "*VAO*" standards.

8.2.2. The last bullet under the ground water data gaps is incomplete. Include AOC 8 in the ground water evaluation.

8.2.3. Develop a proposed sample location map and include it in the RI/FS work plan.

Include information on the condition of existing monitoring wells at the site. If the monitoring wells are being considered for use in the remedial investigation, then they need to be evaluated to determine if any of them are suitable for use. Include the procedures for redeveloping the existing site monitoring wells and ground water sampling techniques in the RI/FS work plan. Address any special well construction requirements for wells in or around wetlands. If the monitoring wells are damaged or otherwise unsuitable, they need to be properly abandoned in accordance with the well sealing guidance, *State of Ohio Technical Guidance for Sealing Unused Wells* by the State Coordinating Committee on Ground Water. See General Comment H.
http://www.dnr.state.oh.us/Portals/7/pubs/pdfs/wellsealing.pdf

8.2.4. The need to determine aquifer characteristics and to measure the ground water flow direction(s) should be addressed in the RI/FS work plan.

8.3 Soil Data Needs

8.3.1. Explain the rationale or statistical basis for the selection of two additional soil borings from many of the AOCs for confirmation and/or characterization.

8.3.2. Explain the sampling rationale for the selection of the 20 soil borings planned for characterizing AOC 8.

8.3.3. Include a drawing showing the approximate location of proposed delineation trenches.

8.3.4. In the HASP, fully describe health and safety precautions when handling MEC and/or UXO constituents.

8.4 Additional Wetlands Identification

See General Comment J on wetland permitting requirements. Also include the date (June 22, 2005) from the referenced Civil & Environmental Consultants, Inc. (CEC) report and include the report in Section 9.0, *References.* See General Comment H.

8.5 DQOs

Develop site specific data quality objectives (DQOs) for the RI/FS and include them in the RI/FS work plan. Laboratory reporting limits (RLs) must be at or below the corresponding RSLs (multiplied by 0.1 for non-carcinogens); otherwise, every chemical with a RL greater than the RSL should be assumed to be present in the respective

medium at a concentration equal to one-half of the RL in order to collect and evaluate data of sufficient quality to support a baseline risk assessment.

Response Required

Within 30 days of receipt of this letter containing Ohio EPA's comments on the PER, unless otherwise specified by Ohio EPA, please submit to Ohio EPA a RI/FS work plan in accordance with the draft consent order, the RI/FS statement of work and applicable state and federal law.

Please submit two copies of the RI/FS work plan documents (one hard copy and one indexed electronic copy on compact disc) to my attention. Additionally, please send one hard copy of the RI/FS work plan documents to Mark Rickrich, DERR Enforcement Coordinator.

Ohio EPA's review of the PER does not constitute an approval of the document. Additionally, the absence of comments on the PER does not eliminate the discussion of any item in the subsequent RI/FS process. If you have any questions concerning this letter, please contact Robin Roth at (614) 466-2476.

Sincerely,

Robin Roth

Robin Roth
Site Coordinator
Division of Emergency and Remedial Response
Central District Office

c: Rebecca Vasquez-Skillings, Otterbein University
Ron Kuis, Ronald L. Kuis & Associates
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ATTACHMENT B

FIELD SAMPLING PLAN

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1.0 PROJECT BACKGROUND

Site background and previous investigations are described in Section 2 of the site specific Work Plan.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

Project organization and responsibilities are outlined in Section 8 of the site specific Work Plan.

3.0 PROJECT SCOPE AND OBJECTIVES

Tetra Tech NUS (TtNUS) has been contracted by Otterbein University (Otterbein) to conduct a Remedial Investigation/Feasibility Study (RI/FS) at the 8 Areas of Concern (AOCs) identified at the former Kilgore Manufacturing Company Facility (the Site). This RI/FS will be conducted in accordance with the proposed consent order between the State of Ohio, Otterbein College, and the United States Department of Defense (2010). Several investigations have been conducted at the Site dating back to when the Site closed operations in 1962. See Section 2 of the site specific Work Plan for details. Figure 1-2 of the Work Plan identifies the layout of the Site and eight associated AOCs:

- AOC 1 – Unidentified Rectangular Features
- AOC 2 – Drainage Ditch Near Former Manufacturing Area
- AOC 3 – Burial Area
- AOC 4 – Burn Pit
- AOC 5 – Manufacturing Area – Former Underground Storage Tank (UST) Location.
- AOC 6 – Former Experimental Area
- AOC 7 – Cinder Area
- AOC 8 – Former Burial Trench Area

Field sampling efforts will be conducted using UXO avoidance procedures. A trained UXO technician will monitor all intrusive drilling activities and will alert and stop work if danger of encountering an Unexploded Ordinances (UXO) becomes apparent. If UXO are encountered the Field Operations Lead (FOL) will notify the Otterbein point of contact and the Project Manager. Further details regarding this process can be found in the Health and Safety Plan (HASP) (Attachment D of the Work Plan)

Additional details regarding the project scope and objectives are described in Section 5 and the project schedule is outlined in Section 7 of the site specific Work Plan.

3.1 Field Sampling Tasks

The field tasks associated with the Former Kilgore Manufacturing Site Remedial Investigation area summarized below along with a brief description of these tasks.

- Mobilization/demobilization
- Monitoring well installation
- Well development
- Groundwater sampling
- Surveying
- Water-level measurements
- Surface/subsurface soil and sediment sampling
- Surface water sampling
- Test Pit sampling
- Field decontamination procedures
- Field documentation procedures
- Waste Handling

Mobilization/Demobilization

Mobilization will consist of delivery of all equipment, materials and supplies to the site, the complete assembly in satisfactory working order of all equipment at the site, and the satisfactory storage at the site of all such materials and supplies. TtNUS will coordinate with Otterbein College to identify locations for storage of equipment and supplies.

Site-specific health and safety training for all TtNUS field staff and subcontractors will be provided as part of the mobilization activities. Health and safety requirements are described in the site-specific TtNUS HASP located in Attachment D of the Work Plan.

Demobilization will consist of the prompt and timely removal of all equipment, materials, and supplies from the site following the completion of work.

Monitoring Well Installation

Eleven new permanent monitoring wells will be installed on site. Seven wells will be installed within the boundaries of established AOCs and four will be installed along the property boundary. PMW-1 will be installed at AOC 5 downgradient of the former UST. All wells will be installed at the first water bearing zone in accordance with Standard Operating Procedure (SOP) GH-2.8 (Appendix B).

Existing Monitoring Well Inspection

Prior to groundwater sampling, existing monitoring wells will be inspected for physical integrity in accordance with SOP GH-1.2 (Appendix B). If wells are damaged or unsuitable this information will be reported in the RI Report.

Monitoring Well Development and Redevelopment

Newly installed monitoring wells will be developed no sooner than 48 hours after well installation. Existing wells have not been sampled or developed in several years and they will be redeveloped prior to sampling. Well development will be completed as described in Section 5.1.2.3.11.

Groundwater Sampling

Groundwater samples will be collected and placed in bottles provided by the laboratory from six existing monitoring wells and the 11 newly installed permanent wells in accordance with SOP SA-1.1 (Appendix B). As described on Table 3-1 all groundwater samples will be analyzed for Target Analyte List (TAL) metals, strontium, perchlorate, and explosives. The three southern boundary wells located downgradient of AOC 8 and PMW-1 downgradient of AOC 5 UST will also be sampled for volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs). All samples will be sent to an Ohio Environmental Protection Agency (OEPA) approved laboratory.

Surveying

The locations of all newly installed monitoring wells will be professionally surveyed by an Ohio certified surveyor. North American Datum (NAD) 1983 will be used as the horizontal datum and survey measurements will be recorded to the nearest 0.10 foot. Vertical elevations of both the ground and top of polyvinyl chloride (PVC) casing will be referenced to 1988 National Geodetic Vertical Datum (NGVD).

Soil borings, test pit, surface water and sediment locations along with any other significant site features will be located using a Global Positioning System (GPS).

Water-Level Measurements

Water-level measurements will be collected from all newly installed and existing monitoring wells in accordance with SOP GH-1.2 (Appendix B). Measurements will be performed at all existing wells at the onset of the field investigation, and a second round of site-wide measurements will be made just prior to the groundwater sampling activity.

Surface/Subsurface Soil and Sediment Sampling

Soil samples will be collected at all eight AOCs for site wide characterization to assist in determining remediation options. Soil sample locations were determined based on historic sampling activities. Most soil sample locations were placed at areas where previous samples reported elevated readings for one or more contaminant. The remainder of the sample locations were placed in a downgradient location at the AOC. After sampling, each borehole will be backfilled to within 6 inches of grade using the soil cuttings removed from the borehole. A minimum 6-inch thick grout/bentonite seal will then be placed to grade at each boring. The surface will be returned to its original condition.

A drilling subcontractor will utilize direct push technology (DPT) methods to advance the proposed soil borings to their required depths as described in Section 5.0. Soil sampling will proceed continuously from the land surface to the total depth of each boring. The subcontractor will provide appropriately sized disposable acetate liners capable of containerizing sample. Sampling will be completed in accordance with SOPs SA-2.5 and SA-1.3 (Appendix B).

A soil boring log will be prepared for each boring with soil descriptions and all relevant information, observations, depth to saturated soil/water table, and photoionization detector (PID) field screening results as in accordance with SOP SA-6.3 (Appendix B). Soil samples will be collected in jars provided by the laboratory and placed immediately in an iced cooler for shipment to a fixed base laboratory as described on Table 5-2 in accordance with SOP SA-1.3 (Appendix B). Soil sample depths will be included on each log.

There are several potential drainage ditches onsite where water accumulates and one onsite pond. Sediment samples will be collected from these areas in accordance with SOP SA-1.2 (Appendix B). Sediment sampling activities are described in Section 5.3.

Surface Water Sampling

There is one existing pond on the site; however, depending on the time of year, water may accumulate in low lying areas in and around the wetlands. The surface water sample in the existing pond will be sampled and if other areas of temporary standing water present during the time of the field event, samples may also be collected there.

There is a borrow pit located approximately 330 feet southeast of the site and just east of the school property. The water in this borrow pit will be sampled as part of the RI.

Surface water sampling, which is scheduled for at least two ponds and potentially from low lying areas that collect water, is described in Section 5.4.

Test Pit Sampling

Two test pits will be installed in AOC 8, the Southeast Landfill Boundary Area to determine the “lateral extent” of contamination. Test pits will be approximately 6 feet deep and extend on the north and west sides for up to 800 feet in total.

If the FOL observes material in the test pits which appears to be buried waste up to eight samples will be collected to determine the nature of the material. The sample locations and frequency will be determined in the field by the FOL.

See Section 5.5 for details concerning test pit operations.

Field Decontamination Procedures

Decontamination of major equipment and non-dedicated sampling equipment will be done in accordance with SOP SA-7.1 (Appendix B). An area for the decontamination pad and a source of potable water for steam washing will be arranged by the FOL through Otterbein College personnel.

Field Documentation Procedures

Field documentation will be performed in accordance with SOP SA-6.3 (Appendix B).

A summary of all field activities will be properly recorded in a bound logbook with consecutively numbered pages that cannot be removed. Logbooks will be assigned to field personnel and will be stored in a secured area when not in use.

Waste Handling

All solid and liquid wastes generated as a result of this investigation will be handled in accordance with the procedures described in accordance with SOP SA7.1 (Appendix B).

All soil and aqueous waste will be collected in separate 55 gallon drums. Drums will be sampled and taken off-site for disposal.

Personal protective equipment (gloves, sampling scoops, acetate liners, etc.) will be properly discarded in dumpsters as non-hazardous waste.

4.0 NON-MEASUREMENT DATA ACQUISITION

The following non-measurement data acquisition procedures will be used during the RI:

- A site geologist will visually observe soil for staining and, discoloration, and olfactory senses will be used to detect odors during soil boring investigation
- UXO personnel will be monitoring the Site for the presence of UXO material.

5.0 FIELD ACTIVITIES BY AREA OF CONCERN

There are eight identified AOCs associated with the site. All eight AOCs require further investigation to better assist in evaluation or remedial action in order to meet applicable regulatory standards.

AOC 1 – Unidentified Rectangular Features

Surface and subsurface soils in this area were determined to contain several metals at concentrations above Ohio Voluntary Action Program (VAP) Residential Standards and are likely to exceed current residential risk-based standards as well. In order to complete the delineation of the impacted soil two additional soil borings will be advanced at this AOC. These two borings will be advanced to six feet bgs. Both a surface and subsurface sample will be collected from each location. The subsurface sample depth will be determined in the field based on visual observations and/or highest PID readings. If no contamination is observed, a sample will be collected from the interval directly above the water table. Samples collected will be sent to a fixed base laboratory and analyzed for TAL metals, strontium, and explosives.

Groundwater will also be further investigated in AOC 1. Two monitoring wells (PMW-3 and PMW-4) will be installed within the areas of AOCs 1, 2, and 6 (Figure 5-1 and Table 3-1). PMW-3 will be installed in the northeastern corner of AOC 6 and PMW-4 will be installed outside of the site boundary between AOCs 1 and 4 (Figure 5-1). These wells will be installed in areas where groundwater might be expected to be impacted if constituents of concern (COCs) had leached from soil into groundwater. The newly-installed wells will be used to define the nature and extent of any potential impacts. These two newly installed wells will be sampled for TAL metals, strontium, explosives, and perchlorate.

AOC 2 – Drainage Ditch Near Former Manufacturing Area

AOC 2 is an intermittent drainage ditch near the former manufacturing area where wastes were reportedly buried. Surface and subsurface soils in this area have been found to contain several metals at concentrations above Ohio VAP Residential Standards, and the extent of munitions and explosives of

concern (MEC) is unknown. To complete the delineation of impacted soil, six additional soil borings will be advanced at this AOC (Figure 5-1 and Table 3-1). These six borings will be advanced to 4 feet bgs. Both a surface and subsurface sample will be collected from each location. The subsurface sample depth will be determined in the field based on visual observations and/or highest PID readings. If no visible, PID or olfactory evidence of contamination is observed, then the sample will be collected from the interval directly above the water table. Samples collected will be sent to a fixed base laboratory and analyzed for target analyte list (TAL) metals, strontium, and explosives.

AOC 3 – Burial Area East of Burn Pit

AOC 3 is a former burial area for cinders and nonflammable materials. Surface and subsurface soils in this area are impacted with several metals at concentrations above Ohio VAP Residential Standards and are likely to exceed current residential risk-based standards as well. To complete the delineation of impacts in this area two additional soil borings will be preformed (Figure 5-1 and Table 3-1). These two borings will be advanced to 6 feet bgs. Both a surface and subsurface sample will be collected from each location. The subsurface sample selected for laboratory analysis will be determined in the field based on visual observations and/or highest PID readings. If no contamination is observed, then the sample will be collected from the interval directly above the water table. Samples collected will be sent to a fixed base laboratory and analyzed for TAL metals, strontium, and explosives. Based on field observations (fly ash and/or evidence of burn material) two samples will be collected for dioxin/furans. If dioxin/furans are detected at this location an additional sample will be collected at AOC 4 where the burn material originated.

A groundwater monitoring well (PMW-6) will be installed downgradient of AOC 6 (Figure 5-1 and Table 3-1) at a location where groundwater might be expected to be impacted if COCs had leached from soils at AOC 3 into groundwater. Samples from this well will assist in the delineation of the nature and extent of any potential groundwater impacts. This newly installed well will be sampled for TAL metals, strontium, explosives, and perchlorate.

AOC 4 – Burn Pit

AOC 4 is the site of a former burn pit used to burn flares, caps and other off-specification materials and waste. Surface and subsurface soils in this area were determined to have several metals at concentrations above Ohio VAP Residential Standards and are likely to exceed current residential risk-based standards as well. Based on To complete the delineation of impacted soil three additional soil borings will be advanced at this AOC (Figure 5-1 and Table 3-1). These three borings will be advanced to 4 feet bgs. One will be advanced within the known fill area and the remaining two will be advanced at the boundary. Both a surface and subsurface sample will be collected from each location. The

subsurface sample depth will be determined in the field based on visual observations and/or highest PID readings. If no contamination is observed, then the sample will be collected from the interval directly above the water table. Samples collected will be sent to a fixed base laboratory and analyzed for TAL metals, strontium, explosives, and PAHs.

One existing monitoring well is located downgradient of AOC 4 (MW#-8). This well will be sampled for TAL metals, strontium, explosives, perchlorate, and PAHs.

AOC 5 – Underground Storage Tank in Former Manufacturing Area East of Burn Pit

AOC 5 is the area surrounding a former underground storage tank (UST) in the former Manufacturing Area. The tank and the surrounding soil were removed in 1997. Surface and subsurface soils in this area were reported to have several metals at concentrations above Ohio VAP Residential Standards and are likely to exceed current residential risk-based standards as well. To complete the delineation of impacted soil, three additional soil borings will be advanced at this AOC (Figure 5-1 and Table 3-1). These three borings will be advanced to 6 feet bgs. Both a surface and subsurface sample will be collected from each location. The subsurface sample depth will be determined in the field based on visual observations and/or highest PID readings. If no contamination is observed, then the sample will be collected from the interval directly above the water table. Samples collected will be sent to a fixed base laboratory and analyzed for TAL metals, strontium, explosives, and PAHs. One subsurface sample at OC-AOC5-SB115 will be collected from the interval directly above the groundwater table and will also be analyzed for VOCs and TPH.

Additional characterization of groundwater in this area will be accomplished by the installation of two permanent monitoring wells. PMW-1 will be installed in the center of the AOC, directly downgradient of the former UST. Well PMW-2 will be installed just outside of the site boundary, in the southeastern corner at a location hydraulically downgradient of AOC 5 (Figure 5-1). These wells will be installed in areas of which would be expected to be impacted if activities at the AOC resulted in releases to the groundwater. Samples collected will be sent to a fixed base laboratory and analyzed for TAL metals, strontium, perchlorate, explosives, and PAHs. PMW-1 will also be sampled for VOCs.

AOC 6 – Former Experimental Area

AOC 6 is an area where the former Kilgore Company conducted research and testing of products. Surface and subsurface soils in this area were reported to have several metals at concentrations above Ohio VAP Residential Standards and are likely to exceed current residential risk-based standards as well. To complete the delineation of impacted soil, three additional soil borings will be advanced at this AOC (Figure 5-1 and Table 3-1). These three borings will be advanced to 12 feet bgs. Both a surface and

subsurface sample will be collected from each location. The subsurface sample depth will be determined in the field based on visual observations and/or highest PID readings. If no contamination is observed, then the sample will be collected from the interval directly above the water table. Samples collected will be sent to a fixed base laboratory and analyzed for TAL metals, strontium, explosives, and PAHs.

One new monitoring well will be installed as described in AOC 1 (above) to evaluate potential groundwater from this AOC.

AOC 7 – Cinder Area South East of Burn Pit

AOC 7 is a small area characterized by cinders, coal fragments, and slag at the ground surface. Previous sampling in this area did not identify any materials that exceeded concentrations above Ohio VAP Residential Standards and are likely to exceed current residential risk-based standards as well. Previous investigation did, however, identify some orange and red materials which require further investigation. To complete the delineation of potential soil impacts three additional soil borings will be advanced at this AOC (Figure 5-1 and Table 3-1). These three borings will be advanced to 4 feet bgs. Both a surface and subsurface sample will be collected from each location. The subsurface sample depth will be determined in the field based on visual observations and PID readings. If no contamination is observed, then the sample will be collected from the interval directly above the water table. Samples collected will be sent to a fixed base laboratory and analyzed for TAL metals, strontium, and explosives.

To gain further characterization of potential groundwater impacts in this area, a permanent monitoring well will be installed just outside of the eastern boundary (downgradient) of AOC 7 (Figure 5-1). Samples from this well will be used to determine the nature and extent of any potential groundwater impacts. Samples collected will be sent to a fixed base laboratory and analyzed for TAL metals, strontium, perchlorate, and explosives.

AOC 8 – Southeast Landfill Area

AOC 8 is a former burial area which has reportedly been investigated previously and “cleaned up” however, it warrants additional investigation to clearly define outer perimeter of the area. Additional data is also needed to evaluate any potential remaining water materials, and provide data to assist in the evaluation of potential remediation alternatives.

To complete the delineation of AOC 8 and associated water materials, twenty additional soil borings will be advanced at this AOC. These twenty borings will be advanced to twelve feet bgs. Both a surface and subsurface sample will be collected from each location. The subsurface sample depth will be determined in the field based on visual observations and/or highest PID readings. If no contamination is observed,

then the sample will be collected from the interval directly above the water table. Samples collected will be sent to a fixed base laboratory and analyzed for TAL metals plus strontium, and explosives.

A subset (up to 25 percent) of the AOC 8 soils will also be analyzed for PAHs and VOCs. Random selection will be used; however, the field personnel will have the authority to use visible olfactory and/or highest PID reading to select additional samples for the additional analysis of PAHs and VOCs.

Two trenches will be dug, using a backhoe to delineate the boundary of the extent of AOC 8. This work will be done along the north and western sides of the landfill boundary to a depth of 6 feet bgs and up to 800 feet total in length. Up to eight samples will be collected if suspicious materials are identified. Samples collected will be sent to a fixed base laboratory and analyzed for TAL metals, strontium, explosives, PAHs, and VOCs.

Groundwater will be further investigated at AOC 8 through the installation of four monitoring wells. Three wells (PMW-9, PMW-10 and PMW-11) will be installed downgradient of the former landfill along the southern boundary of AOC 8 (Figure 5-1). PMW-7 will be installed upgradient north west of AOC 8. Samples collected will be sent to a fixed base laboratory and analyzed for TAL metals, strontium, explosives, perchlorate, VOCs, and PAHs.

Sitewide Groundwater

Groundwater samples will be collected from six existing permanent monitoring wells. Several VAP groundwater exceedances were reported in earlier investigations, but the results were discounted on the basis of turbid samples or temporary monitoring wells. Samples collected will be sent to a fixed base laboratory and analyzed for TAL metals, strontium, perchlorate, and explosives. As described above in AOC 4, groundwater collected from MW#8 will also be analyzed for PAHs. Dioxins/furans are excluded from the groundwater analyses because these compounds bind tightly to soil and detection of these compounds is not anticipated in groundwater.

The data gathered from the six existing monitoring wells will be combined with the 11 new monitoring wells to provide a comprehensive groundwater monitoring network for the Site.

Sitewide-Sediment and Surface Water

There is one existing pond onsite; however, depending on the time of year, water may accumulate in low laying areas in and around the wetlands. The surface water sample in the existing pond will be sampled and if other areas of temporary standing water present during the time of the field event, samples may also be collected there.

There is a borrow pit located approximately 350 feet southeast of the site and just east of the school property. The water in this borrow pit will be sampled as part of the RI.

All surface water and sediment samples will be analyzed for TAL metals, strontium, explosives, and PAHs.

5.1 Groundwater

Currently, there are nine permanent monitoring wells onsite. Six of these wells will be sampled during this field event to obtain current data and identify if the contaminants of concern are present. The other three wells are located in upgradient locations and sampling them is not considered necessary at this time. Eleven new wells will be installed and sampled to further delineate any potential impacts and determine if COCs are present in groundwater.

5.1.1 Rationale/Design

5.1.1.1 Monitoring Well Location and Installation

The locations of new groundwater wells at the Site are shown on Figure 5-1 and will be positioned as follows:

- AOC 5: PMW-1 will be installed in the vicinity of a former leaking UST and the area where subsoils had a “hydrocarbon odor”.

- AOC 5: PMW-2 will be installed within a historic manufacturing area where settling basins have been identified as a potential source of discharge to groundwater.

- AOC 6: PMW-3 will be installed in the location where a past investigation a temporary well yielded samples exceeding VAP standards.

- East-central Property Boundary: PMW-5 a property boundary monitoring point which will be located downgradient of AOC 1 and AOC 2.

- East-central Property Boundary: PMW-6 a property boundary monitoring point which will be located downgradient of AOC 3.

- South-west Property Boundary: PMW-7 a property boundary monitoring point is upgradient of AOC 8.

- South-east Property Boundary: PMW-8 is a property boundary monitoring point downgradient of AOC 7.

- AOC 8: PMWs 9, 10, and 11 are wells downgradient of the former southeast landfill area that will also serve to monitor the southern portion of the site.

5.1.1.2 Sample Collection and Field and Laboratory Analysis

All monitoring wells will be screened with a PID upon opening the well. All wells will be sampled for TAL metals, strontium, explosives and perchlorate. Additionally, PMW-2 will be sampled for PAHs, and PMWs-1,9, 10, and 11 will be sampled for VOCs and PAHs.

5.1.1.3 Upgradient, Quality Assurance/Quality Control, and Blank Samples and Frequency

Site groundwater is assumed to be flowing southeast. Existing and newly installed monitoring wells that are upgradient of the Site will be sampled to confirm the presence or absence of contamination from an off-site source. Existing upgradient monitoring wells that will be sampled are MW#3, MW#12, MW#13 and the newly installed upgradient well is PMW-7. Samples will be collected from these wells for TAL metals, strontium, explosives, and perchlorate.

Quality Assurance/Quality Control (QA/QC) and blank samples and frequencies for all AOCs are outlined in Table 5-1.

5.1.2 Monitoring Well Installation

5.1.2.1 Drilling Methods and Equipment

Hollow-stem auger or drilling techniques capable of creating a minimum 4-inch diameter borehole will be utilized for installing monitoring wells in accordance with SOP GH-1.3 (Appendix B). Soil will be continuously logged and classified during drilling at each location to confirm the lithology identified during the background soil type characterization, as described in the following sections. The observations collected during installation will be used to determine the monitoring well screen interval placement and to make sure wells are screened across the first encountered water bearing zone.

Well construction details will be recorded on a Monitoring Well Construction Log and maintained in the project file.

5.1.2.2 Materials

5.1.2.2.1 Casing/Screen/Centralizers

All wells will be constructed with certified-clean well construction material. Monitoring wells will be constructed of 2-inch inside diameter (ID), flush-threaded, PVC well screen and compatibly threaded PVC well casing. PVC will meet National Sanitation Foundation (NSF) Standard 14 as specified by the United States Environmental Protection Agency's (USEPA) (OEPA, 2009). Screens will be 10-foot-long, 0.01-inch slot PVC.

5.1.2.2.2 Filter Pack, Bentonite Seal, Cement/Bentonite Grout

Sand passing U.S. Standard Sieve No. 20-30 will be used for finer formations (0.010-inch slot size) and/or coarser sand (U.S. Standard sieve No. 16-30) will be used with 0.020-inch slot size screens in coarser formations.

5.1.2.2.3 Surface Completion

Monitoring wells will be completed in accordance with SOP GH-2.8 (Appendix B) with a sealable locking cap and a flush-mount manhole type cover or aboveground protective cover (considering current and future land use) set into a concrete pad or stainless steel stick-up completions dependant on location. Conventional Type I Portland cement will be used for well completion.

5.1.2.2.4 Water Source

Monitoring wells will be installed in the first water bearing zone encountered.

5.1.2.2.5 Delivery, Storage, and Handling of Materials

All materials will be new clean materials and stored onsite.

5.1.2.3 Installation

Prior to monitoring well construction, utilities will be located by Ohio Utility Protection Services (OUPS) and marked out in the proposed monitoring well locations.

5.1.2.3.1 Test Holes

Split-spoon samples will be collected for screening at 2-foot intervals in accordance with SOP GH-1.5 (Appendix B).

5.1.2.3.2 Soil Sampling

Split-spoon soil samples will be collected for screening at 2-foot intervals in accordance with SOP SA-1.3 (Appendix B).and the drilling log will contain the soil type, color, rocks or minerals present, sample intervals, organic vapor, field screening measurements, and a qualitative indication of soil conditions.

5.1.2.3.3 Borehole Diameter and Depth

Monitoring wells will be installed using hollow-stem augers with a 4¼-inch ID (8- to 9-inch outer diameter) that will allow for a minimum 2-inch thick sand pack in the annulus between all sides of each new well and the sidewalls of the boring. The monitoring wells will be installed through the augers upon completion of each boring.

5.1.2.3.4 Screen and Well Casing Placement

The total depth of the well is expected to be approximately 25 to 30 feet bgs. The well screen will be 10 feet in length and placed at the bottom of the well.

5.1.2.3.5 Filter Pack Placement

A primary filter pack of clean silica sand will be installed flush with the bottom of the well to a minimum of 3 feet above the top of the well screen. The annulus surrounding the screen will be backfilled using an appropriately sized sand pack for the slot size and surrounding hydrogeologic unit. Filter packs will be installed utilizing the gravity placement method (OEPA, 2009). During filter pack placement, regular measurements with a weighted tape will be conducted to determine if the desired height has been reached and to reduce bridging.

5.1.2.3.6 Bentonite Seal

A minimum 12-inch-thick seal of 100 percent sodium bentonite pellets will be installed above the primary filter pack and allowed to hydrate in accordance with the manufacturer's recommendations.

5.1.2.3.7 Cement/Bentonite Grout Placement

Depending on the screen/seal placement cement/bentonite grout may be placed above the bentonite seal to up to one foot below the surface.

5.1.2.3.8 Concrete/Gravel Pad Placement

Annular space between the existing ground surface and the protective casing will be filled with concrete. The concrete aprons will be flush with the ground surface, will measure 3 feet by 3 feet, and have a thickness of 6 inches. Wells will be constructed so that the concrete pad is monolithic from the ground surface to 2 feet bgs (depending on the depth of the water table) into the boring. Depending on the screen/seal placement, the concrete will be placed on top of bentonite grout or the bentonite seal at the geologist discretion after proper curing times have been allowed for the grout/seal.

5.1.2.3.9 Protective Cover Placement

A stick-up steel casing equipped with a locking cap will be grouted in place around each well within the concrete aprons down to the frost line. A small drain or “weep hole” will be located just above the surface seal to prevent accumulation of water between the casings. Bumper/barrier guards will be placed around the well to reduce and prevent damage by vehicles and increase visibility.

5.1.2.3.10 Well Identification

Each monitoring well will have a well tag attached to the protective casing in accordance with the USEPA regulation. Each well tag will contain the following information:

- Well identification number
- Date of construction
- Name of contractor
- Depth of well
- Screened interval
- Top of casing elevation
- Northing of well
- Easting of well
- Reference datum
- Well information contact

5.1.2.3.11 Well Development

Newly installed monitoring wells will be developed no sooner than 48 hours after well installation. Existing wells have not been sampled or developed in several years and will be redeveloped prior to sampling. Well development will cease when the following criteria are achieved between 5- to 10 minute interval readings (or 2 hours of purging has passed, whichever is achieved first):

Parameter	Stabilization Criteria
pH	±0.2
specific electric conductance	± 3%
temperature	± 0.5 ºC
turbidity	<= 10 NTUs; ±10% (when turbidity is greater than 10 NTUs)
oxidation -reduction potential (ORP)	± 20 millivolts
dissolved oxygen (DO)	10% or ±0.2 mg/L, whichever is greater

Well development will be completed in accordance with SOP GH 2.8 (Appendix B) and OEPA Technical Guidance (OEPA, 2009).

Well development will be performed using a surge-block and vacuum pump or decontaminated submersible pump to remove fines and reestablish hydrologic communication with the surrounding hydrogeologic unit. Proper development of monitoring wells is critical to obtaining high-quality representative groundwater samples. The pump intake will be moved up and down throughout the 10-foot screen interval to make sure development of the entire screen interval is achieved. A field turbidity meter will be used to determine turbidity during development. A minimum of 10 casing volumes purged from each well. Visual observations of the purge water, along with field turbidity measurements and the volume of water purged from the well, will be recorded in the field log book or on well development logs.

5.1.2.3.12 Well Survey

The locations of all newly installed permanent monitoring wells will be professionally surveyed by an Ohio certified surveyor. NAD 1983 will be used as the horizontal datum to the nearest 0.10 foot. Vertical elevations of both the ground and top of PVC casing will be referenced to 1988 NGVD.

5.1.2.4 Documentation

5.1.2.4.1 Logs and Well Installation Diagrams

Boring logs and monitoring well diagrams will be maintained for each soil boring/monitoring well by the TtNUS field geologist on the form provided in Appendix C. Field screening and a lithologic description of

each soil sample will be recorded on the boring log. The boring logs and well construction diagrams will be included as attachments to the RI/FS Report. Documentation will be done in accordance with the OEPA Technical Guidance Manual (TGM) guidelines (OEPA, 2009) and TtNUS SOP (Appendix B).

5.1.2.4.2 Development Records

Water quality measurements and volumes removed will be recorded for each well on the well development form. A blank copy is provided in Appendix C. The completed well development forms will be included in the RI/FS Report.

5.1.2.4.3 Decommission/Abandonment Records

No decommission or abandonment activities are anticipated during the RI.

5.1.2.4.4 Photographs

Photographs will be taken by field personnel of conditions that they feel are relevant to describe potential problem areas of the site. Photographs will also be taken of selected backhoe pits, trenches and samples in order to illustrate subsurface conditions.

5.1.2.4.5 Monitoring Well Inspection

Prior to groundwater sampling existing monitoring wells will be inspected for physical integrity in accordance with TtNUS SOP GH-1.2 (Appendix B). Inspection will include the following items:

- The condition of the protective casing, cap and lock.
- The condition of the cement seal surrounding the protective casing.
- The presence of depressions or standing water around the casing.
- The presence of and condition of dedicated sampling equipment.
- The presence of a survey mark on the inner well casing.

Any deficiencies will be reported in the RI Report.

5.1.2.4.6 Well Decommission/Abandonment

No well decommission/abandonment activities are anticipated during the RI.

5.1.2.4.7 Water Level Measurement

A round of synoptic water-level measurements will be collected from the newly and previously installed permanent monitoring wells to determine direction of groundwater flow. Water-level measurements will be taken within a short time period (maximum 24 hours) of consistent weather conditions to minimize atmospheric/precipitation effects on groundwater levels. Measurements will be taken with an electronic water-level indicator using the top of the well casing as the reference point for determining depths to water. Water-level measurements will be recorded to the nearest 0.01 foot in the appropriate field log book and/or on a groundwater level measurement form (Appendix C). The tops of the well casings will be surveyed and a groundwater potentiometric surface map will be developed for the RI/FS Report.

5.1.3 Determine Free Product Presence and Sampling

Free product is not expected at the Site. An oil-water interface probe will be used when collecting water level measurements to determine the presence or absence of free product in the wells.

5.1.4 Aquifer Testing

No aquifer testing is planned during the RI. If the groundwater samples reveal impacts to the groundwater in excess of the RSLs, it may be necessary to perform testing of the aquifer to provide data relevant to the assessment of human health or ecological risks, and the development of potential remedial actions.

5.1.4 Field Measurement Procedures and Criteria

All groundwater samples will be collected in accordance with the U.S. EPA FBQSTP (USEPA 2007) and TtNUS SOP SA-1.1, Low Flow Purge and Sampling (Appendix B).

All monitoring wells will be purged before sampling using a low-flow peristaltic pump and polyethylene tubing. Well purging will be performed immediately before each well is sampled. The water level and the total depth of the monitoring well will be measured before the start of purging.

In accordance with TtNUS SOP SA-1.1 and OEPA, pH, temperature, turbidity, specific conductance, dissolved oxygen, and salinity will be measured during purging and will be recorded on sample log sheets (Appendix C). These measurements will be taken at the start of purging and every 5 to 10 minutes thereafter until the following stabilization criteria are reached over a minimum of three readings:

Parameter	Stabilization Criteria
pH	± 0.1 standard units*
specific conductance	± 3%
oxidation-reduction potential (ORP)	± 10 millivolts
turbidity	± 10% (when > 10 NTUs) maintained at < 10 NTUs, consider stabilized
dissolved oxygen (DO)	± 0.3 milligrams per liter
temperature	± 0.5 º Celsius

* The ± 0.1 may not always be obtainable, especially if purging and sampling with bailers. Therefore, professional judgment may be needed to determine that conditions are stable.

In the event that 10 NTUs cannot be achieved, appropriate notation will be recorded in the field logs and the scheduled sample will be collected. All purge water removed from the wells will be containerized and handled/disposed of as investigation derived waste (IDW).

5.1.5 Sampling Methods for Ground Water – General

Groundwater samples will be collected using low-flow sampling procedures. After stabilization has occurred, all samples will be transferred directly from the peristaltic pump tubing to the sample container. Volatile organic samples will be collected first directly from the discharge side of the tubing after reducing the pump's flow rate to minimize turbulence and making sure that zero headspace is present in the filled sample container. Semivolatile organic, TAL metal, strontium, mercury, perchlorate, and explosives sample containers will be filled next at a regular "low" flow rate.

5.1.6 Sample Handling Methods for Ground Water – Filtration

If turbidity in a well does not reach 10 NTUs an additional sample will be collected for dissolved metals analysis. Samples collected for metals analysis will be field-filtered using an appropriately sized filter (i.e., 0.45 micron) to allow naturally suspended colloidal particles to pass, and preserved immediately following filtration.

5.1.7 Sample Containers and Preservation Techniques

All sample bottles will arrive to the site pre-preserved by the lab.

5.1.8 Field Quality Control Sampling Procedures

QA/QC procedures, including field and analytical procedures, equipment calibration, chain-of-custody requirements, sample containers and preservatives, and QA/QC sample types and frequency, are defined in the Site-specific Quality Assurance Project Plan (QAPP) (Attachment C of the Work Plan).

All groundwater samples will be submitted for Level 4 data reporting and validation. The data reporting and validation levels are defined in the site specific QAPP (Attachment C of the Work Plan).

5.1.9 Decontamination Procedures

The non-dedicated equipment involved in field sampling activities will be decontaminated prior to beginning work, between locations, during drilling and sampling activities, and at the completion of the project in a laydown area.

Major Equipment

All downhole drilling equipment, including downhole drilling tools, will be cleaned with potable water prior to beginning work, between boreholes, whenever the drill rig leaves the site prior to completing a boring, and at the conclusion of the drilling program.

Decontamination operations consist of washing equipment using a high-pressure steam wash from a potable water supply. All decontamination activities will be take place at a predetermined area within the site. Additional requirements are found in TtNUS SOP SA-7.1(Appendix B).

Sampling Equipment

Nondisposable sampling equipment will be decontaminated prior to beginning field sampling, between samples, and at the conclusion of the sampling program. Sampling equipment will be washed with potable water and Alconox (or equivalent), rinsed with potable water, then rinsed with deionized water. Disposable sampling equipment used for sampling activities shall be discarded. Field analytical equipment such as pH, conductivity, and temperature instrument probes will be rinsed with Alconox and deionized water. Additional requirements are found in TtNUS SOP SA-7.1 (Appendix B).

5.2 Subsurface Soil

5.2.1 Rationale/Design

5.2.1.1 Soil Boring Locations

All eight AOCs have been identified as needing further sampling. Subsurface samples will be collected at each AOC. A total of 42 soil boring locations will be installed throughout the site to provide full coverage of the investigation area. These locations are identified on Figure 5-1

5.2.1.2 Discrete Soil Sampling Requirement

All of the proposed soil samples will be collected as discrete samples. The use of composite samples is not anticipated at this time.

5.2.1.3 Sample Collection and Field and Laboratory Analysis

One subsurface soil sample will be collected at an interval with staining or other changes in the subsurface soil that appears to be non-native, unnatural odor, and/or highest readings from the PID. If none of these are present then the sample will be collected from the 2 foot interval above the groundwater table. Tables 3-1 and 5-2 identifies by AOC how many soil boring locations will be advanced and samples that will be collected. These tables also identify for what parameters the laboratory will be analyzing.

5.2.1.4 Background, QA/QC, and Blank Samples and Frequency

Currently no background samples are planned for this RI. If it becomes evident that a constituent (such as arsenic) is consistently detected above RSLs, additional soil samples may be collected in order to define background levels.

QA/QC and blank samples and frequencies are outlined on Table 5-1. QA/QC sampling will be done in accordance with the site specific QAPP (Attachment C of the Work Plan).

5.2.2 Field Procedures

5.2.2.1 Boring Methods

Soil sample collection will be performed with the use of DPT in accordance with SOP SA-2.5 (Appendix B).

5.2.2.2 Boring Logs

Soil borings will be logged continuously while the DPT advances to collect soil samples. These logs will be completed in accordance with the SOP for soil boring logging GH-1.5 in Appendix B.

5.2.2.3 Sampling for Chemical Analyses

After soil has been screened and logged soil sample locations will be identified. VOCs will be collected first with minimum disturbance to the soil core, then the remainder of the sample will be collected using a decontaminated stainless steel or disposable plastic scoop and placed in a bowl or ziplock bag homogenized and placed in the appropriate containers. The SOP for soil sampling SA-1.3 is provided in Appendix B.

Soil samples will be representative of the overall soil matrix at each sample location and will be generally free of organic material and gravel unless that material represents the primary soil type at the particular sample location. Portions of samples intended for laboratory analysis will be placed in the appropriate laboratory-supplied containers, labeled, and stored on ice to await shipment to the laboratory.

Soil samples will be collected as discrete or “grab” samples. Reusable equipment will be decontaminated in accordance with the SOP for Decontamination Procedures SA-7.1 (Appendix B) prior to each use, at the end of the sampling event and between each soil sampling location.

5.2.2.4 Sample Containers and Preservation Techniques

All sample bottles will arrive to the site pre-preserved by the lab.

5.2.2.5 Field Quality Control Sampling Procedures

QA/QC procedures, including field and analytical procedures, equipment calibration, chain-of-custody requirements, sample containers and preservatives, and QA/QC sample types and frequency, are defined in the Site-specific QAPP (Attachment C of the Work Plan) .

Analytical results for Site evaluation soil samples (including lateral and vertical delineation samples if needed) will include Level 4 data reporting and validation. The data reporting and validation levels are defined in the site specific QAPP (TtNUS, 2010).

5.2.2.6 Decontamination Procedures

All reusable equipment will be decontaminated in accordance with the SOP for Decontamination SA-7.1 provided in Appendix B. Reusable sampling equipment will be decontaminated prior to the first use and in between each sampling location.

All loose soil will be removed from soil sampling equipment. The sampling equipment will then be placed in a bucket with a detergent and distilled water solution and scrubbed to remove any residual soil. Sampling equipment will then be rinsed in a bucket of clean water. Both the detergent wash and clean water rinse solutions will be periodically changed as needed.

All decontamination liquids will be collected and placed in 55 gallon drums.

5.3 Surface Soil and Sediment

5.3.1 Rationale/Design

5.3.1.1 Surface Soil Sample Locations

All eight AOCs have been identified as needing further sampling. Surface soil samples will be collected at each AOC. A total of 42 surface soil locations will be collected throughout the site to provide full coverage of the investigation area. These locations are identified on Figure 5-1.

5.3.1.2 Sediment Sample Locations from Onsite and/or Offsite Drainage Channels

There are several potential drainage ditches onsite where water accumulates and one onsite pond. Sediment samples will be collected from these areas in accordance with SOP SA-1.2 (Appendix B).

In addition to the 42 surface soil samples up to five sediment sample locations will be based on field observations and at the discretion of the FOL.

No offsite sediment sampling is planned during the RI.

5.3.1.3 Sediment Sample Locations from Onsite Pond(s)

There is one existing pond onsite, however depending on the time of year water may accumulate in other low laying areas in and around the wetlands. The sediment in the existing pond will be sampled and if other ponds are present during the time of the field event samples may also be collected there. Up to five samples will be collected at the discretion of the FOL.

5.3.1.4 Discrete Soil and Sediment Sampling Requirements

Discrete surface soil and sediment samples will be collected in accordance with TtNUS SOP SA-1.2 and SA-1.3 (Appendix B).

5.3.1.5 Sample Collection and Field and Laboratory Analysis

One surface soil sample will be collected at the surface interval of 0-1 foot bgs. Tables 3-1 and 5-2 identify by AOC how many soil boring locations will be advanced and samples that will be collected. The tables also identified for what parameters the laboratory will be analyzing.

5.3.1.6 QA/QC, and Blank Samples and Frequency

QA/QC and blank samples and frequencies are outlined in Table 5-1.

5.3.2 Field Procedures

5.3.2.1 Sampling Methods for Surface Soil/Dry Sediment

Soil samples collected for laboratory analysis will be collected using a decontaminated stainless steel or disposable plastic scoop to fill the appropriate containers. The SOP for soil sampling SA-1.3 is provided in Appendix B.

Soil samples will be representative of the overall soil matrix at each sample location and will be generally free of organic material and gravel unless that material represents the primary soil type at the particular sample location. Portions of samples intended for laboratory analysis will be placed in the appropriate laboratory-supplied containers, labeled, and stored on ice to await shipment to the laboratory.

Soil samples will be collected as discrete or “grab” samples. The sampling procedure will meet USEPA sampling requirements using properly decontaminated or disposable sampling equipment. Reusable equipment will be decontaminated in accordance with the SOP for decontamination (SA-7.1 is provided in Appendix B) prior to each use, at the end of the sampling event and between each soil sampling location.

5.3.2.2 Sample Containers and Preservation Techniques

All sample bottles will arrive to the site pre-preserved by the lab in accordance with the site specific QAPP (Attachment C of the Work Plan).

5.3.2.3 Field QC Sampling Procedures

QA/QC procedures, including field and analytical procedures, equipment calibration, chain-of-custody requirements, sample containers and preservatives, and QA/QC sample types and frequency, are defined in the Site-specific QAPP (Attachment C of the Work Plan).

Analytical results for Site evaluation soil samples (including lateral and vertical delineation samples if needed) will include Level 4 data reporting and validation. The data reporting and validation levels are defined in the site specific QAPP (Attachment C of the Work Plan).

5.3.2.4 Decontamination Procedures

All reusable equipment will be decontaminated in accordance with the TtNUS SOP for decontamination SA-7.1 provided in Appendix B. Reusable sampling equipment will be decontaminated prior to the first use and in between each sampling location.

All loose soil will be removed from soil sampling equipment. The sampling equipment will then be placed in a bucket with a detergent and distilled water solution and scrubbed to remove any residual soil. Sampling equipment will then be rinsed in a bucket of clean water. Both the detergent wash and clean water rinse solutions will be periodically changed, as needed.

All decontamination liquids will be collected and placed in 55 gallon drums.

5.4 Surface Water

5.4.1 Rationale/Design

5.4.1.1 Surface Water Sample Locations

There is one existing pond onsite; however, depending on the time of year water may accumulate in low lying areas in and around the wetlands. The surface water sample in the existing pond will be sampled, and if other ponds are present during the time of the field event, samples may also be collected there. Up to five samples will be collected at the discretion of the FOL.

There is a borrow pit located approximately 350 feet southeast of the site and just east of the school property. The water in this borrow pit will be sampled as part of the RI. (Figure 5-1).

5.4.1.2 Sample Collection and Field and Laboratory Analysis

Surface water samples will be collected in accordance with TtNUS SOP and OEPA guidance.

5.4.1.3 QA/QC, and Blank Samples and Frequency

QA/QC and blank samples and frequencies are outlined in Table 5-1.

5.4.2 Field Procedures

5.4.2.1 Sampling Methods for Surface Water – General

Sample collection procedures will be determined by the FOL at the time of sampling based on field observations. The decision on which procedure will be used is at the discretion of the FOL, in accordance with the TtNUS SOP for surface water and sediment sampling SA-1.2 located in Appendix B.

5.4.2.2 Sample Handling Methods for Surface Water – Filtration

If a turbidity value less than 10 NTUs cannot be achieved water will be field filtered with a hand pump and inline disposable 0.45 micron filter.

5.4.2.3 Field Measurement Procedures and Criteria

During sampling pH, specific conductivity, temperature, ORP, and dissolved oxygen will be measured.

5.4.2.4 Sample Containers and Preservation Techniques

All sample bottles will arrive to the site pre-preserved by the lab.

5.4.2.5 Field Quality Control Sampling Procedures

QA/QC and blank samples and frequencies are outlined in Table 5-1.

5.4.2.6 Decontamination Procedures

All reusable equipment will be decontaminated in accordance with the Tt NUS SOP for decontamination SA-7.1 provided in Appendix B. Reusable sampling equipment will be decontaminated prior to the first use and in between each sampling location.

The sampling equipment will be placed in a bucket with a detergent and distilled water solution and scrubbed to remove any residual soil. Sampling equipment will then be rinsed in a bucket of clean water. Both the detergent wash and clean water rinse solutions will be periodically changed as needed.

All decontamination liquids will be collected and placed in 55 gallon drums.

5.5 Test Pit Sampling

5.5.1 Rationale/Design

Two test pits will be installed in AOC 8, the Southeast Landfill Boundary Area to determine the "lateral extent" of contamination. Test pits will be approximately 6 feet deep and extend on the north and west sides for up to 800 feet total (Figure 5-1).

5.5.1.1 Sample Locations

If the FOL observes material in the test pits which appears to be buried waste up to eight samples will be collected to determine the nature of the material. The sample locations and frequency will be determined in the field by the FOL.

5.5.1.2 Discrete/Composite Sampling Requirements

Discrete samples only will be collected from the test pits. Sample locations will be selected from the backhoe bucket by the FOL using a judgmental approach. The samples will be collected in accordance with the soil sampling SOP SA-1.3 (Appendix B).

5.5.1.3 Sample Collection and Field and Laboratory Analysis

After soil has been screened and logged soil sample locations will be identified. VOCs will be collected first with minimum disturbance to the soil core, then the remainder of the sample will be collected using a decontaminated stainless steel or disposable plastic scoop and placed in a bowl or ziplock bag homogenized and placed in the appropriate containers. The SOP for soil sampling SA-1.3 is provided in Appendix B.

Soil samples will be representative of the overall soil matrix at each sample location and will be generally free of organic material and gravel unless that material represents the primary soil type at the particular sample location. Portions of samples intended for laboratory analysis will be placed in the appropriate laboratory-supplied containers, labeled, and stored on ice to await shipment to the laboratory.

Soil samples will be collected as discrete or “grab” samples. Reusable equipment will be decontaminated in accordance with the SOP for decontamination, SA-7.1 located in Appendix B, prior to each use, at the end of the sampling event and between each soil sampling location.

5.5.1.4 QA/QC, and Blank Samples and Frequency

QA/QC and blank samples and frequencies are outlined in Table 5-1.

5.5.2 Field Procedures

5.5.2.1 Sampling Methods

Test pits will be advanced by a subcontracted backhoe operator to a depth of 6feet. Samples will be collected by the FOL from the backhoe bucket.

5.5.2.2 Sample Containers and Preservation Techniques

All sample bottles will arrive on site pre-preserved by the lab in accordance with the site specific QAPP (Attachment C of the Work Plan).

5.5.2.3 Field Quality Control Sampling Procedures

(QA/QC procedures, including field and analytical procedures, equipment calibration, chain-of-custody requirements, sample containers and preservatives, and QA/QC sample types and frequency, are defined in the Site-specific QAPP (Attachment C of the Work Plan).

Analytical results for Site evaluation soil samples (including lateral and vertical delineation samples if needed) will include Level 4 data reporting and validation. The data reporting and validation levels are defined in the site specific QAPP (Attachment C of the Work Plan).

5.5.2.4 Decontamination Procedures

All reusable equipment will be decontaminated in accordance with SOP SA-7.1 for decontamination, provided in Appendix B. Reusable sampling equipment will be decontaminated prior to the first use and in between each sampling location.

All loose soil will be removed from soil sampling equipment. The sampling equipment will then be placed in a bucket with a detergent and distilled water solution and scrubbed to remove any residual soil.

Sampling equipment will then be rinsed in a bucket of clean water. Both the detergent wash and clean water rinse solutions will be periodically changed as needed.

All decontamination liquids will be collected and placed in 55 gallon drums.

6.0 FIELD OPERATIONS DOCUMENTATION

6.1 Field Logbook and/or Sample Field Sheets

All Site activities will be recorded in a Site-specific field notebook or on Field Report Logs. Included in the documentation will be procedures used for sampling and other activities, weather conditions, personnel working on the Site, and a chronological log of Site activities. Copies of the Chain-of-Custody Form, Field Report Logs, Soil Boring Logs, Well Construction Logs, Groundwater Sampling Logs and Equipment Calibration Logs are provided in Appendix C.

6.2 Photographic Records

Photographs taken during site activities will be documented and photographic logs will be created to identify, at a minimum, the following characteristics:

- Location of photographer
- Orientation (e.g., “looking north”. “facing south”)
- Subject matter
- Date/time photographed.

When appropriate as determined by the photographer (e.g. the FOL or geologist), it may be useful to include the photograph an object of known size to impart an understanding of spatial scale.

6.3 Sample Documentation

6.3.1 Sample Numbering System

Each sample submitted to the laboratory for chemical analysis shall be assigned a unique sample identification number. The sample identification number will consist of a four segment, alpha-numeric code that identifies the site, sample type (medium) and location, and sample depth (Table 4-2).

The alpha-numeric coding to be used in the sample identification system is as follows:

Field Samples

(AA) - (AAAA)	-	(AA)	-	(NNN)	-	(NNNN)
(Site Name)	-	(Sample Type)	-	(Sample Location)	-	(Sample Depth or date)

Character Type: A - Alphabetic; N – Numeric
Site Name: "OC" – Otterbein College
For soil samples AOCs will be identified
Sample Type: SB – Subsurface soil sample
SS - would be used for surface and shallow subsurface soil sample
GW – Groundwater
TP – Test pit
SW – Surface water
SD - Sediment
Sample Location: Soil boring number (e.g., 101, 102, 103, etc. - consecutive numbering for each sample location).

Sample Depth: The first two digits is the top of the sampling interval in feet bgs and the second two digits is the bottom of the sampling interval.

Using this nomenclature scheme, the following is an example for a subsurface soil sample collected from 2-4 feet deep at location number 1: OC-AOC1-SB101-0204.

RB - Rinse Blank
FD - Field Duplicate

QA sample designations will be blind relative to field duplicates. Other pertinent information regarding sample identification will be recorded in the field log books and sample log sheets.

Using this nomenclature scheme, the following is an example for the first field duplicate groundwater sample collected: OC-SB-FD-01. The location of the sample collection points will be noted in the field logbook.

<u>Sample Labels and/or Tags</u>

Samples labels will be created in the field in real time as samples are collected.

Chain-of-Custody Records

The Chain-of-Custody form will be completed by the sampler and sealed inside the cooler during shipment or handed directly to the laboratory currier.

6.4 FIELD ANALYTICAL RECORDS

A PID and water quality meter will be utilized during field sampling. Results will be recorded on field forms (Appendix C) and the equipment calibrated in accordance with the manufactures instructions.

6.5 Documentation Procedures/Data Management and Retention

All Site activities will be recorded in a Site-specific field notebook or on Field Report Logs. Included in the documentation will be procedures used for sampling and other activities, weather conditions, personnel working on the Site, and a chronological log of Site activities. Copies of the Chain-of-Custody Form, Soil Boring Logs, Well Construction Logs, Low Flow Groundwater Purge Sheets, Groundwater Sampling Logs, Soil and Sediment Sampling Logs, Test Pit Logs, Surface Sampling Logs, and Equipment Calibration Logs are provided in Appendix C.

7.0 SAMPLE PACKAGING AND SHIPPING REQUIREMENTS

Samples shipped to the laboratory via overnight courier will be packed inside a cooler, with bubble wrap and ice, in a manner to prevent breakage of sample containers. Sample containers will be securely sealed to prevent damage or loss of the sample. Additional detail regarding sample packaging and shipping requirements is provided in the site specific QAPP (Attachment C of the Work Plan).

The Chain-of-Custody form will be completed by the sampler and sealed inside the cooler during shipment. Custody seals will be placed on the outside of the cooler. Sample coolers will be properly labeled and shipped according to U.S. Department of Transportation requirements.

8.0 INVESTIGATION-DERIVED WASTES (IDW)

Based on results of the IDW samples, IDW generated during the Site evaluation will be disposed of at an appropriately licensed facility. IDW exhibiting contaminant concentrations less than Toxicity Characteristic Leaching Procedure (TCLP) criteria and pH between 2 and 12.5 will be managed as non-hazardous solid waste. Soils exhibiting contaminant concentrations greater than TCLP criteria or pH less than or equal to 2 or pH greater than or equal to 12.5 will be managed as hazardous waste. Existing data suggests that IDW could be both non-hazardous and hazardous waste.

All disposable personal protective equipment (PPE) and sampling supplies will be disposed of with IDW.

9.0 FIELD ASSESSMENT/THREE-PHASE INSPECTION PROCEDURES

A field geologist will observe soil borings for evidence of light non-aqueous phase liquids (LNAPL) and dense non-aqueous phase liquids (DNAPL) when collecting soil cores. After new permanent monitoring wells are installed the field geologist will gauge the well with an oil-water interface probe. An interface probe will also be utilized during synoptic round of water level measurements.

TABLE 3-1

SUMMARY OF PLANNED SAMPLES
SAMPLE RATIONALE
FORMER KILGORE MANUFACTURING COMPANY FACILITY
WESTERVILLE, OHIO

AOC	Analyses (Soil)	No. of Soil Borings	No. Soil Samples	Rationale	Analyses (GW)	No. of Wells	No. GW Samples	Rationale
1	TAL metals, strontium, explosives	2	4	Contaminants from these analyte groups (except dioxins/furans) were detected previously at these AOCs. Sampling depths were selected to target locations of most probable highest contamination, plus additional locations to ensure nature of contamination is completely characterized. Dioxins/Furans were added to the AOC 3 parameter list because soils from AOC 4 were placed in AOC 3. If dioxin/furans are detected additional soil samples may be collected from AOC 4.	TAL metals, strontium, explosives, perchlorate	2 new wells (shared among AOCs 1, 2, and 6)	2	New wells will be installed in areas downgradient of AOCs (assuming that contaminants have leached from soil into groundwater). The new and existing well samples will ensure the nature of contamination and extent of groundwater contamination are well characterized. This is especially important for AOC 8, which has not been as well characterized as other AOCs. The upgradient wells will be sampled to provide a point of comparison for any chemicals detected in groundwater at or down gradient of other AOCs.
2	TAL metals, strontium, explosives	6	12		TAL metals, strontium, explosives, perchlorate	See AOC 1	See AOC 1	
3	TAL metals, strontium, explosives, Dioxin/ Furans (2 samples)	2	4		TAL metals, strontium, explosives, perchlorate	1	1	
4	TAL metals, strontium, explosives, PAHs	1 in fill 2 at boundary	2 4	Contaminants from these analyte groups were detected previously at these AOCs or site history indicated potential presence of these analytes. Previous PAH detection limits were elevated. Proposed sampling depths were selected to target locations of most probable highest contamination plus additional locations to ensure nature of contamination is completely characterized. VOCs and TPH were added to the list of AOC 5 analytes because of the nearby UST. One subsurface soil sample analyzed for VOCs/TPH will be collected from the interval above the groundwater table.	See Note 1 Below Table	See Note 1 Below Table	See Note 1 Below Table	
5	TAL metals, strontium, explosives, PAHs, VOCs, TPH (three carbon ranges)	3	6		TAL metals, strontium, explosives, perchlorate, PAHs, VOCs (PMW-1)	2 (new)	2	
6	TAL metals, strontium, explosives, PAHs	3	6		TAL metals, strontium, explosives, perchlorate	1 (new) See also, AOC 1	1 See also, AOC 1	
7	TAL metals, strontium, explosives	3	6	Contaminants from these analyte groups were detected previously at this AOC or site history indicated potential presence of these analytes. Sampling depths were selected to target locations of most probable highest contamination plus additional locations to ensure nature of contamination is completely characterized.	TAL metals, strontium, explosives perchlorate	1 eastern boundary well down gradient of AOC 7	1	

TABLE 3-1

SUMMARY OF PLANNED SAMPLES
SAMPLE RATIONALE
FORMER KILGORE MANUFACTURING COMPANY FACILITY
WESTERVILLE, OHIO

AOC	Analyses (Soil)	No. of Soil Borings	No. Soil Samples	Rationale	Analyses (GW)	No. of Wells	No. GW Samples	Rationale
8	TAL metals, strontium, explosives, PAHs and VOCs*	20 (plus 2 test pits)	40 samples from soil borings plus 8 test pit soil samples	Contaminants released at other AOCs may also have been disposed at AOC 8, therefore the analyte list must include all potentially disposed contaminants. Sampling depths were selected to target locations of most probable highest contamination plus additional locations to ensure nature of contamination is completely characterized. *A subset (up to 25%) of the AOC 8 soils will also be analyzed for PAHs. Biased selection targeted toward olfactory observations and/or highest PID reading; however, the field samplers will have the authority to select additional suspect samples for the additional analyses. All test pit samples will be analyzed for PAHs and VOCs.	TAL metals, strontium, explosives, perchlorate VOCs PAHs	1 western boundary well; upgradient of AOC 8 3 Southern boundary wells down gradient of AOC 8	1 3	

Note 1: Include 6 additional existing monitor wells: MWs 1, 2, 3, 8, 12 & 14 - sampled one time for TAL metals, strontium, explosives, and perchlorate. Addionally, the MW#8 sample will be analyzed for PAHs.

Note 2: Assume 5 wetland/drainage channel sediment samples and, if present, 5 surface water samples will be collected (field recon needed to determine best locations) from onsite surface water features to determine whether surface migration of contaminants is occurring. Additionally, there is one offsite pond from which one surface water sample will be collected. The analyses will be: TAL metals, strontium, explosives, and PAHs. Total and dissolved metals will be determined in the surface water.

Note 3: Ten soil samples, from across the AOCs, will be analyzed for pH. Two of these, collected from new well PMW-7 location will be analyzed for total organic carbon. These sampling locations will be selected to provide a cross-section of site soil conditions and AOCs.

TABLE 5-1

QA/QC QUANTITY
FORMER KILGORE MANUFACTURING COMPANY FACILITY
WESTERVILLE, OHIO

	Laboratory	Estimated Environ. Sample Quality	Field Quality Control Analyses				Laboratory Quality Control Sample				Total
			Trip Blank		Field Duplicate		Matrix Spike		Matrix Spike Duplicate		
			Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	
Surface Soil Sampling											
TAL Metals		32	NA	--	1/10	4	1/20	2	1/20	2	40
Strontium		32	NA	--	1/10	4	1/20	2	1/20	2	40
TOC		2	NA	--	1/10	1	1/20	2	1/20	2	7
Explosives		32	NA	--	1/10	4	1/20	2	1/20	2	40
Subsurface Soil Sampling											
TAL Metals		40	NA	--	1/10	4	1/20	2	1/20	2	48
Strontium		40	NA	--	1/10	4	1/20	2	1/20	2	48
TOC		2	NA	--	1/10	1	1/20	2	1/20	2	7
Explosives		40	NA	--	1/10	4	1/20	2	1/20	2	48
Surface Water Sampling											
TAL Metals (total and dissolved)		5	NA	--	1/10	1	1/20	1	1/20	1	8
Strontium (total and dissolved)		5	NA	--	1/10	1	1/20	1	1/20	1	8
Explosives		5	NA	--	1/10	1	1/20	1	1/20	1	8
Sediment Sampling											
TAL Metals		5	NA	--	1/10	1	1/20	1	1/20	1	8
Strontium		5	NA	--	1/10	1	1/20	1	1/20	1	8
Explosives		5	NA	--	1/10	1	1/20	1	1/20	1	8
Groundwater Sampling											
TAL Metals		19	NA	--	1/10	2	1/20	1	1/20	1	23
Strontium											
Perchlorate		19	NA	--	1/10	2	1/20	1	1/20	1	23
Explosives		19	NA	--	1/10	2	1/20	1	1/20	1	23
PAHs		1	NA	--	1/10	1	1/20	1	1/20	1	4
VOCs		3	1/day	1	1/10	1	1/20	1	1/20	1	6

Notes:

Freq Frequency.

NA Not Applicable.

No. Number.

TABLE 5-2

DETAILED SAMPLE LIST
FORMER KILGORE MANUFACTURING COMPANY FACILITY
WESTERVILLE, OHIO

Sample Location/ ID Number	Matrix	Depth/ Location	Analytical Group [1]	Number of Samples	Sampling Standard Operating Procedure Reference
OC-AOC1-SB101-XX	Soil	0-1 ft bgs 2-4 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC1-SB102-XX	Soil	0-1 ft bgs 2-4 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC2-SB103-XX	Soil	0-1 ft bgs 2-4 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC2-SB104-XX	Soil	0-1 ft bgs 2-4 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC2-SB105-XX	Soil	0-1 ft bgs 2-4 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC2-SB106-XX	Soil	0-1 ft bgs 2-4 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC2-SB107-XX	Soil	0-1 ft bgs 2-4 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC2-SB108-XX	Soil	0-1 ft bgs 2-4 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC3-SB109-XX	Soil	0-1 ft bgs 4-6 ft bgs	TAL Metals, strontium, explosives (2)	2	SA-2.5 Direct Push Technolog
OC-AOC3-SB110-XX	Soil	0-1 ft bgs 4-6 ft bgs	TAL Metals, strontium, explosives, (2)	2	SA-2.5 Direct Push Technolog
OC-AOC4-SB111-XX	Soil (fill)	0-1 ft bgs 4-6 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC4-SB112-XX	Soil (lateral AOC boundary)	0-1 ft bgs 8-10 ft bgs	TAL Metals, strontium, explosives, PAHs	2	SA-2.5 Direct Push Technolog
OC-AOC4-SB113-XX	Soil (lateral AOC boundary)	0-1 ft bgs 8-10 ft bgs	TAL Metals, strontium, explosives, PAHs	2	SA-2.5 Direct Push Technolog
OC-AOC5-SB114-XX	Soil	0-1 ft bgs 4-6 ft bgs	TAL Metals, strontium, explosives, PAHs	2	SA-2.5 Direct Push Technolog
OC-AOC5-SB115-XX	Soil	0-1 ft bgs 4-6 ft bgs	TAL Metals, strontium, explosives, PAHs, VOCs, TPH (3)	2	SA-2.5 Direct Push Technolog
OC-AOC5-SB116-XX	Soil	0-1 ft bgs 4-6 ft bgs	TAL Metals, strontium, explosives, PAHs	2	SA-2.5 Direct Push Technolog

TABLE 5-2

DETAILED SAMPLE LIST
FORMER KILGORE MANUFACTURING COMPANY FACILITY
WESTERVILLE, OHIO

Sample Location/ ID Number	Matrix	Depth/ Location	Analytical Group [1]	Number of Samples	Sampling Standard Operating Procedure Reference
OC-AOC6-SB117-XX	Soil	0-1 ft bgs 1-3 ft bgs	TAL Metals, strontium, explosives, PAHs	2	SA-2.5 Direct Push Technolog
OC-AOC6-SB118-XX	Soil	0-1 ft bgs 1-3 ft bgs	TAL Metals, strontium, explosives, PAHs	2	SA-2.5 Direct Push Technolog
OC-AOC6-SB119-XX	Soil	0-1 ft bgs 1-3 ft bgs	TAL Metals, strontium, explosives, PAHs	2	SA-2.5 Direct Push Technolog
OC-AOC7-SB120-XX	Soil	0-1 ft bgs 1-3 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC7-SB121-XX	Soil	0-1 ft bgs 1-3 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC7-SB122-XX	Soil	0-1 ft bgs 1-3 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
Field Location (to be determined)	Soil	0-1 ft bgs 4-6 ft bgs	TOC, pH	2	SA-1.3 Soil Sampling
OC-AOC8-SB123-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB124-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB125-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB126-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB127-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB128-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB129-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB130-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB131-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog

TABLE 5-2

DETAILED SAMPLE LIST
FORMER KILGORE MANUFACTURING COMPANY FACILITY
WESTERVILLE, OHIO

Sample Location/ ID Number	Matrix	Depth/ Location	Analytical Group [1]	Number of Samples	Sampling Standard Operating Procedure Reference
OC-AOC8-SB132-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives, PAHs, VOCs	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB133-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives, PAHs, VOCs	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB134-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives, PAHs, VOCs	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB135-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB136-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB137-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB138-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB139-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB140-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives, PAHs	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB141-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives, PAHs	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB142-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives, PAHs	2	SA-2.5 Direct Push Technolog
OC-AOC8-SB143-XX	Soil	0-1 ft bgs 10-12 ft bgs	TAL Metals, strontium, explosives, PAHs	2	SA-2.5 Direct Push Technolog
OC-TP-101	Soil	Field Decision	TAL Metals, strontium, explosives, PAHs, VOCs	1	SA-2.5 Direct Push Technolog
OC-TP-102	Soil	Field Decision	TAL Metals, strontium, explosives, PAHs, VOCs	1	SA-2.5 Direct Push Technolog
OC-TP-103	Soil	Field Decision	TAL Metals, strontium, explosives, PAHs, VOCs	1	SA-2.5 Direct Push Technolog
OC-TP-104	Soil	Field Decision	TAL Metals, strontium, explosives, PAHs, VOCs	1	SA-2.5 Direct Push Technolog

TABLE 5-2

DETAILED SAMPLE LIST
FORMER KILGORE MANUFACTURING COMPANY FACILITY
WESTERVILLE, OHIO

Sample Location/ ID Number	Matrix	Depth/ Location	Analytical Group [1]	Number of Samples	Sampling Standard Operating Procedure Reference
OC-TP-105	Soil	Field Decision	TAL Metals, strontium, explosives, PAHs, VOCs	1	SA-2.5 Direct Push Technolog
OC-TP-106	Soil	Field Decision	TAL Metals, strontium, explosives, PAHs, VOCs	1	SA-2.5 Direct Push Technolog
OC-TP-107	Soil	Field Decision	TAL Metals, strontium, explosives, PAHs, VOCs, perchlorate	1	SA-2.5 Direct Push Technolog
OC-TP-108	Soil	Field Decision	TAL Metals, strontium, explosives, PAHs, VOCs	1	SA-2.5 Direct Push Technolog
PMW-1 - DDDD New well down gradient of AOC 5 UST	Groundwater	--	TAL Metals, strontium, explosives, perchlorate, PAHs, VOCs	1	SA-1.1-Groundwater Sample Acquisition and Onsite Water Quality Testing
PMW-2 - DDDD New well down gradient of manufacturing area settling basin	Groundwater	--	TAL Metals, strontium, explosives, perchlorate	1	SA-1.1-Groundwater Sample Acquisition and Onsite Water Quality Testing
PMW-3 - DDDD New well associated with AOC 6	Groundwater	--	TAL Metals, strontium, explosives, perchlorate	1	SA-1.1-Groundwater Sample Acquisition and Onsite Water Quality Testing
PMW-4 - DDDD New well down gradient of AOCs 1, 2, and 6	Groundwater	--	TAL Metals, strontium, explosives, perchlorate	1	SA-1.1-Groundwater Sample Acquisition and Onsite Water Quality Testing
PMW-5 - DDDD New eastern boundary well down gradient of AOCs 1, 2, and 6	Groundwater	--	TAL Metals, strontium, explosives, perchlorate	1	SA-1.1-Groundwater Sample Acquisition and Onsite Water Quality Testing
PMW-6 - DDDD New eastern boundary well down gradient of AOC 3	Groundwater	--	TAL Metals, strontium, explosives, perchlorate	1	SA-1.1-Groundwater Sample Acquisition and Onsite Water Quality Testing

TABLE 5-2

DETAILED SAMPLE LIST
FORMER KILGORE MANUFACTURING COMPANY FACILITY
WESTERVILLE, OHIO

Sample Location/ ID Number	Matrix	Depth/ Location	Analytical Group [1]	Number of Samples	Sampling Standard Operating Procedure Reference
PMW-7 - DDDD New western boundary well between AOC 8 and quonset hut area	Groundwater	--	TAL Metals, strontium, explosives, perchlorate	1	SA-1.1-Groundwater Sample Acquisition and Onsite Water Quality Testing
PMW-8 New eastern boundary well down gradient of AOC 7	Groundwater	--	TAL Metals, strontium, explosives, perchlorate	1	SA-1.1-Groundwater Sample Acquisition and Onsite Water Quality Testing
PMW-9 New southern boundary well down gradient of AOC 8	Groundwater	--	TAL Metals, strontium, explosives, perchlorate, VOCs, PAHs	1	SA-1.1-Groundwater Sample Acquisition and Onsite Water Quality Testing
PMW-10 Southern Boundary down gradient of AOC 8	Groundwater	--	TAL Metals, strontium, explosives, perchlorate, VOCs, PAHs	1	SA-1.1-Groundwater Sample Acquisition and Onsite Water Quality Testing
PMW-11 Southern Boundary down gradient of AOC 8	Groundwater	--	TAL Metals, strontium, explosives, perchlorate, VOCs, PAHs	1	SA-1.1-Groundwater Sample Acquisition and Onsite Water Quality Testing
MW #1 - DDDD (Exisitng well)	Groundwater	--	TAL Metals, strontium, explosives, perchlorate	1	SA-1.1-Groundwater Sample Acquisition and Onsite Water Quality Testing
MW #2 - DDDD (Exisitng well)	Groundwater	--	TAL Metals, strontium, explosives, perchlorate	1	SA-1.1-Groundwater Sample Acquisition and Onsite Water Quality Testing
MW #3 - DDDD (Exisitng well)	Groundwater	--	TAL Metals, strontium, explosives, perchlorate	1	SA-1.1-Groundwater Sample Acquisition and Onsite Water Quality Testing
MW #8 - DDDD (Exisitng well)	Groundwater	--	TAL Metals, strontium, explosives, perchlorate, PAHs	1	SA-1.1-Groundwater Sample Acquisition and Onsite Water Quality Testing
MW #12 - DDDD (Exisitng well)	Groundwater	--	TAL Metals, strontium, explosives, perchlorate	1	SA-1.1-Groundwater Sample Acquisition and Onsite Water Quality Testing

TABLE 5-2

DETAILED SAMPLE LIST
FORMER KILGORE MANUFACTURING COMPANY FACILITY
WESTERVILLE, OHIO

Sample Location/ ID Number	Matrix	Depth/ Location	Analytical Group [1]	Number of Samples	Sampling Standard Operating Procedure Reference
MW #13 - DDDD (Exisitng well)	Groundwater	--	TAL Metals, strontium, explosives, perchlorate	1	SA-1.1-Groundwater Sample Acquisition and Onsite Water Quality Testing
SW-1	Surface Water (burrow pit)	--	TAL Metals and strontium (total and dissolved), explosives, perchlorate, PAHs, and VOCs	1	SA-1.2 Surface Water and Sediment Sampling
SW-2	Surface Water	--	TAL Metals and strontium (total and dissolved), explosive, perchlorate	1	SA-1.2 Surface Water and Sediment Sampling
SW-3	Surface Water	--	TAL Metals and strontium (total and dissolved), explosives, perchlorate	1	SA-1.2 Surface Water and Sediment Sampling
SW-4	Surface Water	--	TAL Metals and strontium (total and dissolved), explosives, perchlorate	1	SA-1.2 Surface Water and Sediment Sampling
SW-5	Surface Water	--	TAL Metals and strontium (total and dissolved), explosives, perchlorate	1	SA-1.2 Surface Water and Sediment Sampling
SO-6	Drainage Channel Sediment	0-0.5 ft	TAL Metals, strontium, explosives	1	SA-1.2 Surface Water and Sediment Sampling
SO-7	Drainage Channel Sediment	0-0.5 ft	TAL Metals, strontium, explosives	1	SA-1.2 Surface Water and Sediment Sampling
SO-8	Drainage Channel Sediment	0-0.5 ft	TAL Metals, strontium, explosives	1	SA-1.2 Surface Water and Sediment Sampling
SO-9	Drainage Channel Sediment	0-0.5 ft	TAL Metals, strontium, explosives	1	SA-1.2 Surface Water and Sediment Sampling
SO-10	Drainage Channel Sediment	0-0.5 ft	TAL Metals, strontium, explosives	1	SA-1.2 Surface Water and Sediment Sampling

TABLE 5-2

DETAILED SAMPLE LIST
FORMER KILGORE MANUFACTURING COMPANY FACILITY
WESTERVILLE, OHIO

Sample Location/ ID Number	Matrix	Depth/ Location	Analytical Group [1]	Number of Samples	Sampling Standard Operating Procedure Reference

Note: Subsurface sample depths will be determined in the field based on visual observations, field instruments, odor or the interval directly above the groundwater table. The bottom interval is currently listed.

DDDD - Sample date

Explosives - SW-846 Methd 8330 target analytes, plus 2,4,6-trinitrophenol (picric acid), and pentaerythritol tetranitrate (PETN)

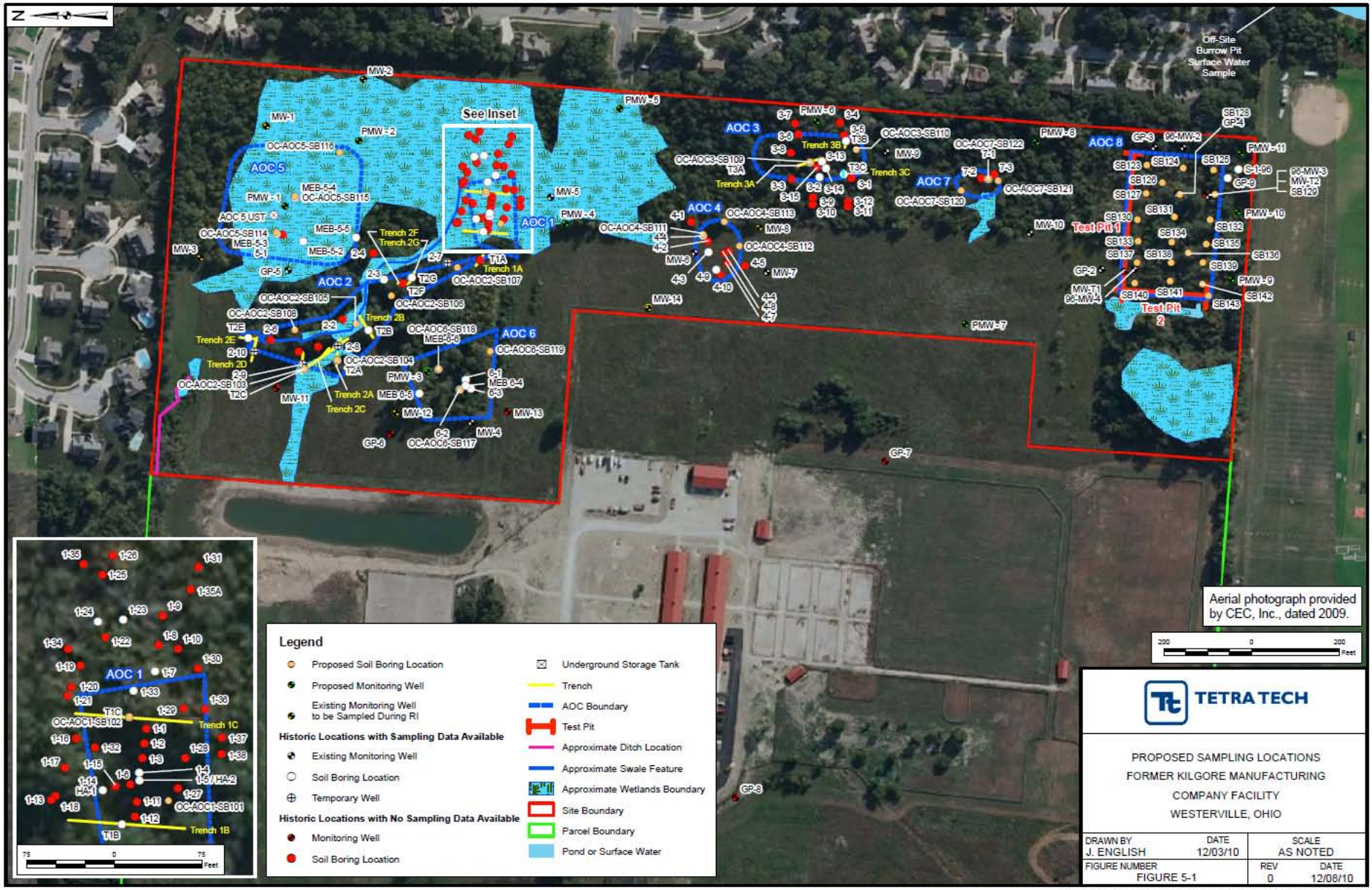
PAH - Polycyclic aromatic hydrocarbons

TOC - Total organic carbon

VOCs - Volatile organic compounds

XX - sample depth - Bottom of sample interval in feet below ground surface (bgs)

(1) 10 samples, including 2 samples from the new PMW-7 well location, will be selected from across the AOCs for pH determination



TETRA TECH

PROPOSED SAMPLING LOCATIONS
FORMER KILGORE MANUFACTURING
COMPANY FACILITY
WESTERVILLE, OHIO

DRAWN BY	DATE	SCALE
J. ENGLISH	12/03/10	AS NOTED
FIGURE NUMBER	REV	DATE
FIGURE 5-1	0	12/08/10

PGH P:\GIS\OTTERBEIN\MAPDOCS\MXD\PROPOSED_SAMPLING_LOCATIONS_1117.MXD 12/08/10 JEE

APPENIDX A

REFERENCES

References

OEPA, 2009. Ohio Environmental Protection Agency. Technical Guidance Manual for Hydrogeological Investigations and Ground Water Monitoring (TGM). 1995-2009. http://www.epa.ohio.gov/ddagw/tgmweb.aspx

TtNUS, 2010. Preliminary Evaluation Report. April 2010.

APPENDIX B

STANDARD OPERATING PROCDURES

FIELD SOPs

CT-04	Sample Nomenclature
GH-1.2	Evaluation of Existing Monitoring Wells and Water Level Measurements
GH-1.3	Soil and Rock Drilling Methods
GH-1.5	Borehole and Sample Logging
GH-2.8	Groundwater Monitoring Well Installation
HS-1.0	Utility Locating and Excavation Clearance
SA-1.1	Groundwater Sample Acquisition and Onsite Water Quality Testing
SA-1.2	Surface Water and Sediment Sampling
SA-1.3	Soil Sampling
SA-2.5	Direct Push Technology (DPT)
SA-6.1	Non-Radiological Sample Handling
SA-6.3	Field Documentation
SA-7.1	Decontamination of Field Equipment

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to specify a consistent sample nomenclature system that will facilitate subsequent data management in a cost-effective manner. The sample nomenclature system has been devised such that the following objectives can be attained:

- Sorting of data by matrix
- Sorting of data by depth
- Maintenance of consistency (field, laboratory, and database sample numbers)
- Accommodation of all project-specific requirements
- Accommodation of laboratory sample number length constraints (maximum of 20 characters)

2.0 SCOPE

The methods described in this SOP shall be used consistently for all projects requiring electronic data. Other contract- or project-specific sample nomenclature requirements may also be applicable.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Program Manager - It shall be the responsibility of the Project Manager (or designee) to inform contract-specific Project Managers (PMs) of the existence and requirements of this SOP.

Project Manager - It shall be the responsibility of the PM to determine the applicability of this SOP based on: (1) program-specific requirements and (2) project size and objectives. It shall be the responsibility of the PM (or designee) to ensure that sample nomenclature requirements are thoroughly specified in the relevant project planning document (e.g., sampling and analysis plan) and are consistent with this SOP if relevant. It shall be the responsibility of the PM to ensure that the FOL is familiar with the sample nomenclature system.

Field Operations Leader (FOL) - It shall be the responsibility of the FOL to ensure that all field technicians or sampling personnel are thoroughly familiar with this SOP and the project-specific sample nomenclature system. It shall be the responsibility of the FOL to ensure that the sample nomenclature system is used during all project-specific sampling efforts.

General personnel qualifications for sample nomenclature activities in the field include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for field documentation, handling, packaging, and shipping.

5.0 PROCEDURES

5.1 INTRODUCTION

The sample identification (ID) system can consist of as few as eight but not more than 20 distinct alpha-numeric characters. The sample ID will be provided to the laboratory on the sample labels and chain-of-custody forms. The basic sample ID provided to the laboratory has three segments and shall be as follows, where "A" indicates "alpha," and "N" indicates "numeric":

A or N 3 or 4 Characters	**AAA 2 or 3 Characters**	**A or N 3 to 6 Characters**
Site Identifier	Sample Type	Sample Location

Additional segments may be added as needed. For example:

(1) Soil and sediment sample ID

A or N 3 or 4 Characters	**AAA 2 or 3 Characters**	**A or N 3 to 6 Characters**	**NNNN 4 Characters**
Site identifier	Sample type	Sample location	Sample depth

(2) Aqueous (groundwater or surface water) sample ID

A or N 3 or 4 Characters	**AAA 2 or 3 Characters**	**A or N 3 to 6 Characters**	**NN 2 Characters**	**-A 1 Character**
Site identifier	Sample type	Sample location	Round number	Filtered sample only

(3) Biota sample ID

A or N 3 or 4 Characters	**AAA 2 or 3 Characters**	**A or N 3 to 6 Characters**	**AA 2 Characters**	**NNN 3 Characters**
Site identifier	Sample type	Sample location	Species identifier	Sample group number

5.2 SAMPLE IDENTIFICATION FIELD REQUIREMENTS

The various fields in the sample ID include but are not limited to the following:

- Site identifier
- Sample type
- Sample location
- Sample depth
- Sampling round number
- Filtered
- Species identifier
- Sample group number

The site identifier must be a three- or four-character field (numeric characters, alpha characters, or a mixture of alpha and numeric characters may be used). A site number is necessary because many facilities/sites have multiple individual sites, Solid Waste Management Units (SWMUs), Operable Units (OUs), etc. Several examples are presented in Section 5.3 of this SOP.

The sample type must be a two- or three-character alpha field. Suggested codes are provided in Section 5.3 of this SOP.

The sample location must be at least a three-character field but may have up to six characters (alpha, numeric, or a mixture). The six characters may be useful in identifying a monitoring well to be sampled or describing a grid location.

The sample depth field is used to note the depth below ground surface (bgs) at which a soil or sediment sample is collected. The first two numbers of the four-number code specify the top interval, and the third and fourth specify the bottom interval in feet bgs of the sample. If the sample depth is equal to or greater than 100, then only the top interval would be represented and the sampling depth would be truncated to three characters. The depths will be noted in whole numbers only; further detail, if needed, will be recorded on the sample log sheet or boring log, in the logbook, etc.

A two-digit round number will be used to track the number of aqueous samples collected from a particular aqueous sample location. The first sample collected from a location will be assigned the round identifier 01, the second 02, etc. This applies to both existing and proposed monitoring wells and surface water locations.

Aqueous samples that are field filtered (dissolved analysis) will be identified with an "-F" in the last field segment. No entry in this segment signifies an unfiltered (total) sample.

The species identifier must be a two-character alpha field. Several suggested codes are provided in Section 5.3 of this SOP.

The three-digit sample group number will be used to track the number of biota sample groups (a particular group size may be determined by sample technique, media type, the number of individual caught, weight issues, time, etc.) by species and location. The first sample group of a particular species collected from a given location will be assigned the sample group number 001, and the second sample group of the same species collected from the same location will be assigned the sample group number 002.

5.3 EXAMPLE SAMPLE FIELD DESIGNATIONS

Examples of each of the fields are as follows:

Site identifier - Examples of site numbers/designations are as follows:

A01 - Area of Concern (AOC) 1
125 - SWMU 125
000 - Base- or facility-wide sample (e.g., upgradient well)
BBG - Base background

The examples cited are only suggestions. Each PM (or designee) must designate appropriate (and consistent) site designations for their individual project.

Sample type - Examples of sample types are as follows:

AH - Ash Sample

AS - Air Sample
BM - Building Material Sample
BSB - Biota Sample Full Body
BSF - Biota Sample Fillet
CP - Composite Sample
CS - Chip Sample
DS - Drum Sample
DU - Dust Sample
FP - Free Product
IDW - Investigation-Derived Waste Sample
LT - Leachate Sample
MW - Monitoring Well Groundwater Sample
OF - Outfall Sample
RW - Residential Well Sample
SB - Soil Boring Sample
SD - Sediment Sample
SC - Scrape Sample
SG - Soil Gas Sample
SL - Sludge Sample
SP - Seep Sample
SS - Surface Soil Sample
ST - Storm Sewer Water Sample
SW - Surface Water Sample
TP - Test Pit Sample
TW - Temporary Well Sample
WC - Well Construction Material Sample
WP - Wipe Sample
WS - Waste/Solid Sample
WW - Wastewater Sample

Sample location - Examples of the location field are as follows:

001 - Monitoring well 1
N32E92 - Grid location 32 North and 92 East
D096 - Investigation-derived waste drum number 96

Species identifier - Examples of species identifier are as follows:

BC - Blue Crab
GB - Blue Gill
CO - Corn
SB - Soybean

5.4 EXAMPLES OF SAMPLE NOMENCLATURE

The first round monitoring well groundwater sample collected from existing monitoring well 001 at SWMU 16 for a filtered sample would be designated as 016MW00101-F.

The second round monitoring well groundwater sample collected from existing monitoring well C20P2 at Site 23 for an unfiltered sample would be designated as 023MWC20P202.

The second surface water sample collected from point 01 at SWMU 130 for an unfiltered sample would be designated as 130SW00102.

A surface soil sample collected from grid location 32 North and 92 East at Site 32 at the 0- to 2-foot interval would be designated as 032SSN32E920002.

A subsurface soil sample from soil boring 03 at SWMU 32 at an interval of 4 to 5 feet bgs would be designated as 032SB0030405.

A sediment sample collected at SWMU 19 from 0 to 6 inches at location 14 would be designated as 019SD0140001. The sample data sheet would reflect the precise depth at which this sample was collected.

During biota sampling for full-body analysis, the first time a minnow trap was checked at grid location A25 of SWMU 1415, three small blue gills were captured, collected, and designated with the sample ID of 1415BSBA25BG001. The second time blue gill were collected at the same location (grid location A25 at SWMU 1415), the sample ID would be 1415BSBA25BG002.

Note: No dash (-) or spacing is used between the segments with the exception of the filtered segment. The "F" used for a filtered aqueous sample is preceded by a dash (-F).

5.5 FIELD QA/QC SAMPLE NOMENCLATURE

Field Quality Assurance (QA)/Quality Control (QC) samples are designated using a different coding system. The QC code will consist of a three- to four-segment alpha-numeric code that identifies the sample QC type, the date the sample was collected, and the number of this type of QC sample collected on that date.

AA	NNNNNN	NN	-F
QC type	Date	Sequence number (per day)	Filtered (aqueous only, if needed)

The QC types are identified as:

TB = Trip Blank
RB = Rinsate Blank (Equipment Blank)
FD = Field Duplicate
AB = Ambient Conditions Blank
WB = Source Water Blank

The sampling time recorded on the chain-of-custody form, labels, and tags for duplicate samples will be 0000 so that the samples are "blind" to the laboratory. Notes detailing the sample number, time, date, and type will be recorded on the routine sample log sheets and will document the location of the duplicate sample (sample log sheets are not provided to the laboratory). Documentation for all other QC types (TB, RB, AB, and WB) will be recorded on the QC Sample Log Sheet (see SOP SA-6.3, Field Documentation).

5.6 EXAMPLES OF FIELD QA/QC SAMPLE NOMENCLATURE

The first duplicate of the day for a filtered groundwater sample collected on June 3, 2000, would be designated as FD06030001-F.

The third duplicate of the day taken of a subsurface soil sample collected on November 17, 2003, would be designated as FD11170303.

The first trip blank associated with samples collected on October 12, 2000, would be designated as TB10120001.

The only rinsate blank collected on November 17, 2001, would be designated as RB11170101.

6.0 DEVIATIONS

Any deviation from this SOP must be addressed in detail in the site-specific planning documents.

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1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the proper methods for evaluating the physical condition and project utility of existing monitoring wells and determining water levels.

2.0 SCOPE

The procedures described herein are applicable to all existing monitoring wells and, for the most part, are independent of construction materials and methods.

3.0 GLOSSARY

Hydraulic Head - The height to which water will rise in a well.

Water Table - A surface in an unconfined aquifer where groundwater pressure is equal to atmospheric pressure (i.e., the pressure head is zero).

4.0 RESPONSIBILITIES

Site Geologist/Hydrogeologist - Has overall responsibility for the evaluation of existing wells, obtaining water level measurements and developing groundwater contour maps. The site geologist/hydrogeologist (in concurrence with the Project Manager) shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number and location of data points which shall be used for constructing a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

Field Personnel - Must have a basic familiarity with the equipment and procedures involved in obtaining water levels and must be aware of any project-specific requirements or objectives.

5.0 PROCEDURES

Accurate, valid and useful groundwater monitoring requires that four important conditions be met:

- Proper characterization of site hydrogeology.
- Proper design of the groundwater monitoring program, including adequate numbers of wells installed at appropriate locations and depths.
- Satisfactory methods of groundwater sampling and analysis to meet the project data quality objectives (DQOs).
- The assurance that specific monitoring well samples are representative of water quality conditions in the monitored interval.

To insure that these conditions are met, adequate descriptions of subsurface geology, well construction methods and well testing results must be available. The following steps will help to insure that the required data are available to permit an evaluation of the utility of existing monitoring wells for collecting additional samples.

5.1 Preliminary Evaluation

A necessary first step in evaluating existing monitoring well data is the study and review of the original work plan for monitoring well installation (if available). This helps to familiarize the site geologist/hydrogeologist with site-specific condition, and will promote an understanding of the original purpose of the monitoring wells.

The next step of the evaluation should involve a review of all available information concerning borehole drilling and well construction. This will allow interpretation of groundwater flow conditions and area geology, and will help to establish consistency between hydraulic properties of the well and physical features of the well or formation. The physical features which should be identified and detailed, if available, include:

- The well identification number, permit number and location by referenced coordinates, the distance from prominent site features, or the location of the well on a map.
- The installation dates, drilling methods, well development methods, past sampling dates, and drilling contractors.
- The depth to bedrock -- where rock cores were not taken, auger refusal, drive casing refusal or penetration test results (blow counts for split-barrel sampling) may be used to estimate bedrock interface.
- The soil profile and stratigraphy.
- The borehole depth and diameter.
- The elevation of the top of the protective casing, the top of the well riser, and the ground surface.
- The total depth of the well.
- The type of well materials, screen type, slot size, and length, and the elevation/depths of the screen, interval, and/or monitored interval.
- The elevation/depths of the tops and bottom of the filter pack and well seals and the type and size.

5.2 Field Inspection

During the onsite inspection of existing monitoring wells, features to be noted include:

- The condition of the protective casing, cap and lock.
- The condition of the cement seal surrounding the protective casing.
- The presence of depressions or standing water around the casing.
- The presence of and condition of dedicated sampling equipment.
- The presence of a survey mark on the inner well casing.

If the protective casing, cap and lock have been damaged or the cement collar appears deteriorated, or if there are any depressions around the well casing capable of holding water, surface water may have infiltrated into the well. This may invalidate previous sampling results unless the time when leakage started can be precisely determined.

The routine physical inspection must be followed by a more detailed investigation to identify other potential routes of contamination or sampling equipment malfunction. Any of these occurrences may invalidate

previously-collected water quality data. If the monitoring well is to be used in the future, considerations shown in the steps described above should be rectified to rehabilitate the well.

After disconnecting any wires, cables or electrical sources, remove the lock and open the cap. Check for the presence of organic vapors with a photoionization detector (PID) or flame-ionization detector (FID) to determine the appropriate worker safety level. The following information should be noted:

- Cap function.
- Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space.
- Presence of grout between the riser and outer protective casing and the existence of drain holes in the protective casing.
- Presence of a riser cap, method of attachment to casing, and venting of the riser.
- Presence of dedicated sampling equipment; if possible, remove such equipment and inspect size, materials of construction and condition.

The final step of the field inspection is to confirm previous hydraulic or physical property data and to obtain data not previously available. This includes the determination of static water levels, total well depth and well obstruction. This may be accomplished using a weighted tape measure which can also be used to check for sediment (the weight will advance slowly if sediment is present, and the presence of sediment on the weight upon removal should be noted). If sediment is present and/or the well has not been sampled in 12 or more months, it should be redeveloped before sampling.

Lastly, as a final step, the location, condition and expected water quality of the wells should be reviewed in light of their usefulness for the intended purpose of the investigation.

See Attachment A, Monitoring Well Inspection Sheet.

5.3 Water Level (Hydraulic Head) Measurements

5.3.1 General

Groundwater level measurements can be made in monitoring wells, private or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well purging or sampling.

All groundwater level measurements shall be made to the nearest 0.01 foot, and recorded in the site geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B), along with the date and time of the reading. The total depth of the well shall be measured and recorded, if not already known. Weather changes that occur over the period of time during which water levels are being taken, such as precipitation and barometric pressure changes, should be noted.

In measuring groundwater levels, there shall be a clearly-established reference point of known elevation, which is normally identified by a mark on the upper edge of the inner well casing. To be useful, the reference point should be tied in with an established USGS benchmark or other properly surveyed elevation datum. An arbitrary datum could be used for an isolated group of wells, if necessary.

Cascading water within a borehole or steel well casings can cause false readings with some types of sounding devices (chalked line, electrical). Oil layers may also cause problems in determining the true water level in a well. Special devices (interface probes) are available for measuring the thickness of oil layers and true depth to groundwater, if required.

Water level readings shall be taken regularly, as required by the site geologist/hydrogeologist. Monitoring wells or open-cased boreholes that are subject to tidal fluctuations should be read in conjunction with a tidal chart (or preferably in conjunction with readings of a tide staff or tide level recorder installed in the adjacent water body); the frequency of such readings shall be established by the site hydrogeologist. All water level measurements at a site used to develop a groundwater contour map shall be made in the shortest practical time to minimize affects due to weather changes.

5.3.2 Water Level Measuring Techniques

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the site geologist/hydrogeologist.

In most instances, preparation of accurate potentiometric surface maps require that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, electrical water level indicator methods have been found to be best, and thus should be utilized. Other, less precise methods, such as the popper or bell sound, or bailer line methods, should be avoided. When a large number of (or continuous) readings are required, time-consuming individual readings are not usually feasible. In such cases, it is best to use a pressure transducer.

5.3.3 Methods

Water levels can be measured by several different techniques, but the same steps shall be followed in each case. The proper sequence is as follows:

1. Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment, as required. Never remove an air-tight lock (such as a J-plug) with your face over the well. Pressure changes within the well may explosively force the cap off once loosened.

2. Record all information specified below in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B):

   - Well number.
   - Water level (to the nearest 0.01 foot). Water levels shall be taken from the surveyed reference mark on the top edge of the inner well casing. If the J-plug was on the well very tightly, it may take several minutes for the water level to stabilize.
   - Time and day of the measurement.
   - Thickness of free product if present.

Water level measuring devices with permanently marked intervals shall be used. The devices shall be free of kinks or folds which will affect the ability of the equipment to hang straight in the well pipe.

5.3.4 Water Level Measuring Devices

Electric Water Level Indicators

These are the most commonly used devices and consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric sounders available, none of which is entirely reliable under all conditions likely to occur in a contaminated monitoring well. In conditions where there is oil on the water, groundwater with high specific conductance, water cascading into the well, steel well casing, or a turbulent water surface in the well, measuring with an electric sounder may be difficult.

For accurate readings, the probe shall be lowered slowly into the well adjacent to the survey mark on the inner well casing. The electric tape is read (to the nearest 0.01 ft.) at the measuring point and recorded where contact with the water surface was indicated.

Popper or Bell Sounder

A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "plopping" or "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight strikes the water. This method is not sufficiently accurate to obtain water levels to 0.01 feet, and thus is more appropriate for obtaining only approximate water levels quickly.

Pressure Transducer

Pressure transducers can be lowered into a well or borehole to measure the pressure of water and therefore the water elevation above the transducer. The transducer is wired into a recorder at the surface to record changes in water level with time. The recorder digitizes the information and can provide a printout or transfer the information to a computer for evaluation (using a well drawdown/recovery model). The pressure transducer should be initially calibrated with another water level measurement technique to ensure accuracy. This technique is very useful for hydraulic conductivity testing in highly permeable material where repeated, accurate water level measurements are required in a very short period of time. A sensitive transducer element is required to measure water levels to 0.01 foot accuracy.

Borehole Geophysics

Approximate water levels can be determined during geophysical logging of the borehole (although this is not the primary purpose for geophysical logging and such logging is not cost effective if used only for this purpose). Several logging techniques will indicate water level. Commonly-used logs which will indicate saturated/unsaturated conditions include the spontaneous potential (SP) log and the neutron log.

5.3.5 Data Recording

Water level measurements, time, data, and weather conditions shall be recorded in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet. All water level measurements shall be measured from a known reference point. The reference point is generally a marked point on the upper edge of the inner well casing that has been surveyed for an elevation. The exact reference point shall be marked with permanent ink on the casing since the top of the casing may not be entirely level. It is important to note changes in weather conditions because changes in the barometric pressure may affect the water level within the well.

5.3.6 Specific Quality Control Procedures for Water Level Measuring Devices

All groundwater level measurement devices must be cleaned before and after each use to prevent cross contamination of wells. Manufacturer's instructions for cleaning the device shall be strictly followed. Some devices used to measure groundwater levels may need to be calibrated. These devices shall be calibrated to 0.01 foot accuracy and any adjustments/corrections shall be recorded in the field logbook/notebook. After the corrections/adjustments are made to the measuring device and entered in the field logbook/notebook, the corrected readings shall be entered onto the Groundwater Level Measurement Sheet (Attachment B). Elevations will be entered on the sheet when they become available.

5.4 Equipment Decontamination

Equipment used for water level measurements provide a mechanism for potentially cross contaminating wells. Therefore, all portions of a device which project down the well casing must be decontaminated prior to advancing to the next well. Decontamination procedures vary based on the project objectives but must be defined prior to conducting any field activities including the collection of water level data. Consult the project planning documents and SA-7.1 Decontamination of Field Equipment.

5.5 Health and Safety Considerations

Groundwater contaminated by volatile organic compounds may release toxic vapors into the air space inside the well pipe. The release of this air when the well is initially opened is a health/safety hazard which must be considered. Initial monitoring of the well headspace and breathing zone concentrations using a PID or FID shall be performed to determine required levels of protection. Under certain conditions, air-tight well caps may explosively fly off the well when the pressure is relieved. Never stand directly over a well when uncapping it.

6.0 RECORDS

A record of all field procedures, tests and observations must be recorded in the site logbook or designated field notebook. Entries in the log/notebook should include the individuals participating in the field effort, and the date and time. The use of annotated sketches may help to supplement the evaluation.

ATTACHMENT A
MONITORING WELL INSPECTION SHEET

Monitoring Well Inspection Sheet

Project Name: _____ Date: _____

Location: _____ Time: _____

Tidally Influenced: Y / N Personnel: _____

Field Measurements				
Well ID	PID Reading PPM	Depth to Water *	Total Depth *	Flush Mt./ Stick-up

Well Construction Details (Taken from construction logs)		
Total Depth *	Ground Elev.	Top/Btm Screen *

Check List:

Riser Pipe Material:
Riser Notched for Surveyors:
Well ID Tag In-place:
Well security:
Photo taken:

Condition of Well:

Protective Case:
Riser:
Well Pad:
Other:

Presence/Evidence of:

Standing Water Around Well:
Existing Sampling Equipment:
Sediment build-up in Well Btm:

Comments:

** = Measurements are from the top of the inner case to the nearest 0.01'*

ATTACHMENT B
GROUNDWATER LEVEL MESUREMENT SHEET

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: _____ Project No.: _____
Location: _____ Personnel: _____
Weather Conditions: _____ Measuring Device: _____
Tidally Influenced: Yes ___ No ___ Remarks: _____

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Water Level Indicator Reading (feet)*	Thickness of Free Product (feet)*	Comments

* All measurements to the nearest 0.01 foot, from surveyed mark (unless noted)

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A DRILLING EQUIPMENT SIZES 25

FIGURE

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1 STANDARD SIZES OF CORE BARRELS AND CASING 20

1.0 PURPOSE

The purpose of this procedure is to describe the methods and equipment necessary to perform soil and rock borings and identify the equipment, sequence of events, and appropriate methods necessary to obtain soil, both surface and subsurface, and rock samples during field sampling activities.

2.0 SCOPE

This guideline addresses most of the accepted and standard drilling techniques, their benefits, and drawbacks. It should be used generally to determine what type of drilling techniques would be most successful depending on site-specific geologic conditions and the type of sampling required.

The sampling methods described within this procedure are applicable to collecting surface and subsurface soil samples, and obtaining rock core samples for lithologic and hydrogeologic evaluation, excavation/foundation design, remedial alternative design and related civil engineering purposes.

3.0 GLOSSARY

Rock Coring - A method in which a continuous solid cylindrical sample of rock or compact rock-like soil is obtained by the use of a double tube core barrel that is equipped with an appropriate diamond-studded drill bit which is advanced with a hydraulic rotary drilling machine.

Wire-Line Coring - As an alternative to conventional coring, this technique is valuable in deep hole drilling, since this method eliminates trips in and out of the hole with the coring equipment. With this technique, the core barrel becomes an integral part of the drill rod string. The drill rod serves as both a coring device and casing.

4.0 RESPONSIBILITIES

Project Manager - In consultation with the project geologist, the Project Manager is responsible for evaluating the drilling requirements for the site and specifying drilling techniques that will be successful given the study objectives and the known or suspected geologic conditions at the site. The Project Manager also determines the disposal methods for products generated by drilling, such as drill cuttings and well development water, as well as any specialized supplies or logistical support required for the drilling operations.

Field Operations Leader (FOL) - The FOL is responsible for the overall supervision and scheduling of drilling activities, and is strongly supported by the project geologist.

Project Geologist - The project geologist is responsible for ensuring that standard and approved drilling procedures are followed. The geologist will generate a detailed boring log for each test hole. This log shall include a description of materials, samples, method of sampling, blow counts, and other pertinent drilling and testing information that may be obtained during drilling (see SOPs SA-6.3 and GH-1.5). Often this position for inspecting the drilling operations may be filled by other geotechnical personnel, such as soils and foundation engineers, civil engineers, etc.

Determination of the exact location for borings is the responsibility of the site geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the Work Plan and/or Sampling and Analysis Plan.

Drilling Subcontractor - Operates under the supervision of the FOL. Responsible for obtaining all drilling permits and clearances, and supplying all services (including labor), equipment and material required to perform the drilling, testing, and well installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical or analytical problems encountered in the field to the FOL within 24 hours of determination, and must provide advance written notification of any changes in field procedures, describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the FOL (with the concurrence of the Project Manager). Depending on the subcontract, the Project Manager may need to obtain written authorization from appropriate administrative personnel before approving any changes.

The drilling subcontractor is responsible for following decontamination procedures specified in the project plan documents. Upon completion of the work, the driller is responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

5.0 PROCEDURES

5.1 General

The purpose of drilling boreholes is:

- To determine the type, thickness, and certain physical and chemical properties of the soil, water and rock strata which underlie the site.
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned between samples and borings using appropriate decontamination procedures as outlined in SOP SA-7.1. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first, and at the most contaminated locations last, to reduce the risk of spreading contamination between locations. All borings must be logged by the site geologist as they proceed (see SOPs SA-6.3 and GH-1.5). Situations where logging would not be required would include installation of multiple well points within a small area, or a "second attempt" boring adjacent to a boring that could not be continued through resistant material. In the latter case, the boring log can be resumed 5 feet above the depth at which the initial boring was abandoned, although the site geologist should still confirm that the stratigraphy at the redrilled location conforms essentially with that encountered at the original location. If significant differences are seen, each hole should be logged separately.

5.2 Drilling Methods

The selected drilling methods described below apply to drilling in subsurface materials, including, but not limited to, sand, gravel, clay, silt, cobbles, boulders, rock and man-made fill. Drilling methods should be selected after studying the site geology and terrain, the waste conditions at the site, and reviewing the purpose of drilling and the overall subsurface investigation program proposed for the site. The full range of different drilling methods applicable to the proposed program should be identified with final selection based on relative cost, availability, time constraints, and how well each method meets the sampling and testing requirements of the individual drilling program.

5.2.1 Continuous-Flight Hollow-Stem Auger Drilling

This method of drilling consists of rotating augers with a hollow stem into the ground. Cuttings are brought to the surface by the rotating action of the auger. This method is relatively quick and inexpensive. Advantages of this type of drilling include:

- Samples can be obtained without pulling the augers out of the hole. However, this is a poor method for obtaining grab samples from thin, discrete formations because of mixing of soils which occurs as the material is brought to the surface. Sampling of such formations requires the use of split-barrel or thin-wall tube samplers advanced through the hollow core of the auger.
- No drilling fluids are required.
- A well can be installed inside the auger stem and backfilled as the augers are withdrawn.

Disadvantages and limitations of this method of drilling include:

- Augering can only be done in unconsolidated materials.

- The inside diameter of hollow stem augers used for well installation should be at least 4 inches greater than the well casing. Use of such large-diameter hollow-stem augers is more expensive than the use of small-diameter augers in boreholes not used for well installation. Furthermore, the density of unconsolidated materials and depths become more of a limiting factor. More friction is produced with the larger diameter auger and subsequently greater torque is needed to advance the boring.

- The maximum effective depth for drilling is 150 feet or less, depending on site conditions and the size of augers used.

- In augering through clean sand formations below the water table, the sand will tend to flow into the hollow stem when the plug is removed for soil sampling or well installation. If the condition of "running" or "flowing" sands is persistent at a site, an alternative method of drilling is recommended, in particular for wells or boreholes deeper than 25 feet.

Hollow-stem auger drilling is the preferred method of drilling. Most alternative methods require the introduction of water or mud downhole (air rotary is the exception) to maintain the open borehole. With these other methods, great care must be taken to ensure that the method does not interfere with the collection of a representative sample (which may be the prime objective of the borehole construction). With this in mind, the preferred order of choice of drilling method after hollow-stem augering (HSA) is:

- Cable tool
- Casing drive (air)
- Air rotary
- Mud rotary
- Rotosonic
- Drive and wash
- Jetting

However, the use of any method will also depend on efficiency and cost-effectiveness. In many cases, mud rotary is the only feasible alternative to hollow-stem augering. Thus, mud rotary drilling is generally acceptable as a first substitute for HSA.

The procedures for sampling soils through holes drilled by hollow-stem auger shall conform with the applicable ASTM Standards: D1587-83 and D1586-84. The guidelines established in SOP SA-1.3 shall

also be followed. The hollow-stem auger may be advanced by any power-operated drilling machine having sufficient torque and ram range to rotate and force the auger to the desired depth. The machine must, however, be equipped with the accessory equipment needed to perform required sampling, or rock coring.

The hollow-stem auger may be used without the plug when boring for geotechnical examination or for well installation. However, when drilling below the water table, specially designed plugs which allow passage of formation water but not solid material shall be used (see Reference 1 of this guideline). This drilling configuration method also prevents blow back and plugging of the auger when the plug is removed for sampling.

Alternately, it may be necessary to keep the hollow stem full of water, at least to the level of the water table, to prevent blowback and plugging of the auger. If water is added to the hole, it must be sampled and analyzed to determine if it is free from contaminants prior to use. In addition, the amount of water introduced, the amount recovered upon attainment of depth, and the amount of water extracted during well development must be carefully logged in order to ensure that a representative sample of the formation water can be obtained. Well development should occur as soon after well completion as practicable (see SOP GH-2.8 for well development procedures). If gravelly or hard material is encountered which prevents advancing the auger to the desired depth, augering should be halted and either driven casing or hydraulic rotary methods should be attempted. If the depth to the bedrock/soil interface and bedrock lithology must be determined, then a 5-foot confirmatory core run should be conducted (see Section 5.2.9).

At the option of the Field Operations Leader (in communication with the Project Manager), when resistant materials prevent the advancement of the auger, a new boring can be attempted. The original boring must be properly backfilled and the new boring started a short distance away at a location determined by the site geologist. If multiple water bearing strata were encountered, the original boring must be grouted. In some formations, it may be prudent to also grout borings which penetrate only the water table aquifer, since loose soil backfill in the boring may still provide a preferred pathway for surface liquids to reach the water table. Backfilling requirements may also be driven by state or local regulations.

5.2.2 Continuous-Flight Solid-Stem Auger Drilling

This drilling method is similar to hollow-stem augering. Practical application of this method is severely restricted compared to use of hollow-stem augers. Split-barrel (split-spoon) sampling cannot be performed without pulling the augers out, which may allow the hole to collapse. The continuous-flight solid-stem auger drilling method is therefore very time consuming and is not cost effective. Also, augers would have to be withdrawn before installing a monitoring well, which again, may allow the hole to collapse. Furthermore, geologic logging by examining the soils brought to the surface is unreliable, and depth to water may be difficult to determine while drilling.

There would be very few situations where use of a solid-stem auger would be preferable to other drilling methods. The only practical applications of this method would be to drill boreholes for well installation where no lithologic information is desired and the soils are such that the borehole can be expected to remain open after the augers are withdrawn. Alternatively, this technique can be used to find depth to bedrock in an area when no other information is required from drilling.

5.2.3 Rotary Drilling

Direct rotary drilling includes air-rotary and fluid-rotary drilling. For air or fluid-rotary drilling, the rotary drill may be advanced to the desired depth by any power-operated drilling machine having sufficient torque

and ram range to rotate and force the bit to the desired depth. The drilling machine must, however, be equipped with any accessory equipment needed to perform required sampling, or coring. Prior to sampling, any settled drill cuttings in the borehole must be removed.

Air-rotary drilling is a method of drilling where the drill rig simultaneously turns and exerts a downward pressure on the drilling rods and bit while circulating compressed air down the inside of the drill rods, around the bit, and out the annulus of the borehole. Air circulation serves to both cool the bit and remove the cuttings from the borehole. Advantages of this method include:

- The drilling rate is high (even in rock).
- The cost per foot of drilling is relatively low.
- Air-rotary rigs are common in most areas.
- No drilling fluid is required (except when water is injected to keep down dust).
- The borehole diameter is large, to allow room for proper well installation procedures.

Disadvantages to using this method include:

- Formations must be logged from the cuttings that are blown to the surface and thus the depths of materials logged are approximate.
- Air blown into the formation during drilling may "bind" the formation and impede well development and natural groundwater flow.
- In-situ samples cannot be taken, unless the hole is cased.
- Casing must generally be used in unconsolidated materials.
- Air-rotary drill rigs are large and heavy.
- Large amounts of Investigation Derived Waste (IDW) may be generated which may require containerization, sampling, and off-site disposal.

A variation of the typical air-rotary drill bit is a down hole hammer which hammers the drill bit down as it drills. This makes drilling in hard rock faster. Air-rotary drills can also be adapted to use for rock coring although they are generally slower than other types of core drills. A major application of the air-rotary drilling method would be to drill holes in rock for well installation.

Fluid-Rotary drilling operates in a similar manner to air-rotary drilling except that a drilling fluid ("mud") or clean water is used in place of air to cool the drill bit and remove cuttings. There are a variety of fluids that can be used with this drilling method, including bentonite slurry and synthetic slurries. If a drilling fluid other than water/cuttings is used, it must be a natural clay (i.e., bentonite) and a "background" sample of the fluid should be taken for analysis of possible organic or inorganic contaminants.

Advantages to the fluid-rotary drilling method include:

- The ability to drill in many types of formations.
- Relatively quick and inexpensive.
- Split-barrel (split-spoon) or thin-wall (Shelby) tube samples can be obtained without removing drill rods if the appropriate size drill rods and bits (i.e., fish-tail or drag bit) are used.

- In some borings temporary casing may not be needed as the drilling fluids may keep the borehole open.
- Drill rigs are readily available in most areas.

Disadvantages to this method include:

- Formation logging is not as accurate as with hollow-stem auger method if split-barrel (split-spoon) samples are not taken (i.e., the depths of materials logged from cuttings delivered to the surface are approximate).
- Drilling fluids reduce permeability of the formation adjacent to the boring to some degree, and require more extensive well development than "dry" techniques (augering, air-rotary).
- No information on depth to water is obtainable while drilling.
- Fluids are needed for drilling, and there is some question about the effects of the drilling fluids on subsequent water samples obtained. For this reason as well, extensive well development may be required.
- In very porous materials (i.e., rubble fill, boulders, coarse gravel) drilling fluids may be continuously lost into the formation. This requires either constant replenishment of the drilling fluid, or the use of casing through this formation.
- Drill rigs are large and heavy, and must be supported with supplied water.
- Groundwater samples can be potentially diluted with drilling fluid.

The procedures for performing direct rotary soil investigations and sampling shall conform with the applicable ASTM standards: D2113-83, D1587-83, and D1586-84.

Soil samples shall be taken as specified by project plan documents, or more frequently, if requested by the project geologist. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool.

When field conditions prevent the advancement of the hole to the desired depth, a new boring may be drilled at the request of the Field Operations Leader. The original boring shall be backfilled using methods and materials appropriate for the given site and a new boring started a short distance away at a location determined by the project geologist.

5.2.4 Rotosonic Drilling

The Rotosonic drilling method employs a high frequency vibrational and low speed rotational motion coupled with down pressure to advance the cutting edge of a drill string. This produces a uniform borehole while providing a continuous, undisturbed core sample of both unconsolidated and most bedrock formations. Rotosonic drilling advances a 4-inch diameter to 12-inch diameter core barrel for sampling and can advance up to a 12-inch diameter outer casing for the construction of standard and telescoped monitoring wells. During drilling, the core barrel is advanced ahead of the outer barrel in increments as determined by the site geologist and depending upon type of material, degree of subsurface contamination and sampling objectives.

The outer casing can be advanced at the same time as the inner drill string and core barrel, or advanced down over the inner drill rods and core barrel, or after the core barrel has moved ahead to collect the undisturbed sample and has been pulled out of the borehole. The outer casing can be advanced dry in most cases, or can be advanced with water or air depending upon the formations being drilled, the depth and diameter of the hole, or requirements of the project.

Advantages of this method include:

- Sampling and well installation are faster as compared to other drilling methods.
- Continuous sampling, with larger sample volume as compared to split-spoon sampling.
- The ability to drill through difficult formations such as cobbles or boulders, hard till and bedrock.
- Reduction of IDW by an average of 70 to 80 percent.
- Well installations are quick and controlled by elimination of potential bridging of annular materials during well installation, due to the ability to vibrate the outer casing during removal.

Disadvantages include:

- The cost for Rotosonic drilling as compared to other methods are generally higher. However, the net result can be a significant savings considering reduced IDW and shortened project duration.
- Rotosonic drill rigs are large and need ample room to drill, however, Rotosonic units can be placed on the ground or placed on an ATV.
- There are a limited number of Rotosonic drilling contractors at the present time.

5.2.5 Reverse Circulation Rotary Drilling

The common reverse-circulation rig is a water or mud-rotary rig with a large-diameter drill pipe which circulates the drilling water down the annulus and up the inside of the drill pipe (reverse flow direction from direct mud-rotary). This type of rig is used for the construction of large-capacity production water wells and is not suited for small, water quality sampling wells because of the use of drilling muds and the large-diameter hole which is created. A few special reverse-circulation rotary rigs are made with double-wall drill pipe. The drilling water or air is circulated down the annulus between the drill pipes and up inside the inner pipe.

Advantages of the latter method include:

- The formation water is not contaminated by the drilling water.
- Formation samples can be obtained, from known depths.
- When drilling with air, immediate information is available regarding the water-bearing properties of formations penetrated.
- Collapsing of the hole in unconsolidated formations is not as great a problem as when drilling with the normal air-rotary rig.

Disadvantages include:

- Double-wall, reverse-circulation drill rigs are rare and expensive to operate.
- Placing cement grout around the outside of the well casing above a well screen often is difficult, especially when the screen and casing are placed down through the inner drill pipe before the drill pipe is pulled out.

5.2.6 Drill-through Casing Driver

The driven-casing method consists of alternately driving casing (fitted with a sharp, hardened casing shoe) into the ground using a hammer lifted and dropped by the drill rig (or an air-hammer) and cleaning out the casing using a rotary chopping bit and air or water to flush out the materials. The casing is driven down in stages (usually 5 feet per stage); a continuous record is kept of the blows per foot in driving the casing (see SOP GH-1.5). The casing is normally advanced by a 300-pound hammer falling freely through a height of 30 inches. Simultaneous washing and driving of the casing is not recommended. If this procedure is used, the elevations within which wash water is used and in which the casing is driven must be clearly recorded.

The driven casing method is used in unconsolidated formations only. When the boring is to be used for later well installation, the driven casing used should be at least 4 inches larger in diameter than the well casing to be installed. Advantages to this method of drilling include:

- Split-barrel (split-spoon) sampling can be conducted while drilling.
- Well installation is easily accomplished.
- Drill rigs used are relatively small and mobile.
- The use of casing minimizes flow into the hole from upper water-bearing layers; therefore, multiple aquifers can be penetrated and sampled for rough field determinations of some water quality parameters.

Some of the disadvantages include:

- This method can only be used in unconsolidated formations.
- The method is slower than other methods (average drilling progress is 30 to 50 feet per day).
- Maximum depth of the borehole varies with the size of the drill rig and casing diameter used, and the nature of the formations drilled.
- The cost per hour or per foot of drilling may be substantially higher than other drilling methods.
- It is difficult and time consuming to pull back the casing if it has been driven very deep (deeper than 50 feet in many formations).

5.2.7 Cable Tool Drilling

A cable tool rig uses a heavy, solid-steel, chisel-type drill bit ("tool") suspended on a steel cable, which when raised and dropped, chisels or pounds a hole through the soils and rock. Drilling progress may be

expedited by the use of "slip-jars" which serve as a cable-activated down hole percussion device to hammer the bit ahead.

When drilling through the unsaturated zone, some water must be added to the hole. The cuttings are suspended in the water and then bailed out periodically. Below the water table, after sufficient ground water enters the borehole to replace the water removed by bailing, no further water needs to be added. When soft caving formations are encountered, it is usually necessary to drive casing as the hole is advanced to prevent collapse of the hole. Often the drilling can be only a few feet below the bottom of the casing. Because the drill bit is lowered through the casing, the hole created by the bit is smaller than the casing. Therefore, the casing (with a sharp, hardened casing shoe on the bottom) must be driven into the hole (see Section 5.2.5 of this guideline).

Advantages of the cable-tool method include the following:

- Information regarding water-bearing zones is readily available during the drilling. Even relative permeabilities and rough water quality data from different zones penetrated can be obtained by skilled operators.
- The cable-tool rig can operate satisfactorily in all formations, but is best suited for caving, boulder, cobble or coarse gravel type formations (e.g., glacial till) or formations with large cavities above the water table (such as limestones).
- When casing is used, the casing seals formation water out of the hole, preventing down hole contamination and allowing sampling of deeper aquifers for field-measurable water quality parameters.
- Split-barrel (split-spoon) or thin-wall (Shelby) tube samples can be collected through the casing.

Disadvantages include:

- Drilling is slow compared with rotary rigs.
- The necessity of driving the casing in unconsolidated formations requires that the casing be pulled back if exposure of selected water-bearing zones is desired. This process complicates the well completion process and often increases costs. There is also a chance that the casing may become stuck in the hole.
- The relatively large diameters required (minimum of 4-inch casing) plus the cost of steel casing result in higher costs compared to rotary drilling methods where casing is not required (e.g., such use of a hollow-stem auger).
- Cable-tool rigs have largely been replaced by rotary rigs. In some parts of the U.S., availability may be difficult.

5.2.8 Jet Drilling (Washing)

Jet drilling, which should be used only for piezometer or vadose zone sampler installation, consists of pumping water or drilling mud down through a small diameter (1/2- to 2-inch) standard pipe (steel or PVC). The pipe may be fitted with a chisel bit or a special jetting screen. Formation materials dislodged by the bit and jetting action of the water are brought to the surface through the annulus around the pipe. As the pipe is jetted deeper, additional lengths of pipe may be added at the surface.

Jet percussion is a variation of the jetting method, in which the casing is driven with a drive weight. Normally, this method is used to place 2-inch-diameter casing in shallow, unconsolidated sand formations, but this method has also been used to install 3- to 4-inch-diameter casings to a depth of 200 feet.

Jetting is acceptable in very soft formations, usually for shallow sampling, and when introduction of drilling water to the formation is acceptable. Such conditions would occur during rough stratigraphic investigation or installation of piezometers for water level measurement. Advantages of this method include:

- Jetting is fast and inexpensive.
- Because of the small amount of equipment required, jetting can be accomplished in locations where access by a normal drilling rig would be very difficult. For example, it would be possible to jet down a well point in the center of a lagoon at a fraction of the cost of using a drill rig.
- Jetting numerous well points just into a shallow water table is an inexpensive method for determining the water table contours, hence flow direction.

Disadvantages include the following:

- A large amount of foreign water or drilling mud is introduced above and into the formation to be sampled.
- Jetting is usually done in very soft formations which are subject to caving. Because of this caving, it is often not possible to place a grout seal above the screen to assure that water in the well is only from the screened interval.
- The diameter of the casing is usually limited to 2 inches.
- Jetting is only possible in very soft formations that do not contain boulders or coarse gravel, and the depth limitation is shallow (about 30 feet without jet percussion equipment).
- Large quantities of water are often needed.

5.2.9 Drilling with a Hand Auger

This method is applicable wherever the formation, total depth of sampling, and the site and groundwater conditions are such as to allow hand auger drilling. Hand augering can also be considered at locations where drill rig access is not possible. All hand auger borings will be performed according to ASTM D1452-80.

Samples should be taken continuously unless otherwise specified by the project plan documents. Any required sampling is performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. Typical equipment used for sampling and advancing shallow "hand auger" holes are Iwan samplers (which are rotated) or post hole diggers (which are operated like tongs). These techniques are slow but effective where larger pieces of equipment do not have access, and where very shallow holes are desired (less than 15 feet). Surficial soils must be composed of relatively soft and non-cemented formations to allow penetration by the auger.

5.2.10 Rock Drilling and Coring

When soil borings cannot be continued using augers or rotary methods due to the hardness of the soil or when rock or large boulders are encountered, drilling and sampling can be performed using a diamond bit corer in accordance with ASTM D2113.

Drilling is done by rotating and applying downward pressure to the drill rods and drill bit. The drill bit is a circular, hollow, diamond-studded bit attached to the outer core barrel in a double-tube core barrel. The use of single-tube core barrels is not recommended, as the rotation of the barrel erodes the sample and limits its use for detailed geological evaluation. Water or air is circulated down through the drill rods and annular space between the core barrel tubes to cool the bit and remove the cuttings. The bit cuts a core out of the rock which rises into an inner barrel mounted inside the outer barrel. The inner core barrel and rock core are removed by lowering a wire line with a coupling into the drill rods, latching onto the inner barrel and withdrawing the inner barrel. A less efficient variation of this method utilizes a core barrel that cannot be removed without pulling all of the drill rods. This variation is practical only if less than 50 feet of core is required.

Core borings are made through the casing used for the soil borings. The casing must be driven and sealed into the rock formation to prevent seepage from the overburden into the hole to be cored (see Section 5.3 of this guideline). A double-tube core barrel with a diamond bit and reaming shell or equivalent should be used to recover rock cores of a size specified in the project plans. The most common core barrel diameters are listed in Attachment A.

Soft or decomposed rock should be sampled with a driven split-barrel whenever possible or cored with a Denison or Pitcher sampler.

When coring rock, including shale and claystone, the speed of the drill and the drilling pressure, amount and pressure of water, and length of run can be varied to give the maximum recovery from the rock being drilled. Should any rock formation be so soft or broken that the pieces continually fall into the hole causing unsatisfactory coring, the hole should be reamed and a flush-joint casing installed to a point below the broken formation. The size of the flush-joint casing must permit securing the core size specified. When soft or broken rock is anticipated, the length of core runs should be reduced to less than 5 feet to avoid core loss and minimize core disturbance.

Advantages of core drilling include:

- Undisturbed rock cores can be recovered for examination and/or testing.
- In formations in which the cored hole will remain open without casing, water from the rock fractures may be recovered from the well without the installation of a well screen and gravel pack.
- Formation logging is extremely accurate.
- Drill rigs are relatively small and mobile.

Disadvantages include:

- Water or air is needed for drilling.
- Coring is slower than rotary drilling (and more expensive).
- Depth to water cannot accurately be determined if water is used for drilling.
- The size of the borehole is limited.

This drilling method is useful if accurate determinations of rock lithology are desired or if open wells are to be installed into bedrock. To install larger diameter wells in coreholes, the hole must be reamed out to the proper size after boring, using air or mud rotary drilling methods.

5.2.11 Drilling & Support Vehicles

In addition to the drilling method required to accomplish the objectives of the field program, the type of vehicle carrying the drill rig and/or support equipment and its suitability for the site terrain, will often be an additional deciding factor in planning the drilling program. The types of vehicles available are extensive, and depend upon the particular drilling subcontractor's fleet. Most large drilling subcontractors will have a wide variety of vehicle and drill types suited for most drilling assignments in their particular region, while smaller drilling subcontractors will usually have a fleet of much more limited diversity. The weight, size, and means of locomotion (tires, tracks, etc.) of the drill rig must be selected to be compatible with the site terrain to assure adequate mobility between borehole locations. Such considerations also apply to necessary support vehicles used to transport water and/or drilling materials to the drill rigs at the borehole locations. When the drill rigs or support vehicles do not have adequate mobility to easily traverse the site, provisions must be made for assisting equipment, such as bulldozers, winches, timber planking, etc., to maintain adequate progress during the drilling program.

Some of the typical vehicles which are usually available for drill rigs and support equipment are:

- Totally portable drilling/sampling equipment, where all necessary components (tripods, samplers, hammers, catheads, etc.) may be hand carried to the borehole site. Drilling/sampling methods used with such equipment include:

  - Hand augers and lightweight motorized augers.
  - Retractable plug samplers--driven by hand (hammer).
  - Motorized cathead - a lightweight aluminum tripod with a small gas-engine cathead mounted on one leg, used to install small-diameter cased borings. This rig is sometimes called a "monkey on a stick."

- Skid-mounted drilling equipment containing a rotary drill or engine-driven cathead (to lift hammers and drill string), a pump, and a dismounted tripod. The skid is pushed, dragged, or winched (using the cathead drum) between boring locations.

- Small truck-mounted drilling equipment using a Jeep, stake body or other light truck (4 to 6 wheels), upon which are mounted the drill and/or a cathead, a pump, and a tripod or small drilling derrick. On some rigs, the drill and/or a cathead are driven by a power take-off from the truck, instead of by a separate engine.

- Track-mounted drilling equipment is similar to truck-mounted rigs, except that the vehicle used has wide bulldozer tracks for traversing soft ground. Sometimes a continuous-track "all terrain vehicle" is also modified for this purpose. Some types of tracked drill rigs are called "bombardier" or "weasel" rigs.

- Heavy truck-mounted drilling equipment is mounted on tandem or dual tandem trucks to transport the drill, derrick, winches, and pumps or compressors. The drill may be provided with a separate engine or may use a power take-off from the truck engine. Large augers, hydraulic rotary and reverse circulation rotary drilling equipment are usually mounted on such heavy duty trucks. For soft-ground sites, the drilling equipment is sometimes mounted on vehicles having low pressure, very wide diameter tires and capable of floating; these vehicles are called "swamp buggy" rigs.

- Marine drilling equipment is mounted on various floating equipment for drilling borings in lakes, estuaries and other bodies of water. The floating equipment varies, and is often manufactured or customized by the drilling subcontractor to suit specific drilling requirements. Typically, the range of flotation vehicles include:

  - Barrel-float rigs - a drill rig mounted on a timber platform buoyed by empty 55-gallon drums or similar flotation units.

  - Barge-mounted drill rigs.

- Jack-up platforms - drilling equipment mounted on a floating platform having retractable legs to support the unit on the sea or lake bed when the platform is jacked up out of the water.

- Drill ships - for deep ocean drilling.

In addition to the mobility for the drilling equipment, similar consideration must be given for equipment to support the drilling operations. Such vehicles or floating equipment are needed to transport drill water, drilling supplies and equipment, samples, drilling personnel, etc. to and/or from various boring locations.

5.2.12 Equipment Sizes

In planning subsurface exploration programs, care must be taken in specifying the various drilling components, so that they will fit properly in the boring or well.

For drilling open boreholes using rotary drilling equipment, tri-cone drill bits are employed with air, water or drilling mud to remove cuttings and cool the bit. Tri-cone bits are slightly smaller than the holes they drill (i.e., 5-7/8-inch or 7-7/8-inch bits will nominally drill 6-inch and 8-inch holes, respectively).

For obtaining split-barrel samples of a formation, samplers are commonly manufactured in sizes ranging from 2 inches to 3-1/2 inches in outside diameter. However, the most commonly used size is the 2-inch O.D., 1-3/8-inch I.D. split-barrel sampler. When this sampler is used and driven by a 140-pound (± 2-pound) hammer dropping 30 inches (± 1 inch), the procedure is called a Standard Penetration Test, and the blows per foot required to advance the sampler into the formation can be correlated to the formation's density or strength.

In planning the drilling of boreholes using hollow-stem augers or casing, in which thin-wall tube samples or diamond core drilling will be performed, refer to the various sizes and clearances provided in Attachment A of this guideline. Sizes selected must be stated in the project plan documents.

5.2.13 Estimated Drilling Progress

To estimate the anticipated rates of drilling progress for a site, the following must be considered:

- The speed of the drilling method employed.

- Applicable site conditions (e.g., terrain, mobility between borings, difficult drilling conditions in bouldery soils, rubble fill or broken rock, etc.).

- Project-imposed restrictions (e.g., drilling while wearing personal protective equipment, decontamination of drilling equipment, etc.).

Based on recent experience in drilling average soil conditions (no boulders) and taking samples at 5-foot intervals, for moderate depth (30 feet to 50 feet) boreholes (not including installation or development of wells), the following daily rates of total drilling progress may be anticipated for the following drilling methods:

Drilling Method	Average Daily Progress (linear feet)
Hollow-stem augers	75'
Solid-stem augers	50'
Mud-Rotary Drilling	100' (cuttings samples)
Rotosonic Drilling	100'-160' (continuous core)
Reverse-Circulation Rotary	100' (cuttings samples)
Skid-Rig with driven casing	30'
Rotary with driven casing	50'
Cable Tool	30'
Hand Auger	Varies
Continuous Rock Coring	50'

5.3 Prevention of Cross-Contamination

A telescoping or multiple casing technique minimizes the potential for the migration of contaminated groundwater to lower strata below a confining layer. The telescoping technique consists of drilling to a confining layer utilizing a spun casing method with a diamond cutting or augering shoe (a method similar to the rock coring method described in Section 5.2.10, except that larger casing is used) or by using a driven-casing method (see Section 5.2.6 of this guideline) and installing a specified diameter steel well casing. The operation consists of three separate steps. Initially, a drilling casing (usually of 8-inch diameter) is installed followed by installation of the well casing (6-inch-diameter is common for 2-inch wells). This well casing is driven into the confining layer to ensure a tight seal at the bottom of the hole. The well casing is sealed at the bottom with a bentonite-cement slurry. The remaining depth of the boring is drilled utilizing a narrower diameter spun or driven casing technique within the outer well casing. A smaller diameter well casing with an appropriate length of slotted screen on the lower end, is installed to the surface.

Clean sand is placed in the annulus around and to a point of about 2 feet above the screen prior to withdrawal of the drilling casing. The annular space above the screen and to a point 2 feet above the bottom of the outer well casing is sealed with a tremied cement-bentonite slurry which is pressure-grouted or displacement-grouted into the hole. The remaining casing annulus is backfilled with clean material and grouted at the surface, or it is grouted all the way to the surface.

5.4 Cleanout of Casing Prior to Sampling

The boring hole must be completely cleaned of disturbed soil, segregated coarse material and clay adhering to the inside walls of the casing. The cleaning must extend to the bottom edge of the casing and, if possible, a short distance further (1 or 2 inches) to bypass disturbed soil resulting from the advancement of the casing. Loss of wash water during cleaning should be recorded.

For disturbed samples both above and below the water table and where introduction of relatively large volumes of wash water is permissible, the cleaning operation is usually performed by washing the material out of the casing with water; however, the cleaning should never be accomplished with a strong, downward-directed jet which will disturb the underlying soil. When clean out has reached the bottom of the casing or slightly below (as specified above), the string of tools should be lifted one foot off the bottom with the water still flowing, until the wash water coming out of the casing is clear of granular soil particles. In formations where the cuttings contain gravel and other larger particles, it is often useful to repeatedly raise and lower the drill rods and wash bit while washing out the hole, to surge these large particles upward out of the hole. As a time saver, the drilling contractor may be permitted to use a split-barrel (split-spoon) sampler with the ball check valve removed as the clean-out tool, provided the material below the spoon is not disturbed and the shoe of the spoon is not damaged. However, because the ball check valve has been removed, in some formations it may be necessary to install a flap valve or spring sample retainer in the split-spoon bit, to prevent the sample from falling out as the sampler is withdrawn from the hole. The use of jet-type chopping bits is discouraged except where large boulders and cobbles or hard-cemented soils are encountered. If water markedly softens the soils above the water table, clean out should be performed dry with an auger.

For undisturbed samples below the water table, or where wash water must be minimized, clean out is usually accomplished with an appropriate diameter clean out auger. This auger has cutting blades at the bottom to carry loose material up into the auger, and up-turned water jets just above the cutting blades to carry the removed soil to the surface. In this manner, there is a minimum of disturbance at the top of the material to be sampled. If any gravel material washes down into the casing and cannot be removed by the clean out auger, a split-barrel sample can be taken to remove it; bailers and sandpumps should not be used. For undisturbed samples above the groundwater table, all operations must be performed in a dry manner.

If all of the cuttings created by drilling through the overlying formations are not cleaned from the borehole prior to sampling, some of the problems which may be encountered during sampling include:

- When sampling is attempted through the cuttings remaining in the borehole, all or part of the sampler may become filled with the cuttings. This limits the amount of sample from the underlying formation which can enter and be retained in the sampler, and also raises questions as to the validity of the sample.

- If the cuttings remaining in the borehole contain coarse gravel and/or other large particles, these may block the bit of the sampler and prevent any materials from the underlying formation from entering the sampler when the sampler is advanced.

- In cased borings, should sampling be attempted through cuttings which remain in the lower portion of the casing, these cuttings could cause the sampler to become bound into the casing, such that it becomes very difficult to either advance or retract the sampler.

- When sampler blow counts are used to estimate the density or strength of the formation being sampled, the presence of cuttings in the borehole will usually give erroneously high sample blow counts.

To confirm that all cuttings have been removed from the borehole prior to attempting sampling, it is important that the site geologist measure the "stickup" of the drill string. This is accomplished by measuring the assembled length of all drill rods and bits or samplers (the drill string) as they are lowered to the bottom of the hole, below some convenient reference point of the drill string, then measuring the height of this reference point above the ground surface. The difference of these measurements is the

depth of the drill string (lower end of the bit or sampler) below the ground surface, which must then be compared with the depth of sampling required (installed depth of casing or depth of borehole drilled). If the length of drill string below grade is more than the drilled or casing depth, the borehole has been cleaned too deeply, and this deeper depth of sampling must be recorded on the log. If the length of drill string below grade is less than the drilled or casing depth, the difference represents the thickness of cuttings which remain in the borehole. In most cases, an inch or two of cuttings may be left in the borehole with little or no problem. However, if more than a few inches of cuttings are encountered, the borehole must be recleaned prior to attempting sampling.

5.5 Materials of Construction

The effects of monitoring well construction materials on specific chemical analytical parameters are described and/or referenced in SOP GH-2.8. However, there are several materials used during drilling, particularly drilling fluids and lubricants, which must be used with care to avoid compromising the representativeness of soil and ground water samples.

The use of synthetic or organic polymer slurries is not permitted at any location where soil samples for chemical analysis are to be collected. These slurry materials could be used for installation of long-term monitoring wells, but the early time data in time series collection of ground water data may then be suspect. If synthetic or organic polymer muds are proposed for use at a given site, a complete written justification including methods and procedures for their use must be provided by the site geologist and approved by the Project Manager. The specific slurry composition and the concentration of suspected contaminants for each site must be known.

For many drilling operations, potable water is an adequate lubricant for drill stem and drilling tool connections. However, there are instances, such as drilling in tight clayey formations or in loose gravels, when threaded couplings must be lubricated to avoid binding. In these instances, to be determined in the field by the judgment of the site geologist and noted in the site logbook, and only after approval by the Project Manager, a vegetable oil or silicone-based lubricant should be used. Petroleum based greases, etc. will not be permitted. Samples of lubricants used must be provided and analyzed for chemical parameters appropriate to the given site.

5.6 Subsurface Soil Samples

Subsurface soil samples are used to characterize subsurface stratigraphy. This characterization can indicate the potential for migration of chemical contaminants in the subsurface. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of the soil samples. Where the remedial activities may include in-situ treatment or excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Engineering and physical properties of soil may also be of interest should site construction activities be planned. Soil types, grain size distribution, shear strength, compressibility, permeability, plasticity, unit weight, and moisture content are some of the physical characteristics that may be determined for soil samples.

Penetration tests are also described in this procedure. The tests can be used to estimate various physical and engineering parameters such as relative density, unconfined compressive strength, and consolidation characteristics of soils.

Surface protocols for various soil sampling techniques are discussed in SOP SA-1.3. Continuous-core soil sampling and rock coring are discussed below. The procedures described here are representative of

a larger number of possible drilling and sampling techniques. The choice of techniques is based on a large number of variables such as cost, local geology, etc. The final choice of methods must be made with the assistance of drilling subcontractors familiar with the local geologic conditions. Alternative techniques must be based upon the underlying principles of quality assurance implicit in the following procedures.

The CME continuous sample tube system provides a method of sampling soil continuously during hollow-stem augering. The 5-foot sample barrel fits within the lead auger of a hollow-auger column. The sampling system can be used with a wide range of I.D. hollow-stem augers (from 3-1/4-inch to 8-1/4-inch I.D.). This method has been used to sample many different materials such as glacial drift, hard clays and shales, mine tailings, etc. This method is particularly used when SPT samples are not required and a large volume of material is needed. Also, this method is useful when a visual description of the subsurface lithology is required. Rotosonic drilling methods also provide a continuous soil sample.

5.7 Rock Sampling (Coring) (ASTM D2113-83)

Rock coring enables a detailed assessment of borehole conditions to be made, showing precisely all lithologic changes and characteristics. Because coring is an expensive drilling method, it is commonly used for shallow studies of 500 feet or less, or for specific intervals in the drill hole that require detailed logging and/or analyzing. Rock coring can, however, proceed for thousands of feet continuously, depending on the size of the drill rig, and yields better quality data than air-rotary drilling, although at a substantially reduced drilling rate. Rate of drilling varies widely, depending on the characteristics of lithologies encountered, drilling methods, depth of drilling, and condition of drilling equipment. Average output in a 10-hour day ranges from 40 to over 200 feet. Down hole geophysical logging or television camera monitoring is sometimes used to complement the data generated by coring.

Borehole diameter can be drilled to various sizes, depending on the information needed. Standard sizes of core barrels (showing core diameter) and casing are shown in Figure 1.

Core drilling is used when formations are too hard to be sampled by soil sampling methods and a continuous solid sample is desired. Usually, soil samples are used for overburden, and coring begins in sound bedrock. Casing is set into bedrock before coring begins to prevent loose material from entering the borehole, to prevent loss of drilling fluid, and to prevent cross-contamination of aquifers.

Drilling through bedrock is initiated by using a diamond-tipped core bit threaded to a drill rod (outer core barrel) with a rate of drilling determined by the downward pressure, rotation speed of drill rods, drilling fluid pressure in the borehole, and the characteristics of the rock (mineralogy, cementation, weathering).

FIGURE 1

STANDARD SIZES OF CORE BARRELS AND CASING

Coring Bit Size	Nominal*		Set Size*	
	O.D.	I.D.	O.D.	I.D.
RWT	1 5/32	3/4	1.160	0.735
EWT	1 1/2	29/32	1.470	0.905
EX, EXL, EWG, EWM	1 1/2	13/16	1.470	0.845
AWT	1 7/8	1 9/32	1.875	1.281
AX, AXL, AWG, AWM	1 7/8	1 3/16	1.875	1.185
BWT	2 3/8	1 3/4	2.345	1.750
BX, BXL, BWG, BWM	2 3/8	1 5/8	2.345	1.655
NWT	3	2 5/16	2.965	2.313
NX, NXL, NWG, NWM	3	2 1/8	2.965	2.155
HWT	3 29/32	3 3/16	3.889	3.187
HWG	3 29/32	3	3.889	3.000
2 3/4 x 3 7/8	3 7/8	2 3/4	3.840	2.690
4 x 5 1/2	5 1/2	4	5.435	3.970
6 x 7 3/4	7 3/4	6	7.655	5.970
AX Wire line ___|___/	1 7/8	1	1.875	1.000
BX Wire line ___|___/	2 3/8	1 7/16	2.345	1.437
NX Wire line ___|___/	3	1 15/16	2.965	1.937

* All dimensions are in inches; to convert to millimeters, multiply by 25.4.

___|___/ Wire line dimensions and designations may vary according to manufacturer.

FIGURE 1
STANDARD SIZES OF CORE BARRELS AND CASING
PAGE TWO

Size Designations			Casing Coupling					Approximate Core Diameter	
Casing; Casing coupling; Casing bits; Core barrel bits	Rod; rod couplings	Casing O.D., Inches	O.D., Inches	I.D., Inches	Casing bit O.D., Inches	Core barrel bit O.D., Inches*	Drill rod O.D., Inches	Normal, Inches	Thinwall, Inches
RX	RW	1.437	1.437	1.188	1.485	1.160	1.094	---	0.735
EX	E	1.812	1.812	1.500	1.875	1.470	1.313	0.845	0.905
AX	A	2.250	2.250	1.906	2.345	1.875	1.625	1.185	1.281
BX	B	2.875	2.875	2.375	2.965	2.345	1.906	1.655	1.750
NX	N	3.500	3.500	3.000	3.615	2.965	2.375	2.155	2.313
HX	HW	4.500	4.500	3.938	4.625	3.890	3.500	3.000	3.187
RW	RW	1.437	Flush Joint	No Coupling	1.485	1.160	1.094	---	0.735
EW	EW	1.812			1.875	1.470	1.375	0.845	0.905
AW	AW	2.250			2.345	1.875	1.750	1.185	1.281
BW	BW	2.875			2.965	2.345	2.125	1.655	1.750
NW	NW	3.500			3.615	2.965	2.625	2.155	2.313
HW	HW	4.500			4.625	3.890	3.500	3.000	3.187
PW	---	5.500			5.650	---	---	---	---
SW	---	6.625			6.790	---	---	---	---
UW	---	7.625			7.800	---	---	---	---
ZW	---	8.625			8.810	---	---	---	---
---	AX __|__\	---	---	---	---	1.875	1.750	1.000	---
---	BX __|__\	---	---	---	---	2.345	2.250	1.437	---
---	NX __|__\	---	---	---	---	2.965	2.813	1.937	---

* All dimensions are in inches; to convert to millimeters, multiply by 25.4.

___|___/ Wire line dimensions and designations may vary according to manufacturer.

NOMINAL DIMENSIONS FOR DRILL CASINGS AND ACCESSORIES. (DIAMOND CORE DRILL MANUFACTURERS ASSOCIATION). 288-D-2889

5.7.1 Diamond Core Drilling

A penetration of typically less than 6 inches per 50 blows using a 140-lb. hammer dropping 30 inches with a 2-inch split-barrel sampler shall be considered an indication that soil sampling methods may not be applicable and that coring may be necessary to obtain samples.

When formations are encountered that are too hard to be sampled by soil sampling methods, the following diamond core drilling procedure may be used:

- Firmly seat a casing into the bedrock or the hard material to prevent loose materials from entering the hole and to prevent the loss of drilling fluid return. Level the surface of the rock or hard material when necessary by the use of a fishtail or other bits. If the drill hole can be retained open without the casing and if cross-contamination of aquifers in the unconsolidated materials is unlikely, leveling may be omitted.

- Begin the core drilling using a double-tube swivel-core barrel of the desired size. After drilling no more than 10 feet (3 m), remove the core barrel from the hole and take out the core. If the core blocks the flow of the drilling fluid during drilling, remove the core barrel immediately. In soft materials, a large starting size may be specified for the coring tools; where local experience indicates satisfactory core recovery or where hard, sound materials are anticipated, a smaller size or the single-tube type may be specified and longer runs may be drilled. NX/NW size coring equipment is the most commonly used size.

- When soft materials are encountered that produce less than 50 percent recovery, stop the core drilling. If soil samples are desired, secure such samples in accordance with the procedures described in ASTM Method D 1586 (Split-barrel Sampling) or in Method D 1587 (Thin-Walled Tube Sampling); sample soils per SOP SA-1.3. Resume diamond core drilling when refusal materials are again encountered.

- Since rock structures and the occurrence of seams, fissures, cavities, and broken areas are among the most important items to be detected and described, take special care to obtain and record these features. If such broken zones or cavities prevent further advance of the boring, one of the following three steps shall be taken: (1) cement the hole; (2) ream and case; or (3) case and advance with the next smaller size core barrel, as conditions warrant.

- In soft, seamy, or otherwise unsound rock, where core recovery may be difficult, M-design core barrels may be used. In hard, sound rock where a high percentage of core recovery is anticipated, the single-tube core barrel may be employed.

5.7.2 Rock Sample Preparation and Documentation

Once the rock coring has been completed and the core recovered, the rock core shall be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). Each core shall be described, classified, and logged using a uniform system as presented in SOP GH-1.5. If moisture content will be determined or if it is desirable to prevent drying (e.g., to prevent shrinkage of clay formations) or oxidation of the core, the core shall be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number, and the footage represented in each sleeve shall be included, as well as designating the top and bottom of the core run.

After sampling, rock cores shall be placed in the sequence of recovery in well-constructed wooden boxes provided by the drilling contractor. Rock cores from two different borings shall not be placed in the same core box unless accepted by the Project Geologist. The core boxes shall be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each and shall be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened down. Wood partitions shall be placed at the end of each core run and between rows.

The depth from the surface of the boring to the top and bottom of the drill run and run number shall be marked on the wooden partitions with indelible ink. A wooden partition (wooden block) shall be placed at the end of each run with the depth of the bottom of the run written on the block. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores shall be the same in all core boxes. Rock core shall be placed in the box so that, when the box is open, with the inside of the lid facing the observer, the top of the cored interval contained within the box is in the upper left corner of the box, and the bottom of the cored interval is in the lower right corner of the box. The top and bottom of each core obtained and its true depth shall be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, an empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:

- Project name.
- Project number.
- Boring number.
- Run numbers.
- Footage (depths).
- Recovery.
- RQD (%).
- Box number and total number of boxes for that boring (Example: Box 5 of 7).

For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number.

Prior to final closing of the core box, a photograph of the recovered core and the labeling on the inside cover shall be taken. If moisture content is not critical, the core shall be wetted and wiped clean for the photograph. (This will help to show true colors and bedding features in the cores).

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ATTACHMENT A

DRILLING EQUIPMENT SIZES

Drilling Component	Designation or Hole Size (Inches)	O.D. (Inches)	I.D. (Inches)	Coupling I.D. (Inches)
Hollow-stem augers (Ref. 7)	6 1/4	5	2 1/4	
	6 3/4	5 3/4	2 3/4	---
	7 1/4	6 1/4	3 1/4	---
	13 1/4	12	6	---
Thin Wall Tube Samplers (Ref. 7)	---	2	1 7/8	---
	---	2 1/2	2 3/8	---
	---	3	2 7/8	---
	---	3 1/2	3 3/8	---
	---	4 1/2	4 3/8	---
	---	5	4 3/4	---
Drill Rods (Ref. 7)	RW	1 3/32	23/32	13/32
	EW	1 3/8	15/16	7/16
	AW	1 3/4	1 1/4	5/8
	BW	2 1/8	1 3/4	3/4
	NW	2 5/8	2 1/4	1 3/8
	HW	3 1/2	3 1/16	2 3/8
	E	1 5/16	7/8	7/16
	A	1 5/8	1 1/8	9/16
	B	1 7/8	1 1/4	5/8
	N	2 3/8	2	1
				Wall Thickness (Inches)
Driven External Coupled Extra Strong Steel* Casing (Ref. 8)	2 1/2	2.875	2.323	0.276
	3	3.5	2.9	0.300
	3 1/2	4.0	3.364	0.318
	4	4.5	3.826	0.337
	5	5.63	4.813	0.375
	6	6.625	5.761	0.432
	8	8.625	7.625	0.500
	10	10.750	9.750	0.500
	12	12.750	11.750	0.500

* Add twice the casing wall thickness to casing O.D. to obtain the approximate O.D. of the external pipe couplings.

ATTACHMENT A
DRILLING EQUIPMENT SIZES
PAGE TWO

Drilling Component	Designation or Hole Size (Inches)	O.D. (Inches)	I.D. (Inches)	Coupling I.D. (Inches)
Flush Coupled Casing (Ref. 7)	RX	1 7/16	1 3/16	1 3/16
	EX	1 13/16	1 5/8	1 1/2
	AX	2 1/4	2	1 29/32
	BX	2 7/8	2 9/16	2 3/8
	NX	3 1/2	3 3/16	3
	HX	4 1/2	4 1/8	3 15/16
Flush Joint Casing (Ref. 7)	RW	1 7/16	1 3/16	
	EW	1 13/16	1 1/2	
	AW	2 1/4	1 29/32	
	BW	2 7/8	2 3/8	
	NW	3 1/2	3	
	HW	4 1/2	4	
	PW	5 1/2	5	
	SW	6 5/8	6	
	UW	7 5/8	7	
	ZW	8 5/8	8	
Diamond Core Barrels (Ref. 7)	EWM	1 1/2	7/8**	
	AWM	1 7/8	1 1/8**	
	BWM	2 3/8	1 5/8**	
	NWM	3	2 1/8	
	HWG	3 7/8	3	
	2 3/4 x 3 7/8	3 7/8	2 11/16	
	4 x 5 1/2	5 1/2	3 15/16	
	6 x 7 3/4	7 3/4	5 15/16	
	AQ (wireline)	1 57/64	1 1/16**	
	BQ (wireline)	2 23/64	1 7/16**	
	NQ (wireline)	2 63/64	1 7/8	
	HQ (wireline)	3 25/32	2 1/2	

** Because of the fragile nature of the core and the difficulty to identify rock details, use of small-diameter core (1 3/8") is not recommended.

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1.0 PURPOSE

The purpose of this document is to establish standard procedures and technical guidance on borehole and sample logging.

2.0 SCOPE

These procedures provide descriptions of the standard techniques for borehole and sample logging. These techniques shall be used for each boring logged to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Geologist. Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used on site, the Site Geologist must make sure that each field geologist is properly trained in logging procedures. A brief review or training session may be necessary prior to the start up of the field program and/or upon completion of the first boring.

5.0 PROCEDURES

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

5.1 Materials Needed

When logging soil and rock samples, the geologist or engineer may be equipped with the following:

- Rock hammer
- Knife
- Camera
- Dilute hydrochloric acid (HCl)
- Ruler (marked in tenths and hundredths of feet)
- Hand Lens

5.2 Classification of Soils

All data shall be written directly on the boring log (Figure 1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

FIGURE 1
BORING LOG (EXAMPLE)

BORING LOG

Page ___ of ___

PROJECT NAME: _____ BORING NUMBER: _____
PROJECT NUMBER: _____ DATE: _____
DRILLING COMPANY: _____ GEOLOGIST: _____
DRILLING RIG: _____ DRILLER: _____

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated response read.

Drilling Area Background (ppm): ☐

Remarks: _____

Converted to Well: Yes _____ No _____ Well I.D. #: _____

FIGURE 1 (CONTINUED)

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE-GRAINED SOILS More Than Half of Material is LARGER Than No. 200 Sieve Size					FINE-GRAINED SOILS More Than Half of Material is SMALLER Than No. 200 Sieve Size						
FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)			GROUP SYMBOL	TYPICAL NAMES	FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)					GROUP SYMBOL	TYPICAL NAMES
					Identification Procedures on Fraction Smaller than No. 40 Sieve Size						
						DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)			
GRAVELS (More Than 50% of Coarse Fraction Larger Than No. 4 Sieve Size)	CLEAN GRAVELS (Less Than 5% Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel-sand mixtures, little or no fines.	SILTS AND CLAYS Liquid Limit Less Than 50	None to Slight	Quick to Slow	None	Medium	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.		Medium to High	None to Very Slow	Medium	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
	GRAVELS WITH FINES (More Than 12% Fines)	Non-plastic fines (for identification procedures, see ML)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures.		Slight to Medium	Slow	Slight	Slight	OL	Organic silts and organic silt-clays of low plasticity.
		Plastic fines (for identification procedures, see CL)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.	SILTS AND CLAYS Liquid Limit Greater Than 50	Slight to Medium	Slow to None	Slight to Medium	Medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
SANDS (More Than 50% of Coarse Fraction Smaller Than No. 4 Sieve Size)	CLEAN SANDS (Less Than 5% Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines.		High to Very High	None	High	High	CH	Inorganic clays of high plasticity, fat clays.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.		Medium to High	None to Very Slow	Slight to Medium	High	OH	Organic clays of medium to high plasticity.
	SANDS WITH FINES (More Than 12% Fines)	Non-plastic fines (for identification procedures, see ML)	SM	Silty sands, poorly graded sand-silt mixtures.	HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.				Pt	Peat and other organic soils
		Plastic fines (for identification procedures, see CL)	SC	Clayey sands, poorly graded sand-clay mixtures.							

Boundary classifications: Soils possessing characteristics of two groups are designated by combining group symbols. For example, GW-GC, well graded gravel-sand mixture with clay binder.
All sieve sizes on this chart are U.S. Standard.

DENSITY OF GRANULAR SOILS	
DESIGNATION	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT
Very Loose	0-4
Loose	5-10
Medium Loose	11-30
Dense	31-50
Very Dense	Over 50

CONSISTENCY OF COHESIVE SOILS			
CONSISTENCY	UNCONFINED COMPRESSIVE STRENGTH (TONS/SQ. FT.)	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very Soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb.
Medium Stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb.
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb.
Very Stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail.
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail.

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)			ROCK BROKENNESS		
Descriptive Terms	Scratcher or Knife Effects	Hammer Effects	Descriptive Terms	Abbreviation	Spacing
Soft	Easily Gouged	Crushes when pressed with hammer	Very Broken	(V.Br.)	0.0-0.1'
Medium Soft	Can be Gouged	Breaks (one blow); crumbly edges	Broken	(Br.)	0.1'-1'
Medium Hard	Can be scratched	Breaks (one blow); sharp edges	Blocky	(Bl.)	1'-3'
Hard	Cannot be scratched	Breaks considerably (several blows); sharp edges	Massive	(M.)	3'-10'

LEGEND :

SOIL SAMPLES - TYPES	ROCK SAMPLES - TYPES	WATER LEVELS
1-3" Split Barrel Sample	X-NX (Conventional) Core (2.1-1.8" O.D.)	12/10
ST (3" O.D. Undisturbed Sample	O-NQ (Wireline) Core (2.1-1.8" O.D.)	▼ 12.5' Initial Level w/Date & Depth
O - Other Samples, Specify in Remarks	Z - Other Core Sizes, Specify in Remarks	12/10
		▼ 12.5' Stabilized Level w/Date & Depth

5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Figure 1 (Continued).
This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse-grained soils shall be divided into rock fragments, sand, or gravel. The terms sand and gravel not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term rock fragments shall be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges typically observed indicate little or no transport from their source area, and therefore the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used it shall be followed by a size designation such as "(1/4 inchΦ-1/2 inchΦ)" or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

5.2.2 Color

Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors. Samplers tend to smear the sample surface creating color variations between the sample interior and exterior.

The term "mottled" shall be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

Soil Color Charts shall not be used unless specified by the project manager.

5.2.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are noncohesive (particles do not adhere well when compressed). Finer-grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split-barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.3. Those designations are:

Designation	Standard Penetration Resistance (Blows per Foot)
Very loose	0 to 4
Loose	5 to 10
Medium dense	11 to 30
Dense	31 to 50
Very dense	Over 50

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140-pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, or SC (see Figure 1).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Figure 2.

Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Figure 1).

The consistency of cohesive soils is determined either by blow counts, a pocket penetrometer (values listed in the table as Unconfined Compressive Strength), or by hand by determining the resistance to penetration by the thumb. The pocket penetrometer and thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample in the split-barrel sampler. The sample shall be broken in half and the thumb or penetrometer pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. Consistency shall not be determined solely by blow counts. One of the other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are shown in Figure 2.

5.2.4 Weight Percentages

In nature, soils are comprised of particles of varying size and shape, and are combinations of the various grain types. The following terms are useful in the description of soil:

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
Trace	0 - 10 percent
Some	11 - 30 percent
Adjective form of the soil type (e.g., "sandy")	31 - 50 percent

FIGURE 2

CONSISTENCY FOR COHESIVE SOILS

Consistency	Standard Penetration Resistance (Blows per Foot)	Unconfined Compressive Strength (Tons/Sq. Foot by pocket penetration)	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented with difficulty by thumbnail

Examples:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.
- Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.
- Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.
- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

5.2.5 Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire drilling job.

Laboratory tests for water content shall be performed if the natural water content is important.

5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Figure 3.

5.2.7 Texture/Fabric/Bedding

The texture/fabric/bedding of the soil shall be described. Texture is described as the relative angularity of the particles: rounded, subrounded, subangular, and angular. Fabric shall be noted as to whether the particles are flat or bulky and whether there is a particular relation between particles (i.e., all the flat particles are parallel or there is some cementation). The bedding or structure shall also be noted (e.g., stratified, lensed, nonstratified, heterogeneous varved).

5.2.8 Summary of Soil Classification

In summary, soils shall be classified in a similar manner by each geologist/engineer at a project site. The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (Optional)
- Soil types
- Moisture content
- Stratification
- Texture, fabric, bedding
- Other distinguishing features

FIGURE 3

BEDDING THICKNESS CLASSIFICATION

Thickness (metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3'	Massive
30 cm - 1 meter	1.0' - 3.3'	Thick Bedded
10 cm - 30 cm	4" - 1.0'	Medium Bedded
3 cm - 10 cm	1" - 4"	Thin Bedded
1 cm - 3 cm	2/5" - 1"	Very Thin Bedded
3 mm - 1 cm	1/8" - 2/5"	Laminated
1 mm - 3 mm	1/32" - 1/8"	Thinly Laminated
< 1 mm	<1/32"	Micro Laminated

(Weir, 1973 and Ingram, 1954)

5.3 Classification of Rocks

Rocks are grouped into three main divisions: sedimentary, igneous and metamorphic. Sedimentary rocks are by far the predominant type exposed at the earth's surface. The following basic names are applied to the types of rocks found in sedimentary sequences:

- Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.
- Siltstone - Made up of granular materials less than 1/16 to 1/256 mm in diameter. Fractures irregularly. Medium thick to thick bedded.
- Claystone - Very fine-grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.
- Shale - A fissile very fine-grained rock. Fractures along bedding planes.
- Limestone - Rock made up predominantly of calcite ($CaCO_3$). Effervesces strongly upon the application of dilute hydrochloric acid.
- Coal - Rock consisting mainly of organic remains.
- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. Conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

In classifying a sedimentary rock the following hierarchy shall be noted:

- Rock type
- Color
- Bedding thickness
- Hardness
- Fracturing
- Weathering
- Other characteristics

5.3.1 Rock Type

As described above, there are numerous types of sedimentary rocks. In most cases, a rock will be a combination of several grain types, therefore, a modifier such as a sandy siltstone, or a silty sandstone can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, etc.

Grain size is the basis for the classification of clastic sedimentary rocks. Figure 4 is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. For example, the division between siltstone and claystone may not be measurable in the field. The boundary shall be determined by use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a hand lens, the rock is a siltstone. If the grains are not distinguishable with a hand lens, the rock is a claystone.

FIGURE 4

GRAIN SIZE CLASSIFICATION FOR ROCKS

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4 - 64 mm
Granules	2 - 4 mm
Very Coarse Sand	1 - 2 mm
Coarse Sand	0.5 - 1 mm
Medium Sand	0.25 - 0.5 mm
Fine Sand	0.125 - 0.25 mm
Very Fine Sand	0.0625 - 0.125 mm
Silt	0.0039 - 0.0625 mm

After Wentworth, 1922

5.3.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples shall be classified while wet, when possible, and air cored samples shall be scraped clean of cuttings prior to color classifications.

Rock color charts shall not be used unless specified by the Project Manager.

5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification (see Figure 3) will also be used for rock classification.

5.3.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

- Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).

- Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.

- Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.

- Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage here of the works "scratch" and "gouge." A scratch shall be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

5.3.5 Fracturing

The degree of fracturing or brokenness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

- Very broken (V. BR.) - Less than 2-inch spacing between fractures
- Broken (BR.) - 2-inch to 1-foot spacing between fractures
- Blocky (BL.) - 1- to 3-foot spacing between fractures
- Massive (M.) - 3 to 10-foot spacing between fractures

The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage.

Method of Calculating RQD
(After Deere, 1964)

$$RQD\ \% = r/l \times 100$$

r = Total length of all pieces of the lithologic unit being measured, which are greater than 4 inches length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.

l = Total length of the coring run.

5.3.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

- Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.
- Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.
- Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.
- Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two rock units. These can be sharp or gradational.
- Stratification (parallel, cross stratified).
- Description of any filled cavities or vugs.
- Cementation (calcareous, siliceous, hematitic).
- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

- Seam - Thin (12 inches or less), probably continuous layer.
- Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."
- Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."
- Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."
- Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

The preceding sections describe the classification of sedimentary rocks. The following are some basic names that are applied to igneous rocks:

- Basalt - A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.
- Rhyolite - A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.
- Granite - A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.
- Diorite - A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.
- Gabbro - A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse-grained dark igneous rock.

The following are some basic names that are applied to metamorphic rocks:

- Slate - A very fine-grained foliated rock possessing a well developed slaty cleavage. Contains predominantly chlorite, mica, quartz, and sericite.
- Phyllite - A fine-grained foliated rock that splits into thin flaky sheets with a silky sheen on cleavage surface.
- Schist - A medium to coarse-grained foliated rock with subparallel arrangement of the micaceous minerals which dominate its composition.
- Gneiss - A coarse-grained foliated rock with bands rich in granular and platy minerals.
- Quartzite - A fine- to coarse-grained nonfoliated rock breaking across grains, consisting essentially of quartz sand with silica cement.

5.4 Abbreviations

Abbreviations may be used in the description of a rock or soil. However, they shall be kept at a minimum. Following are some of the abbreviations that may be used:

C	-	Coarse	Lt	-	Light	Yl	-	Yellow
Med	-	Medium	BR	-	Broken	Or	-	Orange
F	-	Fine	BL	-	Blocky	SS	-	Sandstone
V	-	Very	M	-	Massive	Sh	-	Shale
Sl	-	Slight	Br	-	Brown	LS	-	Limestone
Occ	-	Occasional	Bl	-	Black	Fgr	-	Fine-grained
Tr	-	Trace						

5.5 Boring Logs and Documentation

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceding sections shall be used to complete the logs. A sample boring log has been provided as Figure 5.

The field geologist/engineer shall use this example as a guide in completing each boring log. Each boring log shall be fully described by the geologist/engineer as the boring is being drilled. Every sheet contains space for 25 feet of log. Information regarding classification details is provided either on the back of the boring log or on a separate sheet, for field use.

5.5.1 Soil Classification

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.

- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology at 13.7 feet, shall be lined off at the proportional location between the 13- and 14-foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.

- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split-spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.

- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.

- The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart on back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.

FIGURE 5
COMPLETED BORING LOG (EXAMPLE)

BORING LOG

Page 1 of 1

PROJECT NAME: NSB- SITE
PROJECT NUMBER: 9594
DRILLING COMPANY: SOILTEST CO.
DRILLING RIG: CME-55
BORING NUMBER: SB/MW 1
DATE: 3/8/96
GEOLOGIST: SJ CONTI
DRILLER: R. ROCK

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
S-1 @ 0800	0.0	7/6	1.5/2.0		M DENSE	BRN TO BLK	SILTY SAND - SOME ROCK FR.: TR BRICKS (FILL)	SM	MOIST SL. ORG. ODOR FILL TO 4'±	5	0	0	0
	2.0	9/10											
	4.0			4.0									
S-2 @ 0810		5/7	2.0/2.0		M DENSE	BRN	SILTY SAND - TR FINE GRAVEL	SM	MOIST - W ODOR NAT. MATL. TOOK SAMPLE SB01-0406 FOR ANALYSIS	10	0	-	-
	6.0	9/8											
	•			7' ▽									
	8.0			8.0									
S-3 @ 0820		6/8	1.9/2.0		DENSE	TAN BRN	FINE TO COARSE SAND TR.F. GRAVEL	SW	WET HIT WATER: 7'±	0	0	0	0
	10.0	17/16											
	12.0			12.0									
S-4 @ 0830		7/6	1.6/2.0		STIFF	GRAY	SILTY CLAY	CL	MOIST → WET	0	.5	-	-
	14.0	5/8											
	15.0			15.0					AUGER REF @ 15'				
				LINE 16	M HARD	BRN	SILTSTONE	VBR	WEATHERED				
									LO ∠ JNTS @ 15.5				
9/5	①		4.0/5.0						WATER STAINS @ 16.5, 17.1, 17.5	0	0	0	0
				19'					LOSING SOME				
	20.0				HARD	GRAY	SANDSTONE - SOME SILTSTONE	BR	DRILL H2O @ 17'±				
									SET TEMP 6" CAS TO 15.5				
4.9/5.0	②		5.0/5.0						SET 2"Φ PVC SCREEN 16-25	0	0	0	0
									SAND 14-25				
	25.0			25					PELLETS 12-14				

* When rock coring, enter rock brokeness.
** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated response read.

• 1-20Z
1-80Z

Drilling Area Background (ppm): 0

Remarks: CME-55 R16, 4¼" ID HSA - 9" OD ±
2" SPLIT SPOONS - 140 LB HAMMER - 30" DROP
NX CORE IN BEDROCK RUN ① = 25 min. RUN ② = 15 min

Converted to Well: Yes ✓ No ____ Well I.D. #: MW-1

- Enter color of the material in the appropriate column.

- Describe material using the USCS. Limit this column for sample description only. The predominant material is described last. If the primary soil is silt but has fines (clay) - use clayey silt. Limit soil descriptors to the following:

  - Trace: 0 - 10 percent
  - Some: 11 - 30 percent
  - And/Or: 31 - 50 percent

- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.

- Enter USCS symbol - use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.

- The following information shall be entered under the "Remarks" column and shall include, but is not limited by, the following:

  - Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.

  - Angularity - describe angularity of coarse grained particles using the terms angular, subangular, subrounded, or rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.

  - Particle shape - flat, elongated, or flat and elongated.

  - Maximum particle size or dimension.

  - Water level observations.

  - Reaction with HCl - none, weak, or strong.

- Additional comments:

  - Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.

  - Indicate odor and Photoionization Detector (PID) or Flame Ionization Detector (FID) reading if applicable.

  - Indicate any change in lithology by drawing a line through the lithology change column and indicate the depth. This will help when cross-sections are subsequently constructed.

  - At the bottom of the page indicate type of rig, drilling method, hammer size and drop, and any other useful information (i.e., borehole size, casing set, changes in drilling method).

- Vertical lines shall be drawn (as shown in Figure 5) in columns 6 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.

- Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.2 Rock Classification

- Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent, and core recovery under the appropriate columns.

- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.

- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.

- Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.

- Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.

- Enter brokenness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.

- The following information shall be entered under the remarks column. Items shall include but are not limited to the following:

  - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.
  - Indicate calcareous zones, description of any cavities or vugs.
  - Indicate any loss or gain of drill water.
  - Indicate drop of drill tools or change in color of drill water.

- Remarks at the bottom of Boring Log shall include:

  - Type and size of core obtained.
  - Depth casing was set.
  - Type of rig used.

- As a final check the boring log shall include the following:

  - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.

  - If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying soil and rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole logging based on identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that shall be followed when logging cuttings are:

- Obtain cutting samples at approximately 5-foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future reference, and label the jar or bag (i.e. hole number, depth, date, etc.). Cuttings shall be closely examined to determine general lithology.
- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.
- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.
- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.
- Record this and any other useful information onto the boring log as provided in Figure 1.

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split-barrel and rock core sampling methods be used at selected boring locations during the field investigation to provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

5.6 Review

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

- Checking for consistency of all logs.
- Checking for conformance to the guideline.
- Checking to see that all information is entered in their respective columns and spaces.

6.0 REFERENCES

Unified Soil Classification System (USCS).

ASTM D2488, 1985.

Earth Manual, U.S. Department of the Interior, 1974.

7.0 RECORDS

Originals of the boring logs shall be retained in the project files.

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1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of monitoring wells. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be determined during the project planning phases of the investigation, and any required permits must be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

3.0 GLOSSARY

Monitoring Well - A well which is screened, cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored. Some monitoring wells may be constructed as open boreholes.

Piezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch-diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface representative of the level to which water will rise in a well cased to the screened aquifer.

Well Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a solid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of performing all phases of proper monitoring well installation and construction. The driller may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Field Geologist - The field geologist supervises and documents well installation and construction performed by the driller, and insures that well construction is adequate to provide representative groundwater data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

5.0 PROCEDURES

5.1 Equipment/Items Needed

Below is a list of items that may be needed when installing a monitoring well or piezometer:

- Health and safety equipment (hard hats, safety glasses, etc.) as required by the Site Safety Officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineer's tape, water level indicator, retractable engineers rule, electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installation tools (sledge hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 Well Design

The objectives and intended use for each monitoring well must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity).

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, groundwater flow directions and potential well locations can be determined by an experienced hydrogeologist through the review of geologic data and the site terrain. In addition, data from production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary investigative phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored interval must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the depths at which contaminants are present. Conversely, a fully penetrating well is usually not used to quantify or vertically locate a contaminant plume, since groundwater samples collected in wells that are screened over the full thickness of the water-bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of contamination in the water-bearing zone. The well diameter desired depends upon the hydraulic characteristics of the water-bearing zone, sampling requirements, drilling method and cost.

The decision concerning the monitored interval and well depth is based on the following (and possibly other) information:

- The vertical location of the contaminant source in relation to the water-bearing zone.
- The depth, thickness and uniformity of the water-bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (5 feet or less) are usually required where flow lines are not horizontal, (i.e., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs.

Standard monitoring well diameters are 2, 4, 6, or 8 inches. Drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch-diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open-hole bedrock monitoring wells are used. With smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced; however, the sampling devices that can be used are limited.

In specifying well diameter, sampling requirements must be considered (up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples), particularly if the monitored formation is known to be a low-yielding formation. The unit volume of water contained within a monitoring well is dependent on the well diameter as follows:

Casing Inside Diameter (Inch)	Standing Water Length to Obtain 1 Gallon Water (Feet)
2	6.13
4	1.53
6	0.68

If a well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells (for installation of high capacity pumps); however, in small-diameter wells in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "Schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength". Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation; risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive presentation on this topic). The two most commonly used materials are PVC and stainless steel. Properties of these two materials are compared in Attachment B. Stainless steel is a good choice where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, ease of manipulation, and widespread acceptance. The crushing strength of PVC may limit the depth of installation, but the use of Schedule 80 materials may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps required for sampling or testing. Due to this problem, the minimum well pipe size recommended for Schedule 80 wells is 4-inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe may corrode and release metal ions or chemically react with organic constituents, but this is considered a minor issue. Galvanized steel is not recommended where samples may be collected for metals analyses, as zinc and cadmium levels in groundwater samples may become elevated from leaching of the zinc coating.

Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints. Welded-joint steel casing is also acceptable. Glued PVC may release organic contaminants into the well, and therefore, should not be used if the well is to be sampled for organic constituents.

When the water-bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary, and the annular borehole space around the screened interval is artificially packed with an appropriately sized sand, selected based on formation grain size. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The site geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water-bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. For example, as a standard procedure, a Morie No. 1 or No 10 to No. 20 U.S. Standard Sieve size filter pack is typically appropriate for a 0.020-inch slot screen; however, a No. 20 to No. 40 U.S. Standard Sieve size filter pack is typically appropriate for a 0.010-inch slot screen.

5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a medium- to coarse-grained poorly graded, silica sand and should relate to the grain size of the aquifer sediments. The quantity of sand placed in the annular space is dependent upon the length of the screened interval, but should always extend at least 1 foot above the top of the screen. At least 1 to 3 feet of bentonite pellets or equivalent shall be placed above the sand pack. Cement-bentonite grout (or equivalent) is then placed to extent from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally (i.e., no artificial sand pack installed). In this case, the natural formation material is allowed to collapse around the well screen after the well is installed. This method has been used where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets, extending to the surface. The grout effectively seals the remaining borehole annulus and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom upward, to prevent bridging, and to provide a better seal. In shallow boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of one or two assemblages of material, (e.g., cement and/or bentonite). A cement-bentonite grout, which is the most common type of grout used in monitoring well completions, normally is a mixture of cement, bentonite, and water at a ratio of one 90-pound bag of Portland Type I cement, plus 3 to 5 pounds of granular or flake-type bentonite, and 6-7 gallons of water. A neat cement consists of one ninety-pound bag of Portland Type I cement and 6-7 gallons of water. A bentonite slurry (bentonite and water mixed to a thick but pumpable mixture) is sometimes used instead of grout for deep well installations where placement of bentonite pellets is difficult. Bentonite chips are also occasionally used for annular backfill in place of grout.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets/chips or sand. A short (1- to 2-foot) section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is typically placed over the top of the well. This casing generally has a hinged cap and can be locked to prevent vandalism. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

A protective casing which is level with the ground surface (flush-mounted) is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter, manhole-type protective collar is set into the wet cement around the well with the top set level with or slightly above the pavement. An appropriately-sized jd is placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

5.3 Monitoring Well Installation

Pertinent data regarding monitoring well installation shall be recorded on log sheets as depicted and discussed in SOP SA-6.3. Attachments to this referenced SOP illustrate terms and physical construction of various types of monitoring wells.

5.3.1 Monitoring Wells in Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow-stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineer's rule to ensure proper placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, the sand pack can be installed. A weighted tape measure must be used during the installation procedure to carefully monitor installation progress. The sand is slowly poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur. Centralizers may be used at the geologist's discretion, one above and one below the screen, to assure enough annular space for sand pack placement.

After the sand pack is installed to the desired depth (at least 1 foot above the top of the screen), then the bentonite pellet seal (or equivalent), can be installed in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack. Pellets should be added slowly and their fall monitored closely to ensure that bridging does not occur.

The cement-bentonite grout is then mixed and tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between aquifers. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large-diameter boring through the upper aquifer, 1 to 5 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting a large-diameter casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for

installation of the monitoring well as detailed for overburden monitoring wells. Sufficient time (determined by the field geologist), must be allowed for setting of the grout prior to drilling through the confined layer.

5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 –10 feet into bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout has cured, a smaller diameter boring is continued into bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. If a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be removed when the final well installation is completed.

5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen section is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be manually driven to depths exceeding 10 feet.

Direct push sampling/monitoring point installation methods, using a direct push rig or drilling rig, are described in SOP SA-2.5.

5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only small-diameter tubes extending to the surface. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross-contamination from sampling equipment. Four manufacturers of these samplers include Timco Manufacturing Company, Inc., of Prairie du Sac, Wisconsin, BARCAD Systems, Inc., of Concord, Massachusetts, Westbay Instruments Ltd. of Vancouver, British Columbia, Canada and the University of Waterloo at Waterloo, Ontario, Canada.. Each manufacturer offers various construction materials.

5.4 Well Development Methods

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity, turbidity, and temperature taken during development may yield information (stabilized values) regarding whether sufficient development has been performed. The selection of the well development method shall be made by the field geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

5.4.1 Overpumping and Backwashing

Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to

remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods, including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.

5.4.2 Surging with a Surge Plunger

A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is aggressively moved up and down within the well to agitate the water, causing it to move in and out of the screens. This movement of water pulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

5.4.3 Compressed Air

Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus introducing air into the formation and reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping of the well is subsequently done using the air lift method.

5.4.4 High Velocity Jetting

In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

6.0 RECORDS

A critical part of monitoring well installation is recording of all significant details and events in the site logbook or field notebook. The geologist must record the exact depths of significant hydrogeological features, screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (see Attachments to SOP SA-6.3) shall be completed, ensuring the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information shall include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. Documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded, depending on whether the well is completed in overburden (single- or double-cased), as a cased well in bedrock, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The geologist shall calculate the annular space volume and have an idea of the quantity of material needed to fill the annular

space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in or bridging of the backfill materials. Any problems with rig operation or down-time shall be recorded and may affect the driller's final fee.

7.0 REFERENCES

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Barcelona, M. J., P. P. Gibb and R. A. Miller, 1983. A Guide to the selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

Driscoll, Fletcher G., 1986. Groundwater and Wells. Johnson Division, St. Paul, Minnesota, 1989.

ATTACHMENT A

RELATIVE COMPATIBILITY OF RIGID WELL CASING MATERIAL (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material						
	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless Steel 304	Stainless Steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Mineral Acid/ High Solids Content	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials:

1 Teflon®
2 Stainless Steel 316
3. Stainless Steel 304
4 PVC 1
5 Lo-Carbon Steel
6 Galvanized Steel
7 Carbon Steel

* Trademark of DuPont

RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material								
	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton®*	Silicone	Neoprene	Teflon®*
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/ High Solids Content	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials:

1 Teflon®
2 Polypropylene (PP)
3. PVC Flexible/PE Linear
4 Viton®
5 PE Conventional
6 Plexiglas/Lucite (PMM)
7 Silicone/Neoprene

* Trademark of DuPont

Source: Barcelona et al., 1983

ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength are not critical.
Weight	Relatively heavier.	Light-weight; floats in water.
Cost	Relatively expensive.	Relatively inexpensive.
Corrosivity	Deteriorates more rapidly in corrosive water.	Non-corrosive -- may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated hydrocarbons.
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work with in the field.
Preparation for Use	Should be steam cleaned if organics will be subsequently sampled.	Never use glue fittings -- pipes should be threaded or pressure fitted. Should be steam cleaned when used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized.	May sorb or release organic substances.

* See also Attachment A.

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1.0 PURPOSE

Utilities such as electric service lines, natural or propane gas lines, water and sewage lines, telecommunications, and steam lines are very often in the immediate vicinity of work locations. Contact with underground or overhead utilities can have serious consequences including employee injury/fatality, property and equipment damage, substantial financial impacts, and loss of utility service to users.

The purpose of this procedure is to provide minimum requirements and technical guidelines regarding the appropriate procedures to be followed when performing subsurface and overhead utility locating services. It is the policy of Tetra Tech NUS, Inc. (TtNUS) to provide a safe and healthful work environment for the protection of our employees. The purpose of this Standard Operating Procedure (SOP) is to aid in achieving the objectives of this policy, to present the acceptable procedures pertaining to utility locating and excavation clearance activities, and to present requirements and restrictions relevant to these types of activities. This SOP must be reviewed by any employee potentially involved with underground or overhead utility locating and avoidance activities.

2.0 SCOPE

This procedure applies to all TtNUS field activities where there may be potential contact with underground or overhead utilities. This procedure provides a description of the principles of operation, instrumentation, applicability, and implementability of typical methods used to determine the presence and avoidance of contact with utility services. This procedure is intended to assist with work planning and scheduling, resource planning, field implementation, and subcontractor procurement. Utility locating and excavation clearance requires site-specific information prior to the initiation of any such activities on a specific project. This SOP is not intended to provide a detailed description of methodology and instrument operation. Specialized expertise during both planning and execution of several of the methods presented may also be required.

3.0 GLOSSARY

Electromagnetic Induction (EMI) Survey - A geophysical exploration method whereby electromagnetic fields are induced in the ground and the resultant secondary electromagnetic fields are detected as a measure of ground conductivity.

Magnetometer – A device used for precise and sensitive measurements of magnetic fields.

Magnetic Survey – A geophysical survey method that depends on detection of magnetic anomalies caused by the presence of buried ferromagnetic objects.

Metal Detection – A geophysical survey method that is based on electromagnetic coupling caused by underground conductive objects.

Vertical Gradiometer – A magnetometer equipped with two sensors that are vertically separated by a fixed distance. It is best suited to map near surface features and is less susceptible to deep geologic features.

Ground Penetrating Radar – Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture.

4.0 RESPONSIBILITIES

Project Manager (PM)/Task Order Manager (TOM) - Responsible for ensuring that all field activities are conducted in accordance with this procedure.

Site Manager (SM)/Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved SOPs or as otherwise directed by the approved project plan(s).

Site Health & Safety Officer (SHSO) – Responsible to provide technical assistance and verify full compliance with this SOP. The SHSO is also responsible for reporting any deficiencies to the Corporate Health and Safety Manager (HSM) and to the PM/TOM.

Health & Safety Manager (HSM) – Responsible for preparing, implementing, and modifying corporate health and safety policy and this SOP.

Site Personnel – Responsible for performing their work activities in accordance with this SOP and the TtNUS Health and Safety Policy.

5.0 PROCEDURES

This procedure addresses the requirements and technical procedures that must be performed to minimize the potential for contact with underground and overhead utility services. These procedures are addressed individually from a buried and overhead standpoint.

5.1 Buried Utilities

Buried utilities present a heightened concern because their location is not typically obvious by visual observation, and it is common that their presence and/or location is unknown or incorrectly known on client properties. This procedure must be followed prior to beginning any subsurface probing or excavation that might potentially be in the vicinity of underground utility services. In addition, the Utility Clearance Form (Attachment 3) must be completed for every location or cluster of locations where intrusive activities will occur.

Where the positive identification and de-energizing of underground utilities cannot be obtained and confirmed using the following steps, the PM/TOM is responsible for arranging for the procurement of a qualified, experienced, utility locating subcontractor who will accomplish the utility location and demarcation duties specified herein.

1. A comprehensive review must be made of any available property maps, blue lines, or as-builts prior to site activities. Interviews with local personnel familiar with the area should be performed to provide additional information concerning the location of potential underground utilities. Information regarding utility locations shall be added to project maps upon completion of this exercise.

2. A visual site inspection must be performed to compare the site plan information to actual field conditions. Any findings must be documented and the site plan/maps revised. The area(s) of proposed excavation or other subsurface activities must be marked at the site in white paint or pin flags to identify those locations of the proposed intrusive activities. The site inspection should focus on locating surface indications of potential underground utilities. Items of interest include the presence of nearby area lights, telephone service, drainage grates, fire hydrants, electrical service vaults/panels, asphalt/concrete scares and patches, and topographical depressions. Note the location of any emergency shut off switches. Any additional information regarding utility

locations shall be added to project maps upon completion of this exercise and returned to the PM/TOM.

3. If the planned work is to be conducted on private property (e.g., military installations, manufacturing facilities, etc.) the FOL must identify and contact appropriate facility personnel (e.g., public works or facility engineering) before any intrusive work begins to inquire about (and comply with) property owner requirements. It is important to note that private property owners may require several days to several weeks advance notice prior to locating utilities.

4. If the work location is on public property, the state agency that performs utility clearances must be notified (see Attachment 1). State "one-call" services must be notified prior to commencing fieldwork per their requirements. Most one-call services require, by law, 48- to 72-hour advance notice prior to beginning any excavation. Such services typically assign a "ticket" number to the particular site. This ticket number must be recorded for future reference and is valid for a specific period of time, but may be extended by contacting the service again. The utility service will notify utility representatives who then mark their respective lines within the specified time frame. It should be noted that most military installations own their own utilities but may lease service and maintenance from area providers. Given this situation, "one call" systems may still be required to provide location services on military installations.

5. Utilities must be identified and their locations plainly marked using pin flags, spray paint, or other accepted means. The location of all utilities must be noted on a field sketch for future inclusion on project maps. Utility locations are to be identified using the following industry-standard color code scheme, unless the property owner or utility locator service uses a different color code:

white	excavation/subsurface investigation location
red	electrical
yellow	gas, oil, steam
orange	telephone, communications
blue	water, irrigation, slurry
green	sewer, drain

6. Where utility locations are not confirmed with a high degree of confidence through drawings, schematics, location services, etc., the work area must be thoroughly investigated prior to beginning the excavation. In these situations, utilities must be identified using safe and effective methods such as passive and intrusive surveys, or the use of non-conductive hand tools. Also, in situations where such hand tools are used, they should always be used in conjunction with suitable detection equipment, such as the items described in Section 6.0 of this SOP. Each method has advantages and disadvantages including complexity, applicability, and price. It also should be noted that in some states, initial excavation is required by hand to a specified depth.

7. At each location where trenching or excavating will occur using a backhoe or other heavy equipment, and where utility identifications and locations cannot be confirmed prior to groundbreaking, the soil must be probed using a device such as a tile probe which is made of non-conductive material such as fiberglass. If these efforts are not successful in clearing the excavation area of suspect utilities, hand shoveling must be performed for the perimeter of the intended excavation.

8. All utilities uncovered or undermined during excavation must be structurally supported to prevent potential damage. Unless necessary as an emergency corrective measure, TtNUS shall not make any repairs or modifications to existing utility lines without prior permission of the utility owner, property owner, and Corporate HSM. All repairs require that the line be locked-out/tagged-out prior to work.

5.2 Overhead Power Lines

If it is necessary to work within the minimum clearance distance of an overhead power line, the overhead line must be de-energized and grounded, or re-routed by the utility company or a registered electrician. If protective measures such as guarding, isolating, or insulating are provided, these precautions must be adequate to prevent employees from contacting such lines directly with any part of their body or indirectly though conductive materials, tools, or equipment.

The following table provides the required minimum clearances for working in proximity to overhead power lines.

Nominal Voltage	Minimum Clearance
0 -50 kV	10 feet, or one mast length; whichever is greater
50+ kV	10 feet plus 4 inches for every 10 kV over 50 kV or 1.5 mast lengths; whichever is greater

6.0 UNDERGROUND LOCATING TECHNIQUES

A variety of supplemental utility locating approaches are available and can be applied when additional assurance is needed. The selection of the appropriate method(s) to employ is site-specific and should be tailored to the anticipated conditions, site and project constraints, and personnel capabilities.

6.1 Geophysical Methods

Geophysical methods include electromagnetic induction, magnetics, and ground penetrating radar. Additional details concerning the design and implementation of electromagnetic induction, magnetics, and ground penetrating radar surveys can be found in one or more of the TtNUS SOPs included in the References (Section 8.0).

Electromagnetic Induction

Electromagnetic Induction (EMI) line locators operate either by locating a background signal or by locating a signal introduced into the utility line using a transmitter. A utility line acts like a radio antenna, producing electrons, which can be picked up with a radiofrequency receiver. Electrical current carrying conductors have a 60HZ signal associated with them. This signal occurs in all power lines regardless of voltage. Utilities in close proximity to power lines or used as grounds may also have a 60HZ signal, which can be picked up with an EM receiver. A typical example of this type of geophysical equipment is an EM-61.

EMI locators specifically designed for utility locating use a special signal that is either indirectly induced onto a utility line by placing the transmitter above the line or directly induced using an induction clamp. The clamp induces a signal on the specific utility and is the preferred method of tracing since there is little chance of the resulting signals being interfered with. A good example of this type of equipment is the Schonstedt® MAC-51B locator. The MAC-51B performs inductively traced surveys, simple magnetic locating, and traced nonmetallic surveys.

When access can be gained inside a conduit to be traced, a flexible insulated trace wire can be used. This is very useful for non-metallic conduits but is limited by the availability of gaining access inside the pipe.

Magnetics

Magnetic locators operate by detecting the relative amounts of buried ferrous metal. They are incapable of locating or identifying nonferrous utility lines but can be very useful for locating underground storage tanks (UST's), steel utility lines, and buried electrical lines. A typical example of this type of equipment is the Schonstedt® GA-52Cx locator. The GA-52Cx is capable of locating 4-inch steel pipe up to 8 feet deep.

Non-ferrous lines are often located by using a typical plumbing tool (snake) fed through the line. A signal is then introduced to the snake that is then traced.

Ground Penetrating Radar

Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture. In general, an object which is harder than the surrounding soil will reflect a stronger signal. Utilities, tunnels, UST's, and footings will reflect a stronger signal than the surrounding soil. Although this surface detection method may determine the location of a utility, this method does not specifically identify utilities (i.e., water vs. gas, electrical vs. telephone); hence, verification may be necessary using other methods. This method is somewhat limited when used in areas with clay soil types or with a high water table.

6.2 Passive Detection Surveys

Acoustic Surveys

Acoustic location methods are generally most applicable to waterlines or gas lines. A highly sensitive Acoustic Receiver listens for background sounds of water flowing (at joints, leaks, etc.) or to sounds introduced into the water main using a transducer. Acoustics may also be applicable to determine the location of plastic gas lines.

Thermal Imaging

Thermal (i.e., infrared) imaging is a passive method for detecting the heat emitted by an object. Electronics in the infrared camera convert subtle heat differentials into a visual image on the viewfinder or a monitor. The operator does not look for an exact temperature; rather they look for heat anomalies (either elevated or suppressed temperatures) characteristic of a potential utility line.

The thermal fingerprint of underground utilities results from differences in temperature between the atmosphere and the fluid present in a pipe or the heat generated by electrical resistance. In addition, infrared scanners may be capable of detecting differences in the compaction, temperature and moisture content of underground utility trenches. High-performance thermal imagery can detect temperature differences to hundredths of a degree.

6.3 Intrusive Detection Surveys

Vacuum Excavation

Vacuum excavation is used to physically expose utility services. The process involves removing the surface material over approximately a 1' x 1' area at the site location. The air-vacuum process proceeds with the simultaneous action of compressed air-jets to loosen soil and vacuum extraction of the resulting

debris. This process ensures the integrity of the utility line during the excavation process, as no hammers, blades, or heavy mechanical equipment comes into contact with the utility line, eliminating the risk of damage to utilities. The process continues until the utility is uncovered. Vacuum excavation can be used at the proposed site location to excavate below the "utility window" which is usually 8 feet.

Hand Excavation

When the identification and location of underground utilities cannot be positively confirmed through document reviews and/or other methods, borings and excavations may be cleared via the use of non-conductive hand tools. This should always be done in conjunction with the use of detection equipment. This would be required for all locations where there is a potential to impact buried utilities. The minimum hand-excavation depth that must be reached is to be determined considering the geographical location of the work site. This approach recognizes that the placement of buried utilities is influenced by frost line depths that vary by geographical region. Attachment 2 presents frost line depths for the regions of the contiguous United States. At a minimum, hand excavation depths must be at least to the frost line depth (see Attachment 2) plus two (2) feet, but never less than 4 feet below ground surface (bgs). For hand excavation, the hole created must be reamed large enough to be at least the diameter of the drill rig auger or bit prior to drilling. For soil gas surveys, the survey probe shall be placed as close as possible to the cleared hand excavation. It is important to note that a post-hole digger must not be used in this type of hand excavation activity.

Tile Probe Surveys

For some soil types, site conditions, and excavation requirements, non-conductive tile probes may be used. A tile probe is a "T"-handled rod of varying lengths that can be pushed into the soil to determine if any obstructions exist at that location. Tile probes constructed of fiberglass or other nonconductive material are readily-available from numerous vendors. Tile probes must be performed to the same depth requirements as previously specified. As with other types of hand excavating activities, the use of a non-conductive tile probe, should always be in conjunction with suitable utility locating detection equipment.

7.0 INTRUSIVE ACTIVITIES SUMMARY

The following list summarizes the activities that must be performed prior to beginning subsurface activities:

1. Map and mark all subsurface locations and excavation boundaries using white paint or markers specified by the client or property owner.

2. Notify the property owner and/or client that the locations are marked. At this point, drawings of locations or excavation boundaries shall be provided to the property owner and/or client so they may initiate (if applicable) utility clearance.

   Note: Drawings with confirmed locations should be provided to the property owner and/or client as soon as possible to reduce potential time delays.

3. Notify "One Call" service. If possible, arrange for an appointment to show the One Call representative the surface locations or excavation boundaries in person. This will provide a better location designation to the utilities they represent. You should have additional drawings should you need to provide plot plans to the One Call service.

4. Implement supplemental utility detection techniques as necessary and appropriate to conform utility locations or the absence thereof.

5. Complete Attachment 3, Utility Clearance Form. This form should be completed for each excavation location. In situations where multiple subsurface locations exist within the close proximity of one another, one form may be used for multiple locations provided those locations are noted on the Utility Clearance Form. Upon completion, the Utility Clearance Form and revised/annotated utility location map becomes part of the project file.

8.0 REFERENCES

OSHA Letter of Interpretation, Mr. Joseph Caldwell, Attachment 4
OSHA 29 CFR 1926(b)(2)
OSHA 29 CFR 1926(b)(3)
TtNUS Utility Locating and Clearance Policy
TtNUS SOP GH-3.1; Resistivity and Electromagnetic Induction
TtNUS SOP GH-3.2; Magnetic and Metal Detection Surveys
TtNUS SOP GH-3.4; Ground-penetrating Radar Surveys

ATTACHMENT 1
LISTING OF UNDERGROUND UTILITY CLEARANCE RESOURCES

American Public Works Association
2345 Grand Boulevard, Suite 500, Kansas City, MO 64108-2625
Phone (816) 472-6100 • Fax (816) 472-1610
Web www.apwa.net • E-mail apwa@apwa.net

ONE-CALL SYSTEMS INTERNATIONAL CONDENSED DIRECTORY

Alabama
Alabama One-Call
1-800-292-8525

Alaska
Locate Call Center of Alaska, Inc
1-800-478-3121

Arizona
Arizona Blue Stake
1-800-782-5348

Arkansas
Arkansas One Call System, Inc
1-800-482-8998

California
Underground Service Alert North
1-800-227-2600
Underground Service Alert of Southern California
1-800-227-2600

Colorado
Utility Notification Center of Colorado
1-800-922-1987

Connecticut
Call Before You Dig
1-800-922-4455

Delaware
Miss Utility of Delmarva
1-800-282-8555

Florida
Sunshine State One-Call of Florida, Inc.
1-800-432-4770

Georgia
Underground Protection Center, Inc.
1-800-282-7411

Hawaii
Underground Service Alert North
1-800-227-2600

Idaho
Dig Line Inc.
1-800-342-1585
Kootenai County One-Call
1-800-428-4950
Shoshone - Benewah One-Call
1-800-398-3285

Illinois
JULIE, Inc.
1-800-892-0123
Digger (Chicago Utility Alert Network)
312-744-7000

Indiana
Indiana Underground Plant Protection Service
1-800-382-5544

Iowa
Iowa One-Call
1-800-292-8989

Kansas
Kansas One-Call System, Inc.
1-800-344-7233

Kentucky
Kentucky Underground Protection Inc.
1-800-752-6007

Louisiana
Louisiana One Call System, Inc.
1-800-272-3020

Maine
Dig Safe System, Inc.
1-888-344-7233

Maryland
Miss Utility
1-800-257-7777
Miss Utility of Delmarva
1-800-282-8555

Massachusetts
Dig Safe System, Inc.
1-888-344-7233

Michigan
Miss Dig System, Inc.
1-800-482-7171

Minnesota
Gopher State One Call
1-800-252-1166

Mississippi
Mississippi One-Call System, Inc
1-800-227-6477

Missouri
Missouri One-Call System, Inc.
1-800-344-7483

Montana
Utilities Underground Protection Center
1-800-424-5555
Montana One Call Center
1-800-551-8344

Nebraska
Diggers Hotline of Nebraska
1-800-331-5666

Nevada
Underground Service Alert North
1-800-227-2600

New Hampshire
Dig Safe System, Inc.
1-888-344-7233

New Jersey
New Jersey One Call
1-800-272-1000

New Mexico
New Mexico One Call System, Inc.
1-800-321-2537
Las Cruces- Dona Ana Blue Stakes
1-888-526-0400

New York
Dig Safely New York
1-800-962-7962
New York City- Long Island One Call Center
1-800-272-4480

North Carolina
The North Carolina One-Call Center, Inc.
1-800-632-4949

North Dakota
North Dakota One-Call
1-800-795-0555

Ohio
Ohio Utilities Protection Service
1-800-362-2764
Oil & Gas Producers Underground Protect'n Svc
1-800-925-0988

Oklahoma
Call Okie
1-800-522-6543

Oregon
Oregon Utility Notification Center/One Call Concepts
1-800-332-2344

Pennsylvania
Pennsylvania One Call System, Inc.
1-800-242-1776

Rhode Island
Dig Safe System, Inc.
1-888-344-7233

South Carolina
Palmetto Utility Protection Service Inc.
1-888-721-7877

South Dakota
South Dakota One Call
1-800-781-7474

Tennessee
Tennessee One-Call System, Inc
1-800-351-1111

ATTACHMENT 1 (Continued)

Texas
Texas One Call System
1-800-245-4545
Texas Excavation Safety System, Inc.
1-800-344-8377
Lone Star Notification Center
1-800-669-8344

Utah
Blue Stakes of Utah
1-800-662-4111

Vermont
Dig Safe System, Inc.
1-888-344-7233

Virginia
Miss Utility of Virginia
1-800-552-7001
Miss Utility (Northern Virginia)
1-800-257-7777

Washington
Utilities Underground Location Center
1-800-424-5555
Northwest Utility Notification Center
1-800-553-4344
Inland Empire Utility Coordinating Council
509-456-8000

West Virginia
Miss Utility of West Virginia, Inc.
1-800-245-4848

Wisconsin
Diggers Hotline, Inc.
1-800-242-8511

Wyoming
Wyoming One-Call System, Inc.
1-800-348-1030
Call Before You Dig of Wyoming
1-800-849-2476

District of Columbia
Miss Utility
1-800-257-7777

Alberta
Alberta One-Call Corporation
1-800-242-3447

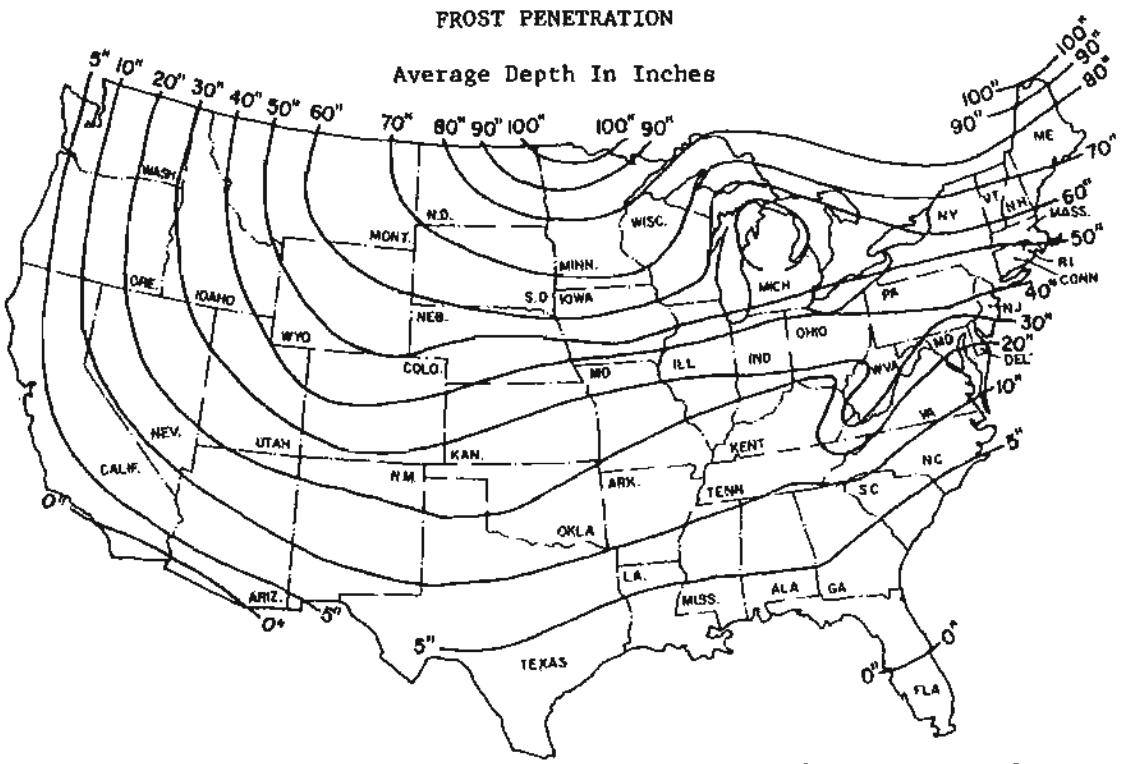
British Columbia
BC One Call
1-800-474-6886

Ontario
Ontario One-Call System
1-800-400-2255

Quebec
Info-Excavation
1-800-663-9228

ATTACHMENT 2

FROST LINE PENETRATION DEPTHS BY GEOGRAPHIC LOCATION



Courtesy U.S. Department Of Commerce

ATTACHMENT 3
UTILITY CLEARANCE FORM

Client: _____ Project Name: _____

Project No.: _____ Completed By: _____

Location Name: _____ Work Date: _____

Excavation Method/Overhead Equipment: _____

1. Underground Utilities — Circle One

a)	Review of existing maps?	yes no N/A
b)	Interview local personnel?	yes no N/A
c)	Site visit and inspection?	yes no N/A
d)	Excavation areas marked in the field?	yes no N/A
e)	Utilities located in the field?	yes no N/A
f)	Located utilities marked/added to site maps?	yes no N/A
g)	Client contact notified Name _____ Telephone: _____ Date: _____	yes no N/A
g)	State One-Call agency called? Caller: _____ Ticket Number: _____ Date: _____	yes no N/A
h)	Geophysical survey performed? Survey performed by: _____ Method: _____ Date: _____	yes no N/A
i)	Hand excavation performed (with concurrent use of utility detection device)? Completed by: _____ Total depth: _____ feet Date: _____	yes no N/A
j)	Trench/excavation probed? Probing completed by: _____ Depth/frequency: _____ Date: _____	yes no N/A

2. Overhead Utilities — Present Absent

a)	Determination of nominal voltage	yes no N/A
b)	Marked on site maps	yes no N/A
c)	Necessary to lockout/insulate/re-route	yes no N/A
d)	Document procedures used to lockout/insulate/re-route	yes no N/A
e)	Minimum acceptable clearance (SOP Section 5.2): _____	

3. Notes:

_____

_____

_____

Approval:

_____ _____

Site Manager/Field Operations Leader Date

c: PM/Project File
Program File

ATTACHMENT 4
OSHA LETTER OF INTERPRETATION

Mr. Joseph Caldwell
Consultant
Governmental Liaison
Pipeline Safety Regulations
211 Wilson Boulevard
Suite 700
Arlington, Virginia 22201

Re: Use of hydro-vacuum or non-conductive hand tools to locate underground utilities.

Dear Mr. Caldwell:

In a letter dated July 7, 2003, we responded to your inquiry of September 18, 2002, regarding the use of hydro-vacuum equipment to locate underground utilities by excavation. After our letter to you was posted on the OSHA website, we received numerous inquiries that make it apparent that aspects of our July 7 letter are being misunderstood. In addition, a number of industry stakeholders, including the National Utility Contractors Association (NUCA), have provided new information regarding equipment that is available for this work.

To clarify these issues, we are withdrawing our July 7 letter and issuing this replacement response to your inquiry.

Question: *Section 1926.651 contains several requirements that relate to the safety of employees engaged in excavation work. Specifically, paragraphs (b)(2) and (b)(3) relate in part to the safety of the means used to locate underground utility installations that, if damaged during an uncovering operation, could pose serious hazards to employees.*

Under these provisions, what constitutes an acceptable method of uncovering underground utility lines, and further, would the use of hydro-vacuum excavation be acceptable under the standard?

Answer

Background

Two sections of 29 CFR 1926 Subpart P (Excavations), 1926.651(Specific excavation requirements), govern methods for uncovering underground utility installations. Specifically, paragraph (b)(2) states:

> When utility companies or owners cannot respond to a request to locate underground utility installations within 24 hours * * * or cannot establish the exact location of these installations, the employer may proceed, provided the employer does so with caution, and provided detection equipment or other acceptable means to locate utility installations are used. (emphasis added).

Paragraph (b)(3) provides:

ATTACHMENT 4 (Continued)

> When excavation operations approach the estimated location of underground installations, the exact location of the installations shall be determined by safe and acceptable means. (emphasis added).

Therefore, "acceptable means" must be used where the location of the underground utilities have not been identified by the utility companies and detection equipment is not used.

Subpart P does not contain a definition of either "other acceptable means" or "safe and acceptable means." The preambles to both the proposed rule and the final rule discussed the rationale behind the wording at issue. For example, the preamble to the proposed rule, 52 Fed. Reg. 12301 (April 15, 1987), noted that a 1972 version of this standard contained language that specified "careful probing or hand digging" as the means to uncover utilities. The preamble then noted that an amendment to the 1972 standard later deleted that language "to allow other, *equally effective means* of locating such installations." The preamble continued that in the 1987 proposed rule, OSHA again proposed using language in section (b)(3) that would provide another example of an acceptable method of uncovering utilities that could be used *where the utilities have not been marked and detection equipment is not being used* – "probing with hand-held tools." This method was rejected in the final version of 29 CFR 1926. As OSHA explained in the preamble to the final rule, 54 Fed. Reg. 45916 (October 31, 1989):

> OSHA received two comments * * * and input from ACCSH [OSHA's Advisory Committee on Construction Safety and Health] * * * on this provision. All commenters recommended dropping 'such as probing with hand-held tools' from the proposed provision, because this could create a hazard to employees by damaging the installation or its insulation.

In other words, the commenters objected to the use of hand tools being used unless detection equipment was used in conjunction with them. OSHA then concluded its discussion relative to this provision by agreeing with the commentators and ultimately not including any examples of "acceptable means" in the final provision.

Non-conductive hand tools are permitted

This raises the question of whether the standard permits the use of hand tools alone -- without also using detection equipment. NUCA and other industry stakeholders have recently informed us that non-conductive hand tools that are appropriate to be used to locate underground utilities are now commonly available.

Such tools, such as a "shooter" (which has a non-conductive handle and a snub nose) and non-conductive or insulated probes were not discussed in the rulemaking. Since they were not considered at that time, they were not part of the class of equipment that was thought to be unsafe for this purpose. Therefore, we conclude that the use of these types of hand tools, when used with appropriate caution, is an "acceptable means" for locating underground utilities.

ATTACHMENT 4 (Continued)

Hydro-vacuum excavation

It is our understanding that some hydro-vacuum excavation equipment can be adjusted to use a minimum amount of water and suction pressure. When appropriately adjusted so that the equipment will not damage underground utilities (especially utilities that are particularly vulnerable to damage, such as electrical lines), use of such equipment would be considered a "acceptable means" of locating underground utilities. However, if the equipment cannot be sufficiently adjusted, then this method would not be acceptable under the standard.

Other technologies

We are not suggesting that these are the only devices that would be "acceptable means" under the standard. Industry stakeholders have informed us that there are other types of special excavation equipment designed for safely locating utilities as well.

We apologize for any confusion our July 7 letter may have caused. If you have further concerns or questions, please feel free to contact us again by fax at: U.S. Department of Labor, OSHA, Directorate of Construction, Office of Construction Standards and Compliance Assistance, fax # 202-693-1689. You can also contact us by mail at the above office, Room N3468, 200 Constitution Avenue, N.W., Washington, D.C. 20210, although there will be a delay in our receiving correspondence by mail.

Sincerely,

Russell B. Swanson, Director
Directorate of Construction

NOTE: OSHA requirements are set by statute, standards and regulations. Our interpretation letters explain these requirements and how they apply to particular circumstances, but they cannot create additional employer obligations. This letter constitutes OSHA=s interpretation of the requirements discussed. Note that our enforcement guidance may be affected by changes to OSHA rules. Also, from time to time we update our guidance in response to new information. To keep apprised of such developments, you can consult OSHA's website at http://www.osha.gov.

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the process to be used for purging groundwater monitoring wells prior to sampling, for collecting groundwater samples, and for measuring groundwater quality parameters.

2.0 SCOPE

This document provides information on proper sampling equipment, onsite water quality testing, safety measures to ensure the safety of the field technician(s), and techniques for groundwater sampling. All personnel are encouraged to review the information contained herein to facilitate planning of the field sampling effort. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology.

3.0 GLOSSARY

Conductivity – Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions and their total concentration, mobility, valence, and relative concentrations and on temperature. Conductivity is highly dependent on temperature and should be reported at a particular temperature, i.e., 20.2 microSiemens per centimeter (mS/cm) at 14°C.

Dissolved Oxygen (DO) – DO levels in natural and wastewater depend on the physical, chemical, and biochemical activities in the water sample.

Groundwater Sample – A quantity of water removed from the ground, usually via a monitoring well that may or may not be lined with a well casing.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode immersed in water, as referenced against a reference electrode. A reference electrode commonly used in the field is the silver/silver chloride electrode, which has a voltage offset of about 210 mV from the standard hydrogen electrode (SHE). To convert field ORP measurements to equivalent SHE values, approximately 210 mV must be added to the ORP values obtained using the silver/silver chloride electrode. The actual offset depends on the concentration of the potassium chloride (KCl) in the field reference electrode and the temperature. Offsets typically range from 199 (saturated KCl) to 205 (3.5 Molar KCl) to 222 mV (1 Molar KCl) at 25°C and are greater at lower temperatures.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

pH Paper - Indicator paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution's pH.

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

Salinity – The measurement of dissolved salts in a given mass of solution. Note: most field meters determined salinity automatically from conductivity and temperature. The value will be displayed in either parts per thousand (ppt) or percent (e.g., 35 ppt equals 3.5 percent). The parts per thousand symbol ($^0/_{00}$) is not the same as the percent symbol (%).

Turbidity – Turbidity in water is caused by suspended matter such as clay, silt, and fine organic and inorganic matter. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - The Project Manager is responsible for determining the sampling objectives, initial sampling locations, and field procedures used in the collection of groundwater samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager identifies sampling locations.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan (HASP). This includes but is not be limited to performing air quality monitoring during sampling, boring and excavation activities, and ensuring that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO or SSO designee may also be required to advise the FOL on other safety-related matters regarding sampling, such as mitigative measures to address potential hazards from hazardous objects or conditions.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP or other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, boring logs, container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

Project Hydrogeologist – This individual is responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), equipment to be used, and providing detailed input in this regard to the project planning documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of site sampling personnel.

Field Operations Leader (FOL) – This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is ultimately responsible for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.
General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.

- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

5.0 HEALTH AND SAFETY

Specific safety and health precautions are identified throughout this SOP. In addition to those precautions, the following general hazards may be incurred during sampling activities:

- Knee injuries from kneeling on hard surfaces
- Slips, trips, and falls
- Cuts and lacerations
- Traffic hazards associated with sampling in parking areas and roadways and along highways.

Methods of avoiding these hazards are provided below.

Knee injuries – Many monitoring wells are installed as flush mounts. Personnel are required to kneel to open these wells and to take groundwater level measurements, etc. This could result in knee injuries from kneeling on stones/foreign objects and general damage due to stress on the joints. To combat this hazard:

- Clear any foreign objects from the work area.
- Wear hard-sided knee pads.

Slips, Trips, and Falls – These hazards exist while traversing varying terrains carrying equipment to sample wells. To minimize these hazards:

- Pre-survey well locations. Eliminate, barricade, or otherwise mark physical hazards leading to the locations.
- Carry small loads that do not restrict the field of vision.
- Travel the safest and clearest route (not necessarily the shortest).

Cuts and Lacerations – To prevent cuts and lacerations associated with groundwater sampling, the following provisions are required:

- Always cut away from yourself and others when cutting tubing or rope. This will prevent injury to yourself and others if the knife slips.
- Do not place items to be cut in your hand or on your knee.
- Change blades as necessary to maintain a sharp cutting edge. Many accidents result from struggling with dull cutting attachments.
- Whenever practical, wear cut-resistant gloves (e.g., leather or heavy cotton work gloves) at least on the hand not using the knife.
- Keep cutting surfaces clean and smooth.
- Secure items to be cut -- do not hold them against the opposing hand, a leg, or other body part.

- When transporting glassware, keep it in a hard-sided container such as a cooler so that if there is a fall, you will be less likely to get cut by broken glass.

- DO NOT throw broken glass or glass ampoules into garbage bags. Place broken glass and glass ampoules in hard-sided containers such as a cardboard box or directly into a dumpster. DO NOT reach into garbage bags to retrieve any item accidentally thrown away. Empty the contents onto a flat surface to avoid punctures and lacerations from reaching where you cannot see.

Vehicular and Foot Traffic Hazards – When sampling along the roadway or near traffic patterns, follow the following precautions:

- Motorists may be distracted by onsite activities – ASSUME THEY DO NOT SEE YOU OR MEMBERS OF YOUR FIELD CREW.

- DO NOT place obstructions (such as vehicles) along the sides of the road that may cause site personnel to move into the flow of traffic to avoid your activities or equipment or that will create a blind spot.

- **Provide a required free space of travel**. Maintain at least 6 feet of space between you and moving traffic. Where this is not possible, use flaggers and/or signs to warn oncoming traffic of activities near or within the travel lanes.

- Face Traffic. Whenever feasible, if you must move within the 6 feet of the required free space or into traffic, attempt to face moving traffic at all times. Always leave yourself an escape route.

- Wear high-visibility vests to increase visual recognition by motorists.

- Do not rely on the vehicle operator's visibility, judgment, or ability. Make eye contact with the driver. Carefully and deliberately use hand signals so they will not startle or confuse motorists or be mistaken for a flagger's direction before moving into traffic.

- Your movements may startle a motorist and cause an accident, so move deliberately. Do not make sudden movements that might confuse a motorist.

6.0 PROCEDURES

6.1 General

For information derived from a groundwater sample to be useful and accurate, the sample must be representative of the particular zone being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of analysis to keep any changes in water quality parameters to a minimum.

CAUTION

A closed well may generate and accumulate gases due to biological degradation, evolution of volatile chemicals from groundwater into the air, or other chemical actions. These gases may also be artificially generated, such as in the case of air sparging or extraction wells, which may take several days to depressurize. See Section 6.6.2 for safety measures to be employed to protect sampling personnel.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air or nitrogen, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water sample due to external influences of the sampling technique(s). In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. Concentration gradients resulting from mixing and dispersion processes, layers of variable geologic permeability, and the presence of separate-phase product (e.g., floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase contaminant concentrations in the collected sample compared to what is representative of the integrated water column as it naturally occurs at that point, resulting in the collection of a non-representative sample. To safeguard against collecting non-representative samples, the following approach shall be followed prior to sample acquisition:

> ***CAUTION***
> Mechanical agitation of well water may cause off-gas generation of volatile contaminants, creating an inhalation exposure to the sampler(s). Where avoiding an inhalation exposure is not possible and mechanical agitation is possible, pump into closed-top containers to control potential air emissions.

1. If possible, position yourself (and the sampling equipment) upwind of the well head.

2. Purge the monitoring well to be sampled prior to obtaining any samples from it. Evacuation of three to five well volumes is recommended prior to sampling, unless low-flow purging and sampling methods are utilized as described in Section 6.7 (Consult the site-specific SAP for exact purging parameters). In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, extensive evacuation prior to sample withdrawal is not as critical as it is in a low-yielding well or in wells containing stagnant water.

3. For wells with low yields that are purged dry during sampling, evacuate the well and allow it to recover to 75 percent of full capacity prior to sample acquisition. If the recovery rate is fairly rapid (generally 300 mL per minute or greater), attempt to continue evacuation until the number of well volumes specified in the SAP is achieved. If this cannot be accomplished, allow recovery to 75 percent of capacity and begin sampling.

> ***CAUTION***
> For moderate to high-yielding monitoring wells, an evacuation rate that does not cause excessive turbulence in the well should be selected. There is no absolute safeguard against contaminating the sample with stagnant water; hence, special techniques are required for purging to minimize the potential for sample contamination (see below).

4. For moderate to high-yielding monitoring wells, use one of the following purge techniques:

   - Place a submersible pump or the intake line of a surface pump or bailer just below the water surface when removing the stagnant water.

   - While purging and as the water level decreases, lower the pump or intake line as the water level drops in the well. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. After this is accomplished, a bailer or other approved device may be used to collect the sample for analysis.

- Unless otherwise directed, place the intake line of the sampling pump (or the submersible pump itself) near the center of the screened section, and pump approximately one casing volume of water from the well at a low purge rate equal to the well's recovery rate (low-flow sampling).

6.2 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform to the guidelines in SOP SA-6.1.

The following equipment shall be on hand when sampling groundwater wells (reference SOPs SA-6.1 and SA-7.1):

- Sample packaging and shipping equipment – Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler materials, ice, labels, and chain-of-custody documents.
- Field tools and instrumentation
  - Multi-parameter water quality meter with an in-line sample chamber capable of measuring ORP, pH, temperature, DO, specific conductance, turbidity, and salinity, or individual meters (as applicable)
  - pH Paper
  - Camera and film (if appropriate)
  - Appropriate keys (for locked wells)
  - Water level indicator and/or oil-water interface probe if separate-phase product is expected
- Pumps
  - Shallow-well pumps: Centrifugal, bladder, suction, or peristaltic pumps with drop lines and air-lift apparatus (compressor and tubing) where applicable.
  - Deep-well pumps: Submersible pump and electrical power-generating unit, or bladder pumps where applicable.
- Other sampling equipment – Bailers, graduated cylinder, stopwatch, and inert line with tripod-pulley assembly (if necessary).
- Pails – Plastic, graduated.
- Clean paper or cotton towels for cleaning equipment.
- Buckets with lids for collecting purge water.
- Decontamination solutions – Deionized water, potable water, phosphate-free laboratory-grade detergent, and analytical-grade solvent (e.g., pesticide-grade isopropanol), as required.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

6.3 Calculations of Well Volume

To ensure that the proper volume of water has been removed from the well prior to sampling, it is first necessary to know the volume of standing water in the well pipe (including well screen where applicable). This volume can be easily calculated by the following method. Calculations shall be entered in the site logbook or field notebook or on a sample log sheet form or equivalent electronic form(s) (see SOP SA-6.3):

1. Obtain all available information on well construction (location, casing, screen, etc.).

2. Determine well or inner casing diameter.

3. Measure and record static water level (depth below ground level or top of casing reference point).

4. Determine depth of well by sounding using a clean, decontaminated, weighted tape measure or water level indicator.

5. Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).

6. Calculate one static well volume in gallons $V = (0.163)(T)(r^2)$

   where: V = Static volume of well in gallons.
   T = Linear feet of water in the well.
   r = Inside radius of well casing in inches.
   0.163 = Conversion factor (compensates for conversion of casing radius from inches to feet and cubic feet to gallons and pi.

7. Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

Measuring devices may become contaminated when gathering the above information if they are submerged in contaminated water. Decontamination of the tape or water level indicator must be conducted between measurements in different wells as follows:

1. Saturate a paper towel or clean cotton towel with deionized water.

2. As the measuring device is extracted, wipe the tape, changing the cleaning surface frequently.

3. After it is extracted, rinse the probe or tape using a spray bottle of deionized water over a bucket or similar collection container.

Based on the contaminant (oily, etc), it may be necessary to use a soap and water wash and rinse to remove contaminants. Isopropanol can be used on the probe/tape. However, it is recommended that the use of solvents on the tape be minimized because they could degrade the protective covering or possibly remove the scale designations. If isopropanol (or some other solvent) is used, assure that the manufacturer/supplier Material Safety Data Sheet (MSDS) is obtained, kept on site at a readily available location with other MSDSs, and reviewed by personnel prior to the first usage of the solvent. Also, add the substance to the site-specific Hazardous Chemical Inventory list (see Section 5 of the TtNUS Health and Safety Guidance Manual [HSGM], Hazard Communication Program and OSHA Standard 29 CFR 1910.1200).

6.4 Evacuation of Static Water – Purging

6.4.1 General

The amount to be purged from each well will be determined prior to sample collection. This amount will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of the aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately, the well can be pumped until parameters such as temperature, specific conductance, pH, and turbidity (as applicable) have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook or field notebook or on standardized data sheets or an equivalent electronic form(s).

6.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for given sampling situations. All of these techniques involve equipment that is portable and readily available.

Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of tubing equipped with a base plate and ball check-valve at the bottom. Bailers are comprised of stainless steel and plastic. They come in a variety of sizes, but the two most often used are 2 inches and 4 inches in diameter. An inert non-absorbent line such as polyethylene rope is used to lower and then raise the bailer to retrieve the sample. As the bailer is lowered into the water column, the ball is pushed up allowing the tube to be filled. When the bailer is pulled upward, the ball seats in the base plate preventing water from escaping.

Advantages of bailers include the following:

- There are few limitations on size and materials used.
- No external power source is needed.
- Bailers are inexpensive and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Splashing the bailer into the water or transfer of sample may cause aeration.
- The use of a bailer does not permit constant in-line monitoring of groundwater parameters.
- Use of bailers is physically demanding, especially in warm temperatures at personal protection equipment (PPE) levels above Level D.

Safety concerns using a bailer include the following:

- Muscle stress and strain, especially when using 4-inch bailers and when pulling from excessively deep wells.
- Entanglement, possible hand/finger injuries, and rope burns during a sudden release of the bailer back down the well.
- Direct contact with contaminants of concern and sample preservatives when discharging the bailer contents because there is not a high level of control during a direct pour, and splashing and indirect contact with contaminants/preservatives could occur.

Control measures for these hazards are provided in Section 6.6.2.

Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, and peristaltic pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low-volume pump that uses rollers to squeeze flexible tubing to create suction. This tubing can be dedicated to a well to prevent cross-contamination from well to well. Suction pumps are all portable, inexpensive, and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause loss of dissolved gases and volatile organics. Another limitation of these pumps is that they require a secondary energy source to drive them. Electrically driven pumps may require portable generators as energy sources. Air diaphragm pumps require air compressors and/or compressed gas cylinders to drive them. The advantage of the peristaltic pump is that it will operate from a portable battery source. Safety measures associated with these pumps are provided below.

Air-Lift and Gas-Lift Samplers

This group of pump samplers uses gas pressure either in the annulus of the well or in a venturi to force groundwater up a sampling tube. These pumps are also relatively inexpensive. Air- or gas-lift samplers are more suitable for well development than for sampling because the samples may be aerated as a result of pump action. Aeration can cause pH changes and subsequent trace metal precipitation or loss of volatile organics.

Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. Operation principles vary, and displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch-diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include the following:

- They may have low delivery rates.
- Many models are expensive.

- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding of the impellers with some of these pumps.
- Decontamination of internal components can be difficult and time consuming.

Compressed Gases

Safety concerns using compressed gases as an energy source in these pumps are numerous. The nitrogen gas or compressed air is provided in a compressed gas cylinder at a pressure of approximately 2,000 psi. If damaged, these cylinders can become dangerous projectiles. Additionally, a sudden release of a cylinder's contents can involve considerable force that could cause significant damage to the eyes and/or skin. Protective measures include the following:

- Always wear safety impact glasses when handling compressed gases.
- Always administer compressed gases through an appropriate pressure-reducing regulator.
- When clearing the cylinder connection port, open the cylinder valve only enough to clear foreign debris. During this process, always position the cylinder valve so that it faces away from you and others.
- If the cylinder is designed to accept a valve protection cap, always keep that protection cap in place, except the cylinder is connected for use.
- When using the cylinder, lay the cylinder on its side to avoid the potential of it falling and knocking the valve off (and becoming a missile).
- DO NOT use the compressed nitrogen or air to clean clothing or to spray off the skin. Small cuts in the protective layer of the skin may permit the gas to enter into the bloodstream, presenting the potential danger of an embolism.

See the project-specific HASP for additional direction concerning cylinder safe handling procedures pertaining to the safe handling, transportation, and storage of compressed gas cylinders.

Electrical Shock

Even in situations where portable batteries are used, the potential for electrical shock exists. This potential risk is increased in groundwater sampling activities because of the presence of groundwater near the batteries. This potential is also increased in (prohibited) situations where jury-rigging of electrical connections is performed. Other potential hazards occur when field samplers open the hood of a running car to access the battery as a power source. To control these hazards:

- If you are unfamiliar with electrical devices, do not experiment, get help, and get the proper equipment necessary to power your device.
- Use the proper portable power inverters for cigarette lighter connections to minimize the need to access the battery under the hood of your vehicle.
- Use of electrical generators may pose a number of hazards including noise, those associated with fueling, and indirect sample influence.

To minimize or eliminate electrical generator hazards:

- Inspect the generator before use. Ensure that the generator and any extension cords are rated for the intended operation and have a Ground Fault Circuit Interrupter (GFCI) in line to control potential electrical shock.
- Fuel the generator before purging and sampling to avoid loss of power during sampling.
- Fuel engines only when they are turned OFF and have cooled sufficiently to prevent a fire hazard.
- Place the generator and any fuel source at least 50 feet from the well to be sampled to avoid indirect influence to the sample from fuel vapors or emission gases.

Lifting Hazards

This hazard may be experienced when moving containers of purge water, equipment, cylinders, etc. To control these potential hazards:

- Do not fill purge buckets to more than 80 percent of their capacity.
- Obtain a gas cylinder of sufficient size to complete the designated task but not too large to handle. K-size cylinders weigh approximately 135 pounds and are difficult to handle. M-size cylinders weigh approximately 50 pounds and are easier to handle and move.
- When necessary, get help lifting and moving gas cylinders and other heavy objects. Minimize twisting and turning while lifting. If it is necessary to move these cylinders or generators over significant distance, use mechanical means (carts, etc.).
- Use proper lifting techniques as described in Section 4.4 of the HSGM.

6.5 Onsite Water Quality Testing

This section describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific conductance
- Temperature
- DO
- ORP
- Turbidity
- Salinity

This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous waste site. The procedures and equipment described are applicable to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, or colloidal material or other suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Because instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use. Most meters

used to measure field parameters require calibration on a daily basis. Refer to SOP SA-6.3 for an example equipment calibration log.

6.5.1 Measurement of pH

6.5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken and recorded on the groundwater sample log sheet (Attachment B) or equivalent electronic form.

Two methods are given for pH measurement: the pH meter and pH indicator paper. Indicator paper is used when only an approximation of the pH is required or when pH meter readings need to be verified, and the pH meter is used when a more accurate measurement is needed. The response of a pH meter can be affected by high levels of colloidal or suspended solids, but the effect is generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, or colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

6.5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution created by the addition of the water sample reacting with the indicator compound on the paper. Various types of pH papers are available, including litmus (for general acidity or alkalinity determination) and specific, or narrower range, pH range paper.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to (in this instance, hydrogen) ion activity (which is usually similar to concentration) across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to the ion concentration is generated and measured.

6.5.1.3 Equipment

The following equipment is to be used for obtaining pH measurements:

- A stand-alone portable pH meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Combination electrode with polymer body to fit the above meter. Alternately, a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs.
- Buffer solutions, as specified by the manufacturer. If the buffer solutions are considered hazardous per 29 Code of Federal Regulations (CFR) 1910.1200 (Hazard Communication) or the volumes used are greater than consumer commodity levels, the SSO shall obtain MSDSs from the manufacturer for the specific buffer solutions (see Section 4 of the HSGM regarding the Hazard Communication Program)

- pH indicator paper to cover the pH range 2 through 12.
- Manufacturer's operation manual. All personnel must be familiar with the equipment operation to ensure that the integrity of samples is preserved and that the equipment is operated safely.

6.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

The following procedure shall be used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

1. Inspect the instrument and batteries prior to initiation of the field effort.
2. Check the integrity of the buffer solutions used for field calibration. Buffer solutions need to be changed often as a result of degradation upon exposure to the atmosphere.
3. If applicable, make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).
4. Calibrate the meter and electrode(s) on a daily use basis (or as recommended by manufacturer) following manufacturer's instructions. Record calibration data on a water quality meter calibration log sheet (Attachment C) or equivalent electronic form.
5. Immerse the electrode(s) in the sample. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. The failure of the measurements to stabilize must be clearly noted in the logbook or equivalent electronic form.
6. Read and record the pH of the sample. pH shall be recorded to the nearest 0.01 pH standard unit. Also record the sample temperature (unless otherwise specified in the SAP, record temperatures to the nearest whole degree Fahrenheit or 0.5 degree Celsius).
7. Rinse the electrode(s) with deionized water.
8. Store the electrode(s) in an accordance with manufacturer's instructions when not in use.

Any visual observation of conditions that may interfere with pH measurement, such as oily materials or turbidity, shall be noted and avoided as much as possible.

pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper and proceed with successively narrower range paper until the sample pH is determined. To measure the pH with pH paper:

1. Collect a small portion of sample into a clean container.

2. Dip the pH paper into this small portion of sample.

3. Compare the color of the paper to the color chart that is provided with the pH paper and read the corresponding pH from the chart.

4. Record the pH value from the chart on the sampling log sheet.

5. Discard the used pH paper as trash.

6. Discard the small volume of sample that was used for the pH measurement with the other investigative derived waste.

6.5.2 Measurement of Specific Conductance

6.5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance measurement soon after taking a sample because temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect specific conductance. Most conductivity meters in use today display specific conductance in units of mS/cm, which is the conductivity normalized to a temperature of 25°C. These are the required units to be recorded on the groundwater sample log field form or equivalent electronic form.

6.5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, and the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases, and salts such as hydrochloric acid, sodium carbonate, and sodium chloride, respectively, are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not dissociate in aqueous solution, conduct a current very poorly if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on the ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell, which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

6.5.2.3 Equipment

The following equipment is needed for taking specific conductance measurements:

- Stand-alone portable conductivity meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

A variety of conductivity meters are available that may also be used to monitor salinity and temperature. Probe types and cable lengths vary, so equipment must be obtained to meet the specific requirements of the sampling program.

6.5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are as follows (calibration shall be conducted according to manufacturer's instructions):

1. Check batteries and calibrate instrument before going into the field.
2. Calibrate on a daily use basis (or as recommended by manufacturer), according to the manufacturer's instructions and record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used for calibration.
3. Rinse the cell with one or more portions of the sample to be tested or with deionized water and shake excess water from the cell.
4. Immerse the electrode in the sample and measure the conductivity.
5. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form.
6. Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for troubleshooting assistance.

6.5.3 Measurement of Temperature

6.5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in situ, or as quickly as possible in the field because collected water samples may rapidly equilibrate with the temperature of their surroundings.

6.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury-filled, dial-type thermometers or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22). In addition, various meters such as specific conductance or DO meters that have temperature measurement capabilities may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

6.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample, use the following procedure:

1. Immerse the thermometer in the sample until temperature equilibrium is obtained (1 to 3 minutes). To avoid the possibility of cross-contamination, the thermometer shall not be inserted into samples that will undergo subsequent chemical analysis.

2. Record values in a field logbook or on a sample log sheet or equivalent electronic form.

If a temperature meter or probe is used:

1. Calibrate the instrument according to manufacturer's recommendations prior to use.

2. Immerse the meter/probe in the sample until temperature equilibrium is obtained (1 to 3 minutes). To avoid the possibility of cross-contamination, the meter/probe shall not be inserted into samples that will undergo subsequent chemical analysis.

3. Record values in a field logbook or on a sample log sheet or equivalent electronic form.

6.5.4 Measurement of Dissolved Oxygen

6.5.4.1 General

DO levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. In addition, the growth of many aquatic organisms and the rate of corrosivity are dependent on DO concentrations. Thus, analysis for DO is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in situ because concentrations may show a large change in a short time if the sample is not adequately preserved.

The monitoring method discussed herein is limited to the use of DO meters. Chemical methods of analysis (i.e., Winkler methods) are available but require more equipment and greater sample manipulation. Furthermore, DO meters using a membrane electrode are suitable for highly polluted waters because the probe is completely submersible and is not susceptible to interference caused by color, turbidity, or colloidal material or suspended matter.

6.5.4.2 Principles of Equipment Operation

DO probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between

the two metals, reduction of oxygen to hydroxide ion (OH^-) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode. This rate is proportional to the oxygen concentration in the water being measured.

Because the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, leaving the surface of the solution undisturbed.

DO probes are relatively unaffected by interferences. Interferences that can occur are reactions with oxidizing gases such as chlorine or with gases such as hydrogen sulfide that are not easily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted in the field logbook and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer. This compensation can counteract some of the temperature effects but not all of them.

6.5.4.3 Equipment

The following equipment is needed to measure DO concentrations:

- A stand-alone portable DO meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

6.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

DO probes differ as to instructions for use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure DO concentrations:

1. Check the DO meter batteries before going to the field.
2. Condition the probe in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
3. Calibrate the instrument in the field according to manufacturer's recommendations or in a freshly air-saturated water sample of known temperature.
4. Record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.
5. Rinse the probe with deionized water.
6. Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane by stirring the sample. Probes without stirrers placed in wells may be moved up and down to achieve the required mixing.

7. Record the DO content and temperature of the sample in a field logbook or on a sample log sheet or equivalent electronic form.

8. Rinse the probe with deionized water.

9. Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable because sample handling is not involved. This however may not always be practical.

Special care shall be taken during sample collection to avoid turbulence that can lead to increased oxygen solubilization and positive test interferences.

6.5.5 Measurement of Oxidation-Reduction Potential

6.5.5.1 General

ORP provides a measure of the tendency of organic or inorganic chemicals to exist in an oxidized state. The ORP parameter therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of reduced to oxidized species in the sample.

6.5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and is dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as DO, may be correlated with ORP to provide knowledge of the quality of the solution, water, or wastewater.

6.5.5.3 Equipment

The following equipment is needed for measuring the ORP of a solution:

- A combination meter with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

6.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring ORP:

1. Check the equipment using the manufacturer's recommended reference solution and check its batteries before going to the field.

2. Thoroughly rinse the electrode with deionized water.

3. If the probe does not respond properly to the recommended reference solution, verify the sensitivity of the electrodes by noting the change in millivolts when the pH of a test solution is altered. The ORP will increase when the pH of a test solution decreases, and the ORP will decrease when the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note that the ORP drops sharply when the caustic is added (i.e., pH increases) thus indicating that the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions or the probe should be replaced.

4. Record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.

6.5.6 Measurement of Salinity

6.5.6.1 General

Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Most field meters determine salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or percent (e.g., 35 ppt equals 3.5 percent).

6.5.6.2 Principles of Equipment Operation

Salinity is determined automatically from the meter's conductivity and temperature readings according to algorithms (such as are found in Standard Methods for the Examination of Water and Wastewater). Depending on the meter, the results are displayed in either ppt or percent. The salinity measurements are carried out in reference to the conductivity of standard seawater (corrected to salinity = 35 ppt).

6.5.6.3 Equipment

The following equipment is needed for salinity measurements:

- A multi-parameter water quality meter capable of measuring conductivity and temperature and converting them to salinity (e.g., Horiba U-22 or YSI 600 series).
- Calibration solution as specified by the manufacturer.
- Manufacturer's operation manual.

6.5.6.4 Measurement Techniques for Salinity

The steps involved in taking salinity measurements are as follows (standardization shall be conducted according to manufacturer's instructions):

1. Check the expiration date of the solutions used for field calibration and replace them if they are expired.

2. Check batteries and calibrate the meter before going into the field.

3. Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.

4. Rinse the cell with the sample to be tested. This is typically accomplished as the probe is placed in line during the collection of the purge water up to the time of sample acquisition.

5. Immerse the multi-probe in the sample and measure the salinity. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form.

6. Rinse the probes with deionized water.

6.5.7 Measurement of Turbidity

6.5.7.1 General

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample. Turbidity in water is caused by suspended matter such as clay, silt, or other finely divided organic and inorganic matter and microscopic organisms including plankton.

It is important to obtain a turbidity reading immediately after taking a sample because irreversible changes in turbidity may occur if the sample is stored too long.

6.5.7.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method, which is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the scattered light intensity, the higher the turbidity.

Formazin polymer is used as the reference turbidity standard suspension because of its ease of preparation combined with a higher reproducibility of its light-scattering properties than clay or turbid natural water. The turbidity of a specified concentration of formazin suspension is defined as 40 nephelometric units. This same suspension has an approximate turbidity of 40 Jackson units when measured on the candle turbidimeter. Therefore, nephelometric turbidity units (NTUs) based on the formazin preparation will approximate units derived from the candle turbidimeter but will not be identical to them.

6.5.7.3 Equipment

The following equipment is needed for turbidity measurements:

- A turbidity meter (e.g., LaMotte 2020) that calibrates easily using test cells with standards of 0.0, 1.0, and 10 NTUs, or a combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).

- Calibration solution and sample tubes, as specified by the manufacturer.

- Manufacturer's operation manual.

6.5.7.4 Measurement Techniques for Turbidity

The steps involved in taking turbidity measurements utilizing an electrode (e) or light meter (l) are listed below (standardization shall be done according to manufacturer's instructions):

1. Check the expiration date of the solutions used for field calibration and replace them if they are expired.

2. Check batteries and calibrate the instrument before going into the field.

3. Calibrate on a daily basis according to the manufacturer's instructions, and record all pertinent information on a turbidity meter calibration log sheet (Attachment C) or equivalent electronic form.

4. When using the YSI and/or Horiba U-22, rinse the electrode with one or more portions of the sample to be tested or with deionized water.

5. When using the Lamotte 2020, fill the light meter's glass test cell with approximately 5 mL of sample, screw on the cap, wipe off glass to remove all residue that could intercept the instrument's light beam, place the test cell in the light meter, and close the lid.

6. Immerse the electrode in the sample and measure the turbidity.

7. The reading must be taken immediately because suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.

8. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.

9. Rinse the electrode or test cell with deionized water.

6.6 Sampling

6.6.1 Sampling Plan

The sampling approach consisting of the following shall be developed as part of the project planning documents approved prior to beginning work in the field:

- Background and objectives of sampling.

- Brief description of area and waste characterization.

- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

- Intended number, sequence, volumes, and types of samples. If the relative degree of contamination between wells is insignificant, a sampling sequence that facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells. In situations where the well is not well-characterized and the nature or extent of airborne contamination is unknown, it is recommended that head space analysis using a photoionization detector (PID) or flame ionization detector (FID) is performed to rate the wells, sampling from least contaminated to most contaminated.

Refer to the project-specific HASP for appropriate information and direction on air monitoring requirements.

- Sample preservation requirements.
- Work schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirements for split samples, access problems, location of keys, etc.
- The FOL shall ensure that the sampling method(s) to be employed is accurately represented in the HASP, indicating the types of sampling to be employed and the hazards. If the methods are not accurately represented, the FOL should rectify this with the HASP author.
- The FOL shall ensure that sampling teams understand the sampling approach that they are to follow. Where sampling teams are made up of personnel from multiple locations, personal sampling experiences may vary. Therefore the FOL shall review project-specific requirements, SOPs, and protocol to be followed. The FOL will conduct periodic surveys to ensure that these methods are being completed per his/her direction.

6.6.2 Sampling Methods as Related to Low-Flow Sampling

The collection of a groundwater sample consists of the following steps:

1. Ensure the safety of the sample location. Take a few minutes to evaluate the area for physical hazards (trip hazards, uneven ground, overhanging branches, etc.) and natural hazards (snakes, bees, spiders, etc.) that may exist in the area or that may have constructed nests in the well head. Snakes often like to sun themselves on concrete well pads. Follow provisions in the project-specific HASP and/or HSGM for addressing natural hazards.

2. As indicated earlier, some monitoring wells have the potential to contain pressurized headspace (e.g., through the generation of gases form contaminated groundwater, due to biological processes, degradation of contaminants, or simply based on location such as near a landfill or in areas that intersect lithological abnormalities) or through intentional artificial means such as those associated with air sparging systems. Injection or extraction wells may be artificially pressurized and may remain so for several days after the system has been turned off. This presents a hazard to people opening these wells. The Field Sampling Technician shall employ the following practices to minimize these hazards:

   - Wear safety glasses to protect the eyes. If site-specific observations and conditions indicate that the wells may be pressurized, wear a full-face shield over the safety impact eye protection.
   - DO NOT place your face or any other part of your body over the well when opening because this may place you in a strike zone.
   - Open the well cover at arms length, then step away and allow the well to off gas and stabilize.

   Follow directions provided in the project-specific HASP, Work Plan and/or Sampling Plan pertaining to the use of volatile chemical detection equipment (PID or FID) within the breathing zone of the sampler

during sampling to determine the need to retreat from the work area and/or for the use of respiratory protection (as specified in the HASP).

3. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data on a groundwater sampling log sheet or equivalent electronic form; then calculate the fluid volume in the well pipe (as previously described in this SOP). It is imperative that downhole equipment be adequately decontaminated between wells to prevent cross-contamination. Just as sampling occurs from the least contaminated to the most contaminated, it is also recommended that groundwater level measurements be taken in this manner.

4. Calculate volume of well water to be removed as described in Section 6.3.

5. Select the appropriate purging equipment (see Attachment A to this SOP) or as designated within your Work Plan/Sampling Plan. If an electric submersible pump with packer is chosen, go to Step 10.

6. Lower the purging equipment or intake into the well to a short distance below the water level or mid-screen as indicated in project-specific documentation and begin water removal. Remember that some contaminants are "bottom dwellers," and in these cases, project-specific direction may specify placing the intake just above (1 to 2 feet) the well bottom. Secure the pump intake at the well and secure the effluent at the collection container and begin pumping. The pumping rate will be determined based on the decrease in the water level (see Section 6.7) or as directed in your project-specific documents or this SOP. Purge water is generally collected in a 5-gallon bucket or similar open- or closed-top container. To minimize the potential for spills and back injuries, do not fill 5-gallon buckets beyond approximately 80 percent of their capacity. Dispose of purge water was as indicated in the planning document(s). Where necessary, slow the pumping rate or lower the pump intake as required to maintain submergence.

7. Estimate the approximate rate of discharge frequently and record it on the Low Flow Purge Data Sheet (see Attachment D). Estimate flow rate by noting the amount of discharge in a bucket or graduated cylinder per unit time using a watch with a second hand or a stopwatch.

8. Observe the peristaltic pump tubing intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics.

9. Purge a minimum of three to five casing volumes before sampling (or as directed by the site-specific SAP). In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Allow the well to recover to 75 percent of initial water level before sampling. Do not overfill purge containers because this increases the potential for spills and lifting injuries.

10. If sampling using a submersible pump, lower the pump intake to mid-screen (or the middle of the open section in uncased wells) and collect the sample. If sampling with a bailer, lower the bailer to just below the water surface.

11. For pump and packer assemblies only: Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

12. If the recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record this

occurrence in the site logbook or equivalent electronic form. When this occurs, contact the analytical laboratory to alert them that a reduced sample volume(s) will be submitted for analysis.

13. Fill sample containers and preserve and label them as described in SOP SA-6.1. Many sample bottles will contain preservative when they are shipped to the field. In those cases, do not add preservative.

14. Replace the well cap and lock it as appropriate. Make sure the well is readily identifiable as the source of the sample.

15. Process sample containers as described in SOP SA-6.1.

16. Decontaminate equipment as described in SOP SA-7.1.

6.7 Low-Flow Purging and Sampling

6.7.1 Scope and Application

Low-flow purging and sampling techniques may be required for groundwater sampling activities. The purpose of low-flow purging and sampling is to collect groundwater samples that contain "representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at or near natural flow conditions. This minimum-stress procedure emphasizes negligible water level drawdown and low pumping rates to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 1 inch or more and a saturated screen length, or open interval, of 10 feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semivolatile organic compounds, pesticides, polychlorinated biphenyls [PCBs], metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This low-flow procedure is not designed for collection of non-aqueous phase liquid samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs).

This procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 10 NTUs and to achieve a water level drawdown of less than 0.3 foot during purging and sampling. If these goals cannot be achieved, sample collection can take place provided that the remaining criteria in this procedure are met.

6.7.2 Equipment

The following equipment is required (as applicable) for low-flow purging and sampling:

- Adjustable rate submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon).

- Disposable clear plastic bottom-filling bailers to be used to check for and obtain samples of LNAPLs or DNAPLs.

- Tubing – Teflon, Teflon-lined polyethylene, polyethylene, polyvinyl chloride (PVC), Tygon, or stainless steel tubing can be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements.

- Water level measuring device with 0.01-foot accuracy (electronic devices are preferred for tracking water level drawdown during all pumping operations).

- Interface probe.
- Flow measurement supplies.
- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.
- Indicator parameter monitoring instruments – pH, turbidity, specific conductance, and temperature. Use of a flow-through cell is recommended. Optional indicators - ORP, salinity, and DO. A flow-through cell (also referred to as an in-line sample chamber) is required.
- Standards to perform field calibration of instruments.
- Decontamination supplies.
- Logbook(s) and other forms (see Attachments B through D) or equivalent electronic form(s).
- Sample bottles.
- Sample preservation supplies (as required by the analytical methods).
- Sample tags and/or labels.
- Well construction data, location map, field data from last sampling event (if available).
- Field Sampling Plan.
- PID or FID instrument for measuring volatile organic compounds (VOCs) per the HASP.

6.7.3 Purging and Sampling Procedure

1. Open the monitoring well as stated earlier and step away. Prepare sampling equipment while allowing 3 to 5 minutes to allow the water level to reach equilibrium. In situations where VOCs are the primary contaminants of concern, air monitoring of the samplers' breathing zone areas may be required by the HASP (typically with a PID or FID).

2 Measure the water level immediately prior to placing the pump in the well and record the water level on the Low-Flow Purge Data Form or equivalent electronic form immediately prior to placing the pump or tubing into the well.

3. Lower the measuring device further into the well to collect the total depth measurement. Again wait 3 to 5 minutes to allow the well to equilibrate to the initial water level prior to placing the pump or pump intake in the well.

4. Record the total well depth on the Low-Flow Purge Data Form or equivalent electronic form immediately prior to placing the pump or tubing into the well

5. Lower the pump or tubing slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible, keep the pump intake at least 2 feet above the bottom of the well to minimize mobilization of sediment that may be present in the bottom of the well. Collection of turbidity-free water samples may be difficult if there is 3 feet or less of standing water in the well.

6. Start with the initial pump rate set at approximately 0.1 liter per minute. Use a graduated cylinder and stopwatch to measure the pumping rate. Adjust the pumping rates as necessary to prevent drawdown from exceeding 0.3 foot during purging. If no drawdown is noted, the pump rate may be increased (to a maximum of 0.4 liter per minute) to expedite the purging and sampling event. The pump rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If groundwater is drawn down below the top of the well screen, purging shall cease or the well shall be pumped to dryness and then allowed to recover before purging continues. Well recovery to 75 percent is necessary prior to sampling. Slow-recovering wells should be identified and purged at the beginning of the workday to maximize field work efficiency. If possible, samples should be collected from these wells within the same workday and no later than 24 hours after the end of purging.

7. Measure the water level in the well every 5 to 10 minutes using the water level meter. Record the well water level on the Low Flow Purge Data Form (Attachment D) or equivalent electronic form.
8. Record on the Low Flow Purge Data Form every 5 to 10 minutes the water quality parameters (pH, specific conductance, temperature, turbidity, ORP, DO, and salinity or as specified by the approved site-specific planning document) measured by the water quality meter and turbidity meter. If the cell needs to be cleaned during purging operations, continue pumping (allow the pump to discharge into a container) and disconnect the cell. Rinse the cell with distilled/deionized water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Low-Flow Purge Data Form or equivalent electronic form.

9. Estimate the flow rate by noting the amount of discharge in a graduated cylinder per unit time using a watch with a second hand. Remeasure the flow rate any time the pump rate is adjusted and periodically during purging. This will determine if a reduction in rate has occurred due to possible battery depletion.

10. During purging, check for the presence of bubbles in the flow-through cell. The presence of bubbles is an indication that connections are not tight. If bubbles are observed, check for loose connections and tighten, repair, or replace them as necessary to achieve a tight connection.

11. Wait until stabilization is achieved, or a minimum of two saturated screen volumes have been removed and three consecutive readings, taken at 5 to 10 minute intervals, are within the following limits, then begin sampling:

    - pH ±0.2 standard units
    - Specific conductance ±10%
    - Temperature ±10%
    - Turbidity less than 10 NTUs
    - DO ±10%

12. If the above conditions have not been met after the well has been purged for 4 hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters from the Low-Flow Purge Data Form onto the Groundwater Sample Log Form or equivalent electronic form.

NOTE: VOC samples are preferably collected first, directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

13. If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples:

- Collect samples for non-VOC analyses first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample for VOCs, and record the new flow rate.

- Reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel) or clamp, which should reduce the flow rate by constricting the end of the tubing. Proceed with sample collection.

- Insert a narrow-diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, then collect the sample from the narrow diameter tubing.

- Prepare samples for shipping as per SOP SA-6.1.

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ATTACHMENT A

PURGING EQUIPMENT SELECTION

Diameter Casing		Bailer	Peristaltic Pump	Vacuum Pump	Air-lift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-Inch	Water level <25 feet	X	X	X	X	X			
	Water Level >25 feet	X			X				
2-Inch	Water level <25 feet	X	X	X	X	X	X		
	Water Level >25 feet	X			X		X		
4-Inch	Water level <25 feet	X	X	X	X	X	X	X	X
	Water Level >25 feet	X			X		X	X	X
6-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X
8-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 2

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	Dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 feet of submergence	$220-350	Requires compressed gas; custom sizes and materials available; acts as piezometer.
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	Portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	$500-600	AC/DC; variable speed control available; other models may have different flow rates.
ECO Pump Corp.	SAMPLifier	Portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	$400-700	AC, DC, or gasoline-driven motors available; must be primed.
Geltek Corp.	Bailer 219-4	Portable; grab (positive displacement)	1.66/38	Teflon®	No limit	1,075 mL	$120-135	Other sizes available.
GeoEngineering, Inc.	GEO-MONITOR	Dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	Probably 0-150	Approximately 1 liter for each 10 feet of submergence	$185	Acts as piezometer; requires compressed gas.
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	Portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2,800 mL/min	$1,500-3,000	Requires compressed gas; other models available; AC, DC, manual operation possible.
IEA	Syringe Sampler	Portable; grab (positive displacement)	1.75/43	SS, Teflon®	No limit	850 mL sample volume	$1,100	Requires vacuum and/or pressure from hand pump.
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	Portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Detrin®, acetal	0-150	0-7,500 mL/min	$990	Requires compressed gas (40 psi minimum).
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	Portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4,500 mL/min	$3,500	DC operated.
Leonard Mold and Die Works, Inc.	GeoFilter Small Diameter Well Pump (#0500)	Portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3,500 mL/min	$1,400-1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Detrin®	No limit	Approximately 250 mL	$125-160	Other materials and models available; for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	Dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2,000 mL/min	$300-400	Requires compressed gas; piezometric level indicator; other materials available.

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 3

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	Portable; peristaltic (suction)	<0.5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	$1,200-1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin® PP, Viton®, acrylic, PE	0-500	0-1,800 mL/min	$2,600-2,700	Requires compressed gas; water level indicator and flow meter; custom models available.
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1,100	250 mL/flushing cycle	$250-350	Requires compressed gas; SS available; piezometer model available; dedicated model available.
Solinst Canada Ltd.	5W Water Sampler	Portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	$1,300-1,800	Requires compressed gas; custom models available.
TIMCO Mfg. Co., Inc.	Std. Bailer	Portable; grab (positive displacement)	1.66/Custom	PVC, PP	No limit	250 mL/ft of bailer	$20-60	Other sizes, materials, models available; optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	$100-200	Requires compressed gas; other sizes, materials, models available; no solvents used.
Tole Devices Co.	Sampling Pump	Portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4,000 mL/min	$800-1,000	Compressed gas required; DC control module; custom built.

Construction Material Abbreviations:

- PE Polyethylene
- PP Polypropylene
- PVC Polyvinyl chloride
- SS Stainless steel
- PC Polycarbonate
- EPDM Ethylene-propylene diene (synthetic rubber)

Other Abbreviations:

- NA Not applicable
- AC Alternating current
- DC Direct current

NOTE: Other manufacturers market pumping devices which could be used for groundwater sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983.

ATTACHMENT B
GROUNDWATER SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[ ] Domestic Well Data
[x] Monitoring Well Data
[ ] Other Well Type: _____
[ ] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____
Type of Sample:
[X] Low Concentration
[ ] High Concentration

SAMPLING DATA:

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	ORP	Other
Time:	Visual	Standard	mS/cm	Degrees C	NTU	mg/l	mV	NA
Method:								

PURGE DATA:

Date:	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	ORP	Other
Method:								
Monitor Reading (ppm):			SEE LOW FLOW PURGE DATA SHEET					
Well Casing Diameter & Material								
Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

Circle if Applicable:

MS/MSD	Duplicate ID No.:	Signature(s):

ATTACHMENT C
EQUIPMENT CALIBRATION LOG

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME : _____ INSTRUMENT NAME/MODEL: _____

SITE NAME: _____ MANUFACTURER: _____

PROJECT No.: _____ SERIAL NUMBER: _____

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration	Post-calibration	Pre-calibration	Post-calibration		

ATTACHMENT D
LOW FLOW PURGE DATA SHEET

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: _____ WELL ID.: _____
PROJECT NUMBER: _____ DATE: _____

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	pH (S.U.)	S. Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celcius)	ORP mV	Salinity % or ppt	Comments

SIGNATURE(S): _____ PAGE___OF___

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes procedures and equipment commonly used for collecting environmental samples of surface water and aquatic sediment for either onsite examination and chemical testing or for offsite laboratory analysis.

2.0 SCOPE

The information presented in this document is applicable to all environmental sampling of surface waters (Section 5.3) and aquatic sediments (Section 5.5), except where the analyte(s) may interact with the sampling equipment. The collection of concentrated sludges or hazardous waste samples from disposal or process lagoons often requires methods, precautions, and equipment different from those described herein.

3.0 GLOSSARY

Analyte – Chemical or radiochemical material whose concentration, activity, or mass is measured.

Composite Sample – A sample representing a physical average of grab samples.

Environmental Sample – A quantity of material collected in support of an environmental investigation that does not require special handling or transport considerations as detailed in SOP SA-6.1.

Grab Sample – A portion of material collected to represent material or conditions present at a single unit of space and time.

Hazardous Waste Sample – A sample containing (or suspected to contain) concentrations of contaminants that are high enough to require special handling and/or transport considerations per SOP SA-6.1.

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - The Project Manager is responsible for determining the sampling objectives, initial sampling locations, and field procedures used in the collection of soil samples. The Project Manager also has the overall responsibility for seeing that all surface water and sediment sampling activities are properly conducted by appropriately trained personnel in accordance with applicable planning documents.

Field Operations Leader - This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that

custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is responsible for finalizing the locations for collection of surface water and sediment samples. The FOL is ultimately responsible for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan (HASP). This includes but is not be limited to performing air quality monitoring during sampling and boring and excavation activities, and ensuring that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO or SSO designee may also be required to advise the FOL on other safety-related matters regarding boring and sampling, such as mitigative measures to address potential hazards from hazardous objects or conditions.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP and other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, , container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

5.0 HEALTH AND SAFETY

Precautions to preserve the health and safety of field personnel implementing this SOP are distributed throughout. The following general hazards may also exist during field activities, and the means of avoiding them must be used to preserve the health and safety of field personnel:

Bridge/Boat Sampling – Potential hazards associated with this activity include:

- Traffic – one of the primary concerns as samplers move across a bridge because free space of travel is not often provided. Control measures should include:
  - When sampling from a bridge, if the samplers do not have at least 6 feet of free travel space or physical barriers separating them and the traffic patterns, the HASP will include a Traffic Control Plan.
  - The use of warning signs and high-visibility vests are required to warn oncoming traffic and to increase the visibility of sample personnel.
- Slips, trips, and falls from elevated surfaces are a primary concern. Fall protection shall be worn when or if samplers must lean over a rail to obtain sample material. A Fall Protection Competent

Person (in accordance with Occupational safety and Health Administration [OSHA] fall protection standards) must be assigned to ensure that fall protection is appropriately and effectively employed

- Water hazards/drowning – if someone enters the water from an elevated surface (such as a bridge or dock) and when sampling from a boat. To minimize this potential, personnel shall wear United states Coast Guard (USCG)-approved floatation devices, and the sampling crew must also have on hand a Type IV Throwable Personal Floatation Device with at least 90 feet of 3/8-inch rope. See Section 5.5.2 of this SOP.

- Within the HASP, provisions will also be provided concerning the requirement of a Safe Vessel Certification or the necessity to conduct a boat inspection prior to use. In addition, the HASP shall also specify requirements as to whether the operator must be certified as a commercial boat operator and whether members of the sampling team must have a state-specific safe boating certification.

Entering Water to Collect Samples – Several hazards are associated with this activity and can be mitigated as follows:

- Personnel must wear a USCG-approved Floatation Device (selected and identified in the HASP). The SSO shall ensure that the device selected is in acceptable condition and suitable for the individual using it. This includes consideration of the weight of the individual.

- Lifelines shall be employed from a point on the shore. This activity will always be conducted with a Buddy. See Section 6.5.2.

- Personnel shall carry a probe to monitor the bottom ahead of them for drop offs or other associated hazards.

- The person in the water shall exercise caution concerning the path traveled so that the lifeline does not become entangled in underwater obstructions such as logs, branches, stumps, etc., thereby restricting its effectiveness in extracting the person from the water.

- Personnel shall not enter waters on foot in situations where natural hazards including alligators, snakes, as well as sharks, gars, and other predators within inland waterways may exist.

- In all cases, working along and/or entering the water during high currents or flood conditions shall be prohibited.

- Personnel shall not enter bodies of water where known debris exists that could result in injuries from cuts and lacerations.

Sampling in marshes or tidal areas in some instances can be accomplished using an all-terrain vehicle (ATV). This is not the primary recommended approach because the vehicle may become disabled, or weather conditions or tidal changes could result in environmental damage as well as loss of the vehicle. The primary approach is recommended to be on foot where minimal disturbance would occur. The same precautions specified above with regard to sediment disturbance apply as well as the previously described safety concerns associated with natural hazards. The natural hazards include alligators, bees (nests in dead falls and tree trunks), snakes, etc. In addition, moving through and over this terrain is difficult and could result in muscle strain and slips, trips, and falls. Common sense dictates that the sampler selects the most open accessible route over moderate terrain. Move slowly and deliberately through challenging terrain to minimize falls. Mud boots or other supportive PPE should be considered and specified in the HASP to permit samplers to move over soft terrain with the least amount of effort. In these situations, it is also recommended, as the terrain allows, that supplies be loaded and transported in a sled over the soft ground.

Working in these areas, also recognize the following hazards and means of protection against them:

Insects are also a primary concern. These include mosquitoes, ticks, spiders, bees, ants, etc. The HASP will identify those particular to your area. Typical preventative measures include:

- Use insect repellant. Approval of various repellants should be approved by the Project Chemist or Project Manager.
- Wearing light-colored clothing to control heat load due to excessive temperatures. In addition, it makes it easier to detect crawling insects on your clothing.
- Taping pants to boots to deny access. Again, this is recommended to control access to the skin by crawling insects. Consultation with the Project Health and Safety Officer SSO/Health and Safety Manager is recommended under extreme heat loads because this will create conditions of heat stress.
- Performing a body check to remove insects. The quicker you remove ticks, the less likely they will become attached and transfer bacteria to your bloodstream. Have your Buddy check areas inaccessible to yourself. This includes areas such as the upper back and between shoulder blades where it is difficult for you to examine and even more difficult for you to remove.

Safety Reminder

If you are allergic to bee or ant stings, it is especially critical that you carry your doctor-recommended antidote with you in these remote sampling locations due to the extended time required to extract incapacitated individuals as well as the effort required to extract them. In these scenarios, instruct your Buddy in the proper administration of the antidote. In all cases, if you have received a sting, administer the antidote regardless of the immediate reaction, evacuate, and seek medical attention as necessary. The FOL and/or SSO will determine when and if you may return to the field based on the extent of the immune response and hazards or potential hazards identified in these locations. To the FOL and SSO, this is a serious decision you have to make as to whether to take someone vulnerable to these hazards into a remote location where you may not be able to carry them out. Consider it wisely.

Poisonous Plants – To minimize the potential of encountering poisonous plants in the field, at least one member of the field team needs to have basic knowledge of what these plants look like so that they can be recognized, pointed out to other field personnel, and avoided if at all possible. If the field team cannot avoid contact and must move through an area where these plants exist, the level of personal protective equipment (PPE) shall include Tyvek coveralls and enhanced decontamination procedures for the removal of oils from the tooling and/or equipment.

Temperature-Related Stress – Excessively cold temperatures may result in cold stress, especially when entering the water either intentionally or by accident. Provisions for combating this hazard should be maintained at the sample location during this activity. Excessively hot temperatures may result in heat stress especially in scenarios where equipment is packed through the marsh.

Because all of these activities are conducted outside, electrical storms are a significant concern. The following measures will be incorporated to minimize this hazard:

- Where possible, utilize commercial warning systems and weather alerts to detect storms moving into the area.

- If on or in the water, get out of the water. Move to vehicles or preferably into enclosed buildings with plumbing and wiring.

- Where warning systems are not available, follow the 30/30 Rule (i*f there are less than 30 seconds between thunder and lightning, go inside for at least 30 minutes after the last thunder).*

See Section 4.0 of the Health and Safety Guidance Manual (HSGM) for additional protective measures.

6.0 PROCEDURES

6.1 Introduction

Collecting a representative sample of surface water or sediment may be difficult because of water movement, stratification, or heterogeneous distribution of the targeted analytes. To collect representative samples, one must standardize sampling methods related to site selection, sampling frequency, sample collection, sampling devices, and sample handling, preservation, and identification. Regardless of quality control applied during laboratory analyses and subsequent scrutiny of analytical data packages, reported data are no better than the confidence that can be placed in the representativeness of the samples. Consult Appendix C for guidance on sampling that should be considered during project planning and that may be helpful to field personnel.

6.1.1 Surface Water Sampling Equipment

The selection of sampling equipment depends on the site conditions and sample type to be acquired. In general, the most representative samples are obtained from mid-channel at a stream depth of 0.5 foot in a well-mixed stream; however, project-specific planning documents will address site-specific sampling requirements including sample collection points and sampling equipment. The most frequently used samplers include the following:

- Peristaltic pump
- Bailer
- Dip sampler
- Weighted bottle
- Hand pump
- Kemmerer
- Depth-integrating sampler

The dip sampler and weighted bottle sampler are used most often, and detailed discussions for these devices and the Kemmerer sampler are addressed subsequently in this section.

The criteria for selecting a sampler include:

1. Disposability and/or easy decontamination.

2. Inexpensive cost (if the item is to be disposed).

3. Ease of operation.

4. Non-reactive/non-contaminating properties - Teflon-coated, glass, stainless-steel or polyvinyl chloride (PVC) sample chambers are preferred (in that order).

Measurements collected for each sample (grab or each aliquot collected for compositing) shall include but not be limited to:

- Specific conductance
- Temperature
- pH
- Dissolved oxygen

Sample measurements shall be conducted as soon as the sample is acquired. Measurement techniques described in SOP SA-1.1 shall be followed. All pertinent data and results shall be recorded in a field notebook or on sample log sheets (see Attachment A) or an equivalent electronic form(s). These analyses may be selected to provide information on water mixing/stratification and potential contamination. Various types of water bodies have differing potentials for mixing and stratification.

In general, the following equipment if necessary for obtaining surface water samples:

- Required sampling equipment, which may include a remote sampling pole, weighted bottle sampler, Kemmerer sampler, or other device.

- Real-time air monitoring instrument (e.g., PID, FID) as directed in the project-specific planning document.

- Required PPE as directed in the project-specific planning document, which may include:

  - Nitrile surgeon's or latex gloves (layered as necessary).

  - Safety glasses.

  - Other items identified on the Safe Work Permit that may be required based on location-specific requirements (e.g., hearing protection, steel-toed work boots, hard hat). These provisions will be listed in the HASP or addressed by the FOL and/or SSO.

> ***Safety Reminder***
> The use of latex products may elicit an allergic reaction in some people. Should this occur, remove the latex gloves, treat for an allergic reaction, and seek medical attention as necessary.

  - Required paperwork (see SOP SA-6.3 and Attachments A and B to this SOP).

  - Required decontamination equipment.

  - Required sample containers.

  - Sealable polyethylene bags (e.g., Ziploc® baggies).

  - Heavy-duty cooler.

  - Ice.

- Paper towels and garbage bags.

- Chain-of-custody records and custody seals.

Dip Sampling

Specific procedures for collecting a dip or grab sample of surface water can vary based on site-specific conditions (e.g., conditions near the shore and how closely a sampler can safely get to the shore). The general procedure for collecting a sample using a pole or directly from the water body is as follows:

1. If using a remote sampling pole, securely attach the appropriate sample container to a pole of sufficient length to reach the water to be sampled. Samples for volatile analysis should be collected first. Use PPE as described in the HASP. When sample containers are provided pre-preserved or if the pole cannot accommodate a particular sample container, use a dedicated, clean, unpreserved bottle/container for sampling and transfer to an appropriately preserved container.

2. Remove the cap. Do not place the cap on the ground or elsewhere where it might become contaminated.

3. Carefully dip the container into the water just below the surface (or as directed by project-specific planning documents), and allow the bottle to fill. Sample bottles for volatile analysis must be filled with no headspace. Avoid contacting the bottom of the water body because this will disturb sediment that may interfere with the surface water sample.

4. Retrieve the container and carefully replace the cap securely. If using a container other than the sample bottle, pour the water from that container into the sample bottle and replace the cap securely.

5. Use a clean paper towel to clean and dry the outside of the container.

6. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.

7. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

Constituents measured in grab samples collected near the water surface are only indicative of conditions near the surface of the water and may not be a true representation of the total concentration distributed throughout the water column and in the cross section. Therefore, as possible based on site conditions, the sampler may be required to augment dip samples with samples that represent both dissolved and suspended constituents and both vertical and horizontal distributions.

CAUTION

In areas prone to natural hazards such as alligators and snakes, etc., always use a buddy as a watch. Always have and use a lifeline or throwable device to extract persons who could potentially fall into the water. Be attentive to the signs, possible mounds indicating nests, and possible slides into the water. Remember that although snakes are typically encountered on the ground, it is not unheard of to see them on low-hanging branches. Be attentive to your surroundings because these may indicate that hazards are nearby.

Weighted Bottle Sampling

A grab sample can also be collected using a weighted holder that allows a bottle to be lowered to any desired depth, opened for filling, closed, and returned to the surface. This allows discrete sampling with depth. Several of these samples can be combined to provide a vertical composite. Alternatively, an open bottle can be lowered to the bottom and raised to the surface at a uniform rate so that the bottle collects sample throughout the total depth and is just filled on reaching the surface. The resulting sample using either method will roughly approach what is known as a depth-integrated sample.

A closed weighted bottle sampler consists of glass or plastic bottle with a stopper, a weight and/or holding device, and lines to open the stopper and lower or raise the bottle. The general procedure for sampling with this device is as follows:

1. Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).

2. When the desired depth is reached, pull out the stopper with a sharp jerk of the stopper line.

3. Allow the bottle to fill completely, as evidenced by the absence of air bubbles.

4. Raise the sampler and cap the bottle.

5. Use a paper towel to clean and dry the outside of the container. This bottle can be used as the sample container as long as the bottle is an approved container type.

6. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.

7. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

Kemmerer Sampler

If samples are desired at a specific depth, and the parameters to be measured do not require a Teflon-coated sampler, a standard Kemmerer sampler may be used. The Kemmerer sampler is a brass, stainless steel or acrylic cylinder with rubber stoppers that leave the ends open while it is lowered in a vertical position (thus allowing free passage of water through the cylinder). A "messenger" is sent down the line when the sampler is at the designated depth to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill sample bottles. The general procedure for sampling with this device is as follows:

1. Gently lower the sampler to the desired depth.

2. When the desired depth is reached, send down the messenger to close the cylinder and then raise the sampler.

3. Open the sampler valve to fill each sample bottle (filling bottles for volatile analysis first).

4. Use a paper towel to clean and dry the outside of the container.

5. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.

6. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

6.1.2 Surface Water Sampling Techniques

Samples collected during site investigations may be grab samples or composite samples. The following general procedures apply to various types of surface water collection techniques:

- If a clean, pre-preserved sample container is not used, rinse the sample container least once with the water to be sampled before the sample is collected. This is not applicable when sample containers are provided pre-preserved because doing so will wash some or all of the preservative out of the bottle.

- For sampling moving water, collect the farthest downstream sample first, and continue sample collection in an upstream direction. In general, work from zones suspected of low contamination to zones of high contamination.

- Take care to avoid excessive agitation of the water because loss of volatile constituents could result.

- When obtaining samples in 40 mL vials with septum-lined lids for volatile organics analysis, fill the container completely (with a meniscus) to exclude any air space in the top of the bottle and to be sure that the Teflon liner of the septum faces in after the vial is filled and capped. Turn the vial upside down and tap gently on your wrist to check for air bubbles. If air bubbles rise in the bottle, add additional sample volume to the container.

- Do not sample at the surface, unless sampling specifically for a known constituent that is immiscible and on top of the water. Instead, invert the sample container, lower it to the approximate depth, and hold it at about a 45-degree angle with the mouth of the bottle facing upstream.

6.2 Onsite Water Quality Testing

Onsite water quality testing shall be conducted as described in SOP SA-1.1.

6.3 Sediment Sampling

6.3.1 General

If composite surface water samples are collected, sediment samples are usually collected at the same locations as the associated surface water samples. If only one sediment sample is to be collected, the sampling location shall be approximately at the center of the water body, in a depositional area if possible based on sample location restraints (see below), unless the SAP states otherwise.

Generally, coarser-grained sediments are deposited near the headwaters of reservoirs. Bed sediments near the center of a water body will be composed of fine-grained materials that may, because of their lower porosity and greater surface area available for adsorption, contain greater concentrations of contaminants. The shape, flow pattern, bathymetry (i.e., depth distribution), and water circulation patterns must all be considered when selecting sediment sampling sites. In streams, areas likely to have sediment accumulation (e.g., bends, behind islands or boulders, quiet shallow areas or very deep, low-velocity areas) shall be sampled, in general, and areas likely to show net erosion (i.e., high-velocity, turbulent areas) and suspension of fine solid materials shall be generally avoided. Follow instructions in the SAP, as applicable.

Chemical constituents associated with bottom material may reflect an integration of chemical and biological processes. Bottom samples reflect the historical input to streams, lakes, and estuaries with

respect to time, application of chemicals, and land use. Bottom sediments (especially fine-grained material) may act as a sink or reservoir for adsorbed heavy metals and organic contaminants (even if water column concentrations are less than detection limits). Therefore, it is important to minimize the loss of low-density "fines" during any sampling process.

Samples collected for volatile organic compound (VOC) analysis must be collected prior to any sample homogenization. Regardless of the method used for collection, the aliquot for VOC analysis must be collected directly from the sampling device (hand auger bucket, scoop, trowel), to the extent practical. If a device such as a dredge is used, the aliquot should be collected after the sample is placed in the mixing container prior to mixing.

In some cases, the sediment may be soft and not lend itself to collection by plunging Encore™ or syringe samplers into the sample matrix. In these cases, it is appropriate to open the sampling device, (Encore™ barrel or syringe) prior to sample collection, and carefully place the sediment in the device, filling it fully with the required volume of sample.

On active or former military sites, ordnance items may be encountered in some work areas. Care should be exercised when handling site media (such as if unloading a dredge as these materials may be scooped up). If suspected ordnance items are encountered, stop work immediately, move to shore and notify the Project Manager and Health and Safety Manager.

All relevant information pertaining to sediment sampling shall be documented as applicably described in SOP SA-6.3 and Attachment B or an equivalent electronic form.

6.3.2 Sampling Equipment and Techniques for Bottom Materials

A bottom-material sample may consist of a single scoop or core, or may be a composite of several individual samples in the cross section. Sediment samples may be obtained using onshore or offshore techniques.

SAFETY REMINDER

The following health and safety provisions apply when working on/over/near water:

- At least two people are required to be present at the sampling location in situations where the water depth and/or movement deem it necessary, each wearing a USCG-approved Personal Flotation Devices

- A minimum of three people are required if *any* of the following conditions are anticipated or observed:

  - Work in a waterway that is turbulent *or* swift that could sweep a sampler down stream should he or she fall in accidentally.

  - The underwater walking surface (e.g., stream/river bed) is suspected or observed to involve conditions that increase the potential for a worker to fall into the water. Examples include large/uneven rocks or boulders, dense mud or sediment that could entrap worker's feet, etc.

  - Waterway is tidal, and conditions such as those listed above could rapidly change.

The third person in the above condition must be equipped and prepared to render emergency support [e.g., lifeline, tethered Personal Flotation Device (Throwable Type IV, life saver), skiff, means to contact external emergency response support, etc.]

The following samplers may be used to collect sediment samples:

- Scoop sampler
- Dredge samplers
- Coring samplers

Each type of sampler is discussed below.

In general, the following equipment if necessary for obtaining sediment samples:

- Required sampling equipment, which may include a scoop sampler, dredge sampler, coring sampler, or stainless steel or pre-cleaned disposable trowel.

- Stainless bowl or pre-cleaned disposable bowl to homogenize sample.

- Real-time air monitoring instrument (e.g., PID, FID) as directed in the project-specific planning document.

- Required PPE as directed in the project-specific planning document, which may include:

  - Nitrile surgeon's or latex gloves (layered as necessary).

  - Safety glasses.

  - Other items identified on the Safe Work Permit that may be required based on location-specific requirements (e.g., hearing protection, steel-toed work boots, hard hat). These provisions will be listed in the HASP or addressed by the FOL and/or SSO.

  - Required paperwork (see SOP SA-6.3 and Attachments A and B to this SOP).

  - Required decontamination equipment.

  - Required sample containers.

  - Sealable polyethylene bags (e.g., Ziploc® baggies).

  - Heavy-duty cooler.

  - Ice.

  - Paper towels and garbage bags.

  - Chain-of-custody records and custody seals.

Scoop Sampler

A scoop sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood, PVC, or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.

If the water body can be sampled from the shore or if the sampler can safely wade to the required location, the easiest and best way to collect a sediment sample is to use a scoop sampler. Scoop sampling also reduces the potential for cross-contamination. The general scoop sampling procedure is as follows:

1. Reach over or wade into the water body.

2. While facing upstream (into the current), scoop the sampler along the bottom in an upstream direction. Although it is very difficult not to disturb fine-grained materials at the sediment-water interface when using this method, try to keep disturbances to a minimum.

Dredge Samplers

Dredges are generally used to sample sediments that cannot easily be obtained using coring devices (e.g., coarse-grained or partially cemented materials) or when large quantities of sample are required. Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a "messenger." Some dredges are heavy and may require use of a winch and crane assembly for sample retrieval. The three major types of dredges are Peterson, Eckman and Ponar.

The Peterson dredge is used when the bottom is rocky, in very deep water, or when the flow velocity is high. The Peterson dredge shall be lowered very slowly as it approaches bottom, because it can force out and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high flow velocities.

The Ponar dredge is a Peterson dredge modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends, thus reducing the "shock wave." The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates.

The general procedure for using dredge samplers is as follows:

1. Gently lower the dredge to the desired depth.

2. When the desired depth is reached, send the messenger down to cable to close the cylinder and then carefully raise the sampler.

3. Open the sampler to retrieve the sediment.

4. Transfer the sediment to the bowl in which it will be homogenized. Fill the sample bottle(s) for volatile analysis *prior to* homogenization. Homogenize the remainder of the sediment collected.

5. Fill the containers for all analyses other and VOCs.

6. Use a paper towel to clean and dry the outside of each container.

7. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.

8. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

SAFETY REMINDER
Safety concerns using these dredges include lifting hazards, pinches, and compressions (several pinch points exist within the jaws and levers). In all cases, handle the dredge by the rope to avoid capturing fingers/hands.

Coring Samplers

Coring samplers are used to sample vertical columns of sediment. Many types of coring devices have been developed depending on the depth of water from which the sample is to be obtained, the nature of the bottom material, and the length of core to be collected. They vary from hand-push tubes to electronic vibrational core tube drivers.

Coring devices are particularly useful in pollutant monitoring because turbulence created by descent through the water is minimal, thus the fines at the sediment-water interface are only minimally disturbed. The sample is withdrawn intact, permitting the removal of only those layers of interest.

In shallow, wadeable waters, the use of a core liner or tube manufactured of Teflon or plastic is recommended for the collection of sediment samples. Caution should be exercised not to disturb the bottom sediments when the sample is obtained by wading in shallow water. The general procedure to collecting a sediment sample with a core tube is as follows:

1. Push the tube into the substrate until 4 inches or less of the tube is above the sediment-water interface. When sampling hard or coarse substrates, a gentle rotation of the tube while it is being pushed will facilitate greater penetration and decrease core compaction.

2. Cop the top of the tube to provide suction and reduce the chance of losing the sample.

3. Slowly extract the tube so as not to lose sediment from the bottom of the tube. Cap the bottom of the tube before removing it from the water. This will also help to minimize loss of sample.

4. Transfer the sediment to the bowl in which it will be homogenized. Fill the sample bottle(s) for volatile analysis prior to homogenization. Homogenize the remainder of the sediment collected.

5. Fill the containers for all analyses other and VOCs.

6. Use a paper towel to clean and dry the outside of each container.

7. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.

8. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

In deeper, non-wadeable water bodies, sediment cores may be collected from a bridge or boat using different coring devices such as Ogeechee Sand Pounders, gravity cores, and vibrating coring devices.

All three devices utilize a core barrel with a core liner tube system. The core liners can be removed from the core barrel and replaced with a clean core liner after each sample. Before extracting the sediment from the coring tubes, the clear supernatant above the sediment-water interface in the core should be decanted from the tube. This is accomplished by turning the core tube to its side and gently pouring the liquid out until fine sediment particles appear in the waste liquid. Post-retrieval processing of samples is the same as above.

7.0 REFERENCES

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ATTACHMENT A
SURFACE WATER SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

SURFACE WATER SAMPLE LOG SHEET

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Project Site Name: _____
Project No.: _____

[] Stream
[] Spring
[] Pond
[] Lake
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Date:	Visual	Standard	mS/cm	Degrees C	NTU	mg/l	%	NA
Time:								
Depth:								
Method:								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

ATTACHMENT B
SOIL & SEDIMENT SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

Date:	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

APPENDIX C
GUIDANCE ON SAMPLING DESIGN AND SAMPLE COLLECTION

C.1 Defining the Sampling Program

Many factors are considered in developing a sampling program for surface water and/or sediment, including study objectives, accessibility, site topography, physical characteristics of the water body (e.g., flow and mixing), point and diffuse sources of contamination, and personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on vertical and lateral mixing within the body of water. For sediment, dispersion depends on bottom current or flow characteristics, sediment characteristics (e.g., density, size), and geochemical properties (that affect adsorption/desorption). The hydrogeologist developing the sampling plan must therefore know not only the mixing characteristics of streams and lakes but must also understand the role of fluvial-sediment transport, deposition, and chemical sorption.

C.1.1 Sampling Program Objectives

The scope of the sampling program must consider the sources and potential pathways for transport of contamination to or within a surface water body. Sources may include point sources (leaky tanks, outfalls, etc.) or nonpoint sources (e.g., contaminated runoff). The major pathways for surface water contamination (not including airborne deposition) are overland runoff, leachate influx to the water body, direct waste disposal (solid or liquid) into the water body, and groundwater flow influx from upgradient. The relative importance of these pathways, and therefore the design of the sampling program, is controlled by the physiographic and hydrologic features of the site, the drainage basin(s) that encompasses the site, and the history of site activities.

Physiographic and hydrologic features to be considered include slopes and runoff direction, areas of temporary flooding or pooling, tidal effects, artificial surface runoff controls such as berms or drainage ditches (and when they were constructed relative to site operation), and locations of springs, seeps, marshes, etc. In addition, the obvious considerations such as the locations of man-made discharge points to the nearest stream (intermittent or flowing), pond, lake, estuary, etc. shall be considered.

A more subtle consideration in designing the sampling program is the potential for dispersion of dissolved or sediment-associated contaminants away from the source. The dispersion could lead to a more homogeneous distribution of contamination at low or possibly non-detectable concentrations. Such dispersion does not, however, always readily occur. For example, obtaining a representative sample of contamination from a main stream immediately below an outfall or a tributary is difficult because the inflow frequently follows a stream bank with little lateral mixing for some distance. Sampling alternatives to overcome this situation include: (1) moving the sampling location far enough downstream to allow for adequate mixing, or (2) collecting integrated samples in a cross section. Also, non-homogeneous distribution is a particular problem with regard to sediment-associated contaminants, which may accumulate in low-energy environments (coves, river bends, deep spots, or even behind boulders) near or distant from the source while higher-energy areas (main stream channels) near the source may show no contaminant accumulation.

The distribution of particulates within a sample itself is an important consideration. Many organic compounds are only slightly water soluble and tend to adsorb onto particulate matter. Nitrogen, phosphorus, and heavy metals may also be transported by particulates. Samples must be collected with a representative amount of suspended material; transfer from the sampling device shall include transferring a proportionate amount of the suspended material.

C.1.2 Location of Sampling Stations

Accessibility is the primary factor affecting sampling costs. The desirability and utility of a sample for analysis and consideration of site conditions must be balanced against the costs of collection as controlled by accessibility. Bridges or piers are the first choice for locating a sampling station on a stream because bridges provide ready access and also permit the sampling technician to sample any point across the stream. A boat or pontoon (with an associated increase in cost) may be needed to sample locations on lakes, reservoirs, or larger rivers. Frequently, however, a boat will take longer to cross a water body and will hinder manipulation of the sampling equipment. Wading for samples is not recommended unless it is known that contaminant levels are low so that skin contact will not produce adverse health effects. This provides a built in margin of safety in the event that wading boots or other protective equipment should fail to function properly. If it is necessary to wade into the water body to obtain a sample, the sampler shall be careful to minimize disturbance of bottom sediments and must enter the water body downstream of the sampling location. If necessary, the sampling technician shall wait for the sediments to settle before taking a sample.

Under ideal and uniform contaminant dispersion conditions in a flowing stream, the same concentrations of each contaminant would occur at all points along the cross section. This situation is most likely downstream of areas of high turbulence. Careful site selection is needed to ensure, as nearly as possible, that samples are taken where uniform flow or deposition and good mixing conditions exist.

The availability of stream flow and sediment discharge records can be an important consideration in choosing sampling sites in streams. Stream flow data in association with contaminant concentration data are essential for estimating the total contaminant loads carried by the stream. If a gaging station is not conveniently located on a selected stream, the project hydrogeologist shall explore the possibility of obtaining stream flow data by direct or indirect methods. Remember these locations are also where you may encounter natural hazards as these are areas where they hunt. Always exercise extreme caution.

C.1.3 Frequency of Sampling

The sampling frequency and objectives of the sampling event will be defined by the project planning documents. For single-event site or area characterization sampling, both bottom material and overlying water samples shall be collected at the specified sampling stations. If valid data are available on the distribution of a contaminant between the solid and aqueous phases, it may be appropriate to sample only one phase, although this is not often recommended. If samples are collected primarily for monitoring purposes (i.e., consisting of repetitive, continuing measurements to define variations and trends at a given location), water samples should be collected at a pre-established and constant interval as specified in the project plans (often monthly or quarterly and during droughts and floods). Samples of bottom material should generally be collected from fresh deposits at least yearly, and preferably seasonally, during both spring and fall.

The variability in available water quality data shall be evaluated before determining the number and collection frequency of samples required to maintain an effective monitoring program.

C.2 <u>Surface Water Sample Collection</u>

C.2.1 Streams, Rivers, Outfalls and Drainage Features

Methods for sampling streams, rivers, outfalls, and drainage features (ditches, culverts) at a single point vary from the simplest of hand-sampling procedures to the more sophisticated multi-point sampling techniques known as the equal-width-increment (EWI) method or the equal-discharge-increment (EDI) methods (see below).

Samples from different depths or cross-sectional locations in the watercourse taken during the same sampling episode shall be composited. However, samples collected along the length of the watercourse or at different times may reflect differing inputs or dilutions and therefore shall not be composited. Generally, the number and type of samples to be taken depend on the river's width, depth, and discharge and on the suspended sediment the stream or river transports. The greater the number of individual points that are sampled, the more likely that the composite sample will truly represent the overall characteristics of the water.

In small streams less than about 20 feet wide, a sampling site can generally be found where the water is well mixed. In such cases, a single grab sample taken at mid-depth in the center of the channel is adequate to represent the entire cross section.

For larger streams, at least one vertical composite shall be taken with one sample each from just below the surface, at mid-depth, and just above the bottom. The measurement of dissolved oxygen (DO), pH, temperature, conductivity, etc., shall be made on each aliquot of the vertical composite and on the composite itself. For rivers, several vertical composites shall be collected, as directed in the project planning documents.

C.2.2 Lakes, Ponds and Reservoirs

Lakes, ponds, and reservoirs have a much greater tendency to stratify than rivers and streams. The relative lack of mixing requires that more samples be obtained. The number of water sampling sites on a lake, pond, or impoundment will vary with the size and shape of the basin. In ponds and small lakes, a single vertical composite at the deepest point may be sufficient. Similarly, measurement of DO, pH, temperature, etc. is to be conducted on each aliquot of the vertical composite and on the composite itself. In naturally formed ponds, the deepest point may have to be determined empirically; in impoundments, the deepest point is usually near the dam.

In lakes and larger reservoirs, several vertical composites shall be composited to form a single sample if a sample representative of the water column is required. These vertical composites are often collected along a transect or grid. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones. In a stratified lake, the epilimnion is the thermocline that is exposed to the atmosphere. The hypolimnion is the lower, "confined" layer that is only mixed with the epilimnion and vented to the atmosphere during seasonal "overturn" (when density stratification disappears). These two zones may thus have very different concentrations of contaminants if input is only to one zone, if the contaminants are volatile (and therefore vented from the epilimnion but not the hypolimnion), or if the epilimnion only is involved in short-term flushing (i.e., inflow from or outflow to shallow streams). Normally, however, a composite consists of several vertical composites with samples collected at various depths.

In lakes with irregular shape and with bays and coves that are protected from the wind, separate composite samples may be needed to adequately represent water quality because it is likely that only poor mixing will occur. Similarly, additional samples are recommended where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

Many lake measurements are now made in situ using sensors and automatic readout or recording devices. Single and multi-parameter instruments are available for measuring temperature, depth, pH, oxidation-reduction potential (ORP), specific conductance, DO, some cations and anions, and light penetration.

C.2.3 Estuaries

Estuarine areas are, by definition, zones where inland freshwaters (both surface and ground) mix with oceanic saline waters. Knowledge of the estuary type may be necessary to determine sampling locations. Estuaries are generally categorized into one of the following three types dependent on freshwater inflow and mixing properties:

- Mixed Estuary - characterized by the absence of a vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically, this type of estuary is shallow and is found in major freshwater sheet flow areas. Because this type of estuary is well mixed, sampling locations are not critical.

- Salt Wedge Estuary - characterized by a sharp vertical increase in salinity and stratified freshwater flow along the surface. In these estuaries, the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally back and forth with the tidal phase. If contamination is being introduced into the estuary from upstream, water sampling from the salt wedge may miss it entirely.

- Oceanic Estuary - characterized by salinities approaching full-strength oceanic waters. Seasonally, freshwater inflow is small, with the preponderance of the fresh-saline water mixing occurring near or at the shore line.

Sampling in estuarine areas is normally based on the tidal phase, with samples collected on successive slack tides (i.e., when the tide turns). Estuarine sampling programs shall include vertical salinity measurements at 1- to 5-foot increments, coupled with vertical DO and temperature profiles.

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures to be used to collect surface, near-surface, and subsurface soil samples. Additionally, it describes the methods for sampling of test pits and trenches to determine subsurface soil and rock conditions and for recovery of small-volume or bulk samples from pits.

2.0 SCOPE

This document applies to the collection of surface, near-surface, and subsurface soil samples exposed through hand digging, hand augering, drilling, or machine excavating at hazardous substance sites for laboratory testing, onsite visual examination, and onsite testing.

3.0 GLOSSARY

Composite Sample - A composite sample is a combination of more than one grab sample from various locations and/or depths and times that is homogenized and treated as one sample. This type of sample is usually collected when determination of an average waste concentration for a specific area is required. Composite samples shall not be collected for volatile organics analysis.

Confined Space - As stipulated in 29 Code of Federal Regulations (CFR) 1910.146, a confined space means a space that: (1) is large enough and so configured that an employee can bodily enter and perform assigned work; (2) has limited or restricted means for entry or exit (e.g., tanks, vessels, silos, storage bins, hoppers, vaults, pits, and excavations); and (3) is not designed for continuous employee occupancy. TtNUS considers all confined space as permit-required confined spaces.

Grab Sample - One sample collected at one location and at one specific time.

Hand Auger - A sampling device used to extract soil from the ground.

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

Sample for Non-Volatile Analyses - Includes all chemical parameters other than volatile organics (e.g., semivolatiles, pesticides/PCBs, metals, etc.) and those engineering parameters that do not require undisturbed soil for their analysis.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split-barrel sampler is typically available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch-long samples, respectively. These split-barrel samplers commonly range in size from 2 to 3.5 inches OD. The larger sizes are commonly used when a larger volume of sample material is required (see Attachment B).

Test Pit and Trench - Open, shallow excavations, typically rectangular (if a test pit) or longitudinal (if a trench), excavated to determine shallow subsurface conditions for engineering, geological, and soil chemistry exploration and/or sampling purposes. These pits are excavated manually or by machine (e.g., backhoe, clamshell, trencher, excavator, or bulldozer).

Thin-Walled Tube Sampler - A thin-walled metal tube (also called a Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches outside diameter (OD) and from 18 to 54 inches in length.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - The Project Manager is responsible for determining the sampling objectives, selecting proposed sampling locations, and selecting field procedures used in the collection of soil samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager establishes the need for test pits or trenches and determines their approximate locations and dimensions.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan. This will include (but not be limited to) performing air quality monitoring during sampling, boring, and excavation activities and to ensure that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO/designee may also be required to advise the FOL on other safety-related matters regarding boring, excavation, and sampling, such as mitigative measures to address potential hazards from unstable trench walls, puncturing of drums or other hazardous objects, etc.

Field Operations Leader (FOL) - This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is responsible for finalizing the locations for collection of surface, near-surface, and subsurface (hand and machine borings, test pits/trenches) soil samples. He/she is ultimately responsible for the sampling and backfilling of boreholes, test pits, and trenches and for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP and/or other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, boring logs, test pit logs, container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

Competent Person - A Competent Person, as defined in 29 CFR 1929.650 of Subpart P - Excavations, means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions that are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.

- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

5.0 HEALTH AND SAFETY

Health and safety precautions are identified for individual sample collection procedures throughout this SOP. In addition to those precautions, the following general hazards may be incurred during sampling activities:

- Knee injuries from kneeling on hard or uneven surfaces
- Slips, trips, and falls
- Cuts and lacerations
- Traffic hazards associated with sampling in parking areas, along roadways and highways.

Methods of avoiding these hazards are provided below.

Knee injuries – If kneeling is required during soil sampling, this could result in knee injuries from stones/foreign objects and general damage due to stress on the joints. To minimize this hazard:

- Clear any foreign objects from the work area.
- Wear hard-sided knee pads.
- Stretch ligaments, tendons and muscles before, during and after. Take breaks as frequently as necessary.
- Report pre-existing conditions to the SSO if you feel this activity will aggravate an existing condition.

Slips, Trips, and Falls – These hazards exist while traversing varying terrains carrying equipment to sample locations. To minimize these hazards:

- Pre-survey sampling locations. Eliminate, barricade, or otherwise mark physical hazards leading to the locations.
- Carry small loads that do not restrict the field of vision.
- Travel the safest and clearest route (not necessarily the shortest).

Cuts and Lacerations - To prevent cuts and lacerations associated with soil sampling, the following provisions are required:

- Always cut away from yourself and others when cutting tubing or rope. This will prevent injury to yourself and others if the knife slips.
- Do not place items to be cut in your hand or on your knee.
- Change blades as necessary to maintain a sharp cutting edge. Many accidents result from struggling with dull cutting attachments.

- Whenever practical, wear cut-resistant gloves (e.g., leather or heavy cotton work gloves) at least on the hand not using the knife.
- Keep cutting surfaces clean and smooth.
- Secure items to be cut – do not hold them against the opposing hand, a leg, or other body part.
- When transporting glassware, keep it in a hard-sided container such as a cooler so that if there is a fall, you will be less likely to get cut by broken glass.
- DO NOT throw broken sample jars or glass ampoules into garbage bags. Place broken glass and glass ampoules in hard-sided containers such as a cardboard box or directly into a dumpster. DO NOT reach into garbage bags to retrieve any item accidentally thrown away. Empty the contents onto a flat surface to avoid punctures and lacerations from reaching where you cannot see.

Vehicular and Foot Traffic Hazards – When sampling along the roadway or near traffic patterns, follow the following precautions:

- Motorists may be distracted by onsite activities – ASSUME THEY DO NOT SEE YOU OR MEMBERS OF YOUR FIELD CREW.
- DO NOT place obstructions (such as vehicles) along the sides of the road that may cause site personnel to move into the flow of traffic to avoid your activities or equipment or that will create a blind spot.
- **Provide a required free space of travel**. Maintain at least 6 feet of space between you and moving traffic. Where this is not possible, use flaggers and/or signs to warn oncoming traffic of activities near or within the travel lanes.
- Face Traffic. Whenever feasible, if you must move within the 6 feet of the required free space or into traffic, attempt to face moving traffic at all times. Always leave yourself an escape route.
- Wear high-visibility vests to increase visual recognition by motorists.
- Do not rely on the vehicle operator's visibility, judgment, or ability. Make eye contact with the driver. Carefully and deliberately use hand signals so they will not startle or confuse motorists or be mistaken for a flagger's direction before moving into traffic.
- Your movements may startle a motorist and cause an accident, so move deliberately. Do not make sudden movements that might confuse a motorist.

6.0 PROCEDURES

The following procedures address surface and subsurface sampling.

CAUTION

Each situation must be evaluated individually to determine the applicability and necessity for obtaining a utility clearance ticket/dig permit. Common sense dictates, prior to digging or boring with power equipment, no matter what the depth, or digging by hand in a manner that could damage unprotected underground utilities, that a dig permit is required. See SOP HS-1.0, Utility Locating and Excavation Clearance, for additional clarification. If you do not know or are unsure as to whether a ticket is necessary – **Get the Ticket**.

6.1 Overview

Soil sampling is an important adjunct to groundwater monitoring. Sampling of the soil horizons above the groundwater table can detect contaminants before they migrate to the water table, and can establish the amount of contamination absorbed or adsorbed on aquifer solids that have the potential of contributing to groundwater contamination.

Soil types can vary considerably on a hazardous waste site. These variations, along with vegetation, can affect the rate of contaminant migration through the soil. It is important, therefore, that a detailed record be maintained during sampling operations, particularly noting sampling locations, depths, and such characteristics as grain size, color, and odor. Subsurface conditions are often stable on a daily basis and may demonstrate only slight seasonal variation especially with respect to temperature, available oxygen and light penetration. Changes in any of these conditions can radically alter the rate of chemical reactions or the associated microbiological community, thus further altering specific site conditions. Certain vegetation species can create degradation products that can alter contaminant concentrations in soil. This is why vegetation types and extent of degradation of this foliage must be recorded. To prevent degradation, samples must be kept at their at-depth temperature or lower, protected from direct light, sealed tightly in approved glass containers, and be analyzed as soon as possible after collection. In addition, to the extent possible, vegetation should be removed from the sample.

The physical properties of the soil, its grain size, cohesiveness, associated moisture, and such factors as depth to bedrock and water table, will limit the depth from which samples can be collected and the method required to collect them. It is the intent of this document to present the most commonly employed soil sampling methods used at hazardous waste sites.

6.2 Soil Sample Collection

6.2.1 Procedure for Preserving and Collecting Soil Samples for Volatile Organic Compound Analysis

Samples collected using traditional methods such as collection in a jar with no preservation have been known to yield non-representative samples due to loss of volatile organic compounds (VOCs). To prevent such losses, preservation of samples with methanol or sodium bisulfate may be used to minimize volatilization and biodegradation. This preservation may be performed either in the field or laboratory, depending on the sampling methodology employed. Because of the large number of sampling methods and associated equipment required, careful coordination between field and laboratory personnel is needed.

Soil samples to be preserved by the laboratory are currently being collected using Method SW-846, 5035. For samples preserved in the field, laboratories are currently performing low-level analyses (sodium bisulfate preservation) and high- to medium-level analyses (methanol preservation) depending on the needs of the end user.

The following procedures outline the necessary steps for collecting soil samples to be preserved at the laboratory, and for collecting soil samples to be preserved in the field with methanol or sodium bisulfate.

6.2.1.1 Soil Samples to be Preserved at the Laboratory

Soil samples collected for volatile organic analysis that are to be preserved at the laboratory shall be obtained using a hermetically sealed sample vial such as an EnCore™ sampler. Each sample shall be

obtained using a reusable sampling handle (T-handle) that can be provided with the EnCore™ sampler when requested and purchased. Collect the sample in the following manner for each EnCore™ sampler:

1. Scene Safety - Evaluate the area where sampling will occur. Ensure that the area is safe from physical, chemical, and natural hazards. Clear or barricade those hazards that have been identified.

2. Wear the appropriate personal protective equipment (PPE). This will include, at a minimum, safety glasses and nitrile surgeon's gloves. If you must kneel on the ground or place equipment on the surface being sampled, cover the ground surface with plastic to minimize surface contamination of your equipment and clothing. Wear knee pads to protect your knees from kneeling on hard or uneven surfaces.

3. Load the Encore™ sampler into the T-handle with the plunger fully depressed.

4. Expose the area to be sampled using a hand trowel or similar device to remove surface debris.

5. Press the T-handle against the freshly exposed soil surface, forcing soil into the sampler. The plunger will be forced upward as the cavity fills with soil.

6. When the sampler is full, rotate the plunger and lock it into place. If the plunger does not lock, the sampler is not full. This method ensures there is no headspace. Soft soil may require several plunges or forcing soil against a hard surface such as a sample trowel to ensure that headspace is eliminated.

7. Use a paper towel to remove soil from the side of the sampler so a tight seal can be made between the sample cap and the rubber O-ring.

8. With soil slightly piled above the rim of the sampler, force the cap on until the catches hook the side of the sampler.

9. Remove any surface soil from the outside of the sampler and place in the foil bag provided with the sampler. Good work hygiene practices and diligent decontamination procedures prevents the spread of contamination even on the outside of the containers.

10. Label the bag with appropriate information in accordance with SOP SA-6.3.

11. Place the full sampler inside a lined cooler with ice and cool to 4˚C ± 2 ˚C. Make sure any required trip blanks and temperature blanks are also in the cooler. Secure custody of the cooler in accordance with SOP SA-6.3.

12. Typically, collect three Encore™ samplers at each location. Consult the SAP or laboratory to determine the required number of Encore™ samplers to be collected.

13. The T-handle shall be decontaminated before moving to the next interval or location using a soap and water wash and rinse, and where applicable, the selected solvent as defined in the project planning documents.

Using this type of sampling device eliminates the need for field preservation and the shipping restrictions associated with preservatives. A complete set of instructions is included with each Encore™ sampler.

After the Encore™samples are collected, they should be placed on ice immediately and delivered to the laboratory within 48 hours (following the chain-of-custody and documentation procedures outlined in SOP SA-6.1). Samples must be preserved by the laboratory within 48 hours of sample collection.

6.2.1.2 Soil Samples to be Preserved in the Field

Soil samples preserved in the field may be prepared for analyses using both the low-level (sodium bisulfate preservation) and high- to medium-level (methanol preservation) methods.

Safety Reminder

When using chemicals in the field to preserve samples, the FOL and/or SSO must ensure that Materials Safety Data Sheets (MSDSs) have been provided with the chemicals to be used. They also must ensure that these chemicals have been added to the Chemical Inventory List contained within Section 5.0, Hazard Communication, of your Health and Safety Guidance Manual (HSGM). Lastly, but most importantly, the FOL and/or SSO must review the hazards with personnel using these chemicals and ensure that provisions are available for recommended PPE and emergency measures (e.g., eyewash, etc.).

Methanol Preservation (High to Medium Level):

Bottles may be pre-spiked with methanol in the laboratory or prepared in the field. Soil samples to be preserved in the field with methanol shall utilize 40 to 60 mL glass vials with septum-lined lids. Each sample bottle shall be filled with 25 mL of demonstrated analyte-free purge-and-trap grade methanol. The preferred method for adding methanol to the sample bottle is by removing the lid and using a pipette or scaled syringe to add the methanol directly to the bottle.

CAUTION

NEVER attempt to pipette by mouth

In situations where personnel are required to spike the septum using a hypodermic needle, the following provisions for handling sharps must be in place:

- Training of personnel regarding methods for handling of sharps
- Hard-sided containers for the disposal of sharps
- Provisions for treatment in cases where persons have received a puncture wound

Soil shall be collected with the use of a decontaminated (or disposable), small-diameter coring device such as a disposable tube/plunger-type syringe with the tip cut off. The outside diameter of the coring device must be smaller than the inside diameter of the sample bottle neck.

A small electronic balance or manual scale will be necessary for measuring the volume of soil to be added to the methanol-preserved sample bottle. Calibration of the scale shall be performed prior to use and intermittently throughout the day according to the manufacturer's requirements.

The sample should be collected as follows:

1. Weigh the unused syringe and plunger to the nearest 0.01 gram.

2. Pull the plunger back and insert the syringe into the soil to be sampled.

3. Collect 8 to 12 grams of soil by pushing the syringe barrel into the soil.

4. Weigh the sample and adjust until obtaining the required amount of sample.

5. Record the sample weight to the nearest 0.01 gram in the field logbook and/or on the sample log sheet.

6. Extrude the weighed soil sample into the methanol-preserved sample bottle taking care not to contact the sample container with the syringe.

7. If dirty, wipe soil particles from the threads of the bottle and cap. Cap the bottle tightly.

8. After capping the bottle, swirl the sample (do not shake) in the methanol and break up the soil such that all of the soil is covered with methanol.

9. Place the sample on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

Sodium Bisulfate Preservation (Low Level):

> ***CAUTION***
> Care should be taken when adding the soil to the sodium bisulfate solution. A chemical reaction of soil containing carbonates (limestone) may cause the sample to effervesce or the vial to possibly explode. To avoid this hazard or hazards of this type, a small sample aliquot should be subjected to the sample preservative. If it effervesces in an open air environment, utilize an alternative method such as Encore™ or 2-ounce jar.

Bottles may be prepared in the laboratory or in the field with sodium bisulfate solution. Samples to be preserved in the field using the sodium bisulfate method are to be prepared and collected as follows:

1. Add 1 gram of sodium bisulfate to 5 mL of laboratory-grade deionized water in a 40 to 60 mL glass vial with septum-lined lid.

2. Collect the soil sample and record the sample weight to the nearest 0.01 gram in the field logbook or on the sample log sheet as described for methanol preservation

3. Add the weighed sample to the sample vial.

4. Collect duplicate samples using the methanol preservation method on a one-for-one sample basis because it is necessary for the laboratory to perform both low-level and medium-level analyses.

5. Place the samples on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

> ***NOTE***
> If lower detection limits are necessary, an option to field preserving with sodium bisulfate may be to collect EnCore™ samplers at a given sample location. Consult the planning documents to determine whether this is required. If it is, collect samples in accordance with the Encore™ sampling procedure above and then send all samplers to the laboratory to perform the required preservation and analyses.

6.2.2 Procedure for Collecting Soil Samples for Non-Volatile Analyses

Samples collected for non-volatile analyses may be collected as either grab or composite samples as follows:

1. With a stainless steel trowel or other approved tool, transfer a portion of soil to be sampled to a stainless steel bowl or disposable inert plastic tray.

2. Remove roots, vegetation, sticks, and stones larger than the size of a green pea.

3. Thoroughly mix the soil in the bowl or tray to obtain as uniform a texture and color as practicable. The soil type, moisture content, amount of vegetation, and other factors may affect the amount of time required to obtain a properly mixed sample. In some cases, it may be impossible to obtain a uniform sample appearance. Use the field logbook to describe any significant difficulties encountered in obtaining a uniform mixture.

4. Transfer the mixed soil to the appropriate sample containers and close the containers.

5. Label the sample containers in accordance with SOP SA-6.3.

6. Place the containers in a cooler of ice as soon after collection as possible.

7. Prepare the sample shipment and ship the samples in accordance with SOP SA-6.1.

NOTE
Cooling may not be required for some samples depending on the scheduled analyses. Consult the planning documents if in doubt regarding correct sample preservation conditions. When in doubt – Cool to 4˚C.

NOTE
Head space is permitted in soil sample containers for non-volatile analyses to allow for sample expansion.

6.2.3 Procedure for Collecting Undisturbed Soil Samples

NOTE
Use of thin-walled undisturbed tube samplers is restricted by the consistency of the soil to be sampled. Often, very loose and/or wet samples cannot be retrieved by the samplers, and soil with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Dennison or Pitcher core samplers can be used to obtain undisturbed samples of stiff soil. Using these devices normally increases sampling costs, and therefore their use should be weighed against the need for acquiring an undisturbed sample. These devices are not discussed in this SOP because they are not commonly used.

When it is necessary to acquire undisturbed samples of soil for purposes of engineering parameter analysis (e.g., permeability), a thin-walled, seamless tube sampler (Shelby tube) shall be employed using the following collection procedure:

1. In preparation for sampling utilizing a drill rig, field personnel must complete the following activities:

   - Ensure that all subsurface drilling activities are preceded by a utility clearance for the area to be investigated. This includes activities described in SOP HS-1.0, Utility Location and Excavation Clearance, as well as any location-specific procedures that may apply.

REMEMBER
If you are digging near a marked utility (within the diameter of an underground utility that has been marked plus 18 inches), you must first locate the utility through vacuum extraction or hand digging to ensure that your activities will not damage the utility.

- Complete an Equipment Inspection Checklist for the drill rig or direct-push technology (DPT) rig. This checklist will be provided in the HASP.
- Review the Safe Work Permit prior to conducting the activity.
- Review the activity to be conducted.

2. Remove all surface debris (e.g., vegetation, roots, twigs, etc.) from the specific sampling location and drill and/or clean out the borehole to the desired sampling depth. Be careful to minimize potential disturbance of the material to be sampled. In saturated material, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and to maintain the water level in the hole at or above groundwater level.

CAUTION
The use of bottom-discharge bits or jetting through an open-tube sampler to clean out the borehole shall not be allowed. Only the use of side-discharge bits is permitted.

3. Determine whether a stationary piston-type sampler is required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used.

4. Prior to inserting the tube sampler into the borehole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the rods from pushing the sample out the tube sampler during sample withdrawal. In addition, the check valve maintains a positive suction within the tube to help retain the sample.

5. A stainless steel tube sampler is typically used to minimize chemical reaction between the sample and the sampling tube.

6. With the sampling tube resting on the bottom of the hole and the water level in the boring at groundwater level or above, push the tube into the soil with a continuous and rapid motion, without impacting or twisting. If the soil is too hard to penetrate by pushing alone, careful hammering may be used by minimizing drop distance (tapping) of the hammer. Before pulling the tube, turn it at least one revolution to shear the sample off at the bottom. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.

7. Upon removal of the sampling tube from the hole, measure the length of sample in the tube and also the length penetrated.

8. Remove disturbed material in the upper end of the tube and measure the length of sample again.

9. After removing at least 1 inch of soil from the lower end, place enough packing material (clean inert material such as paper or cloth) tightly in each end of the Shelby tube and then pour melted wax into each end to make at least a ½-inch wax plug and then add more packing material to fill the voids at both ends.

10. Place plastic caps on the ends, tape the caps in place, and dip the ends in wax to prevent loss of soil.

11. Affix label(s) to the tube as required and record sample number, depth, penetration, and recovery length on the label.

12. Mark the "up" direction on the side and upper end of the tube with indelible ink.

13. Complete a chain-of-custody form (see SOP SA-6.3) and other required forms (including Attachment A of this SOP).

14. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

CAUTION

To preserve sample integrity do not allow tubes to freeze, and store the samples vertically with the same orientation they had in the ground, (i.e., top of sample is up) in a cool place out of the sun at all times.

CAUTION

A primary concern in the preparation of the wax plugs is the potential for the heat source and melted wax to cause a fire and/or burns. Follow the directions below to prevent injury or fire.

Electrical Heating

Using hot plates to melt the wax is acceptable. In an outdoor setting, make sure a Ground Fault Circuit Interrupter (GFCI) is employed within the electrical circuit. If a portable generator is used, ensure that the generator is an adequate distance from the sampling operation (at least 50 feet). Ensure that the extension cord is rated for the intended load and for outdoor use and is free from recognizable damage. Ensure flammable preservatives are not employed or stored near the hot plate. Although a Hot Work Permit is not required, scene safety evaluation by site personnel of the above elements is. As always, if a fire potential exists, the provisions for extinguishing must be immediately accessible as well as any provisions for first aid measures.

Open Flame

If an open flame is used, the following provisions are necessary:

- Complete a Hot Work Permit and any local permit required for elevated temperature applications. The Hot Work Permit, provided in your HASP, will aid the FOL and/or the SSO in ensuring that fire protection provisions (extinguishers, fire watches, etc.) are in place as well as ensuring that local requirements have been addressed.

- Ensure that water is available to address any wax splashes or contact. If possible, immerse the contacted area. Where this is not possible, run water over the area and apply cold compresses. The need for medical attention or first aid shall be determined on site under the direction of the SSO.

6.3 Surface Soil Sampling

The simplest, most direct method of collecting surface soil samples for subsequent analysis is by use of a stainless steel shovel, hand auger, soil corer, or stainless steel or disposable plastic trowel.

> ***NOTE***
> Multiple depth intervals are used to describe surface soil. Sometimes surface soil is defined as soil from 0 to 2 inches below ground surface (bgs), and sometimes it is defined as soil from other depths such as 0 to 2 feet bgs. Ensure that the definition of surface soil depth is clear before collecting surface soil samples.
>
> For the purposes of instruction, the terms "surface soil" and "near-surface soil" are used in this SOP as follows:
>
> - Surface soil - 0 to 6 inches bgs
> - Near-surface soil - 6 to 18 inches bgs
>
> If these intervals are defined differently in the planning documents, substitute the appropriate depth ranges.

In general, the following equipment is necessary for obtaining surface soil samples:

- Stainless steel or pre-cleaned disposable trowel.
- Stainless steel hand auger, soil corer, or shovel.
- Real-time air monitoring instrument (e.g., PID, FID) as directed in project planning document.
- Required PPE.
  - Nitrile surgeon's or latex gloves may be used, layered as necessary.
  - Safety glasses
  - Other – Items identified on the Safe Work Permit may be required based on location-specific requirements such as hearing protection, steel-toed work boots, and a hard hat when working near a drill rig. These provisions will be listed in the HASP or directed by the FOL and/or SSO.

> ***Safety Reminder***
> The use of latex products may elicit an allergic reaction in some people. Should this occur, remove the latex gloves, treat for an allergic reaction, and seek medical attention as necessary.

- Required paperwork (see SOP SA-6.3 and Attachment A of this SOP)
- Required decontamination equipment
- Required sample container(s)
- Wooden stakes or pin flags

- Sealable polyethylene bags (e.g., Ziploc® baggies)
- Heavy duty cooler
- Ice
- Chain-of-custody records and custody seals

When acquiring surface soil samples, use the following procedure:

1. Place padding or use knee pads when kneeling near the sample location. If necessary, place plastic sheeting to provide a clean surface for sample equipment to avoid possible cross- contamination.
2. Carefully remove vegetation, roots, twigs, litter, etc. to expose an adequate soil surface area to accommodate sample volume requirements.
3. Using a precleaned syringe or EnCore™ samplers, follow the procedure in Section 6.2.1 for collecting surface soil samples for volatile analysis. Surface soil samples for volatile organic analysis should be collected deeper than 6 inches bgs because shallower material has usually lost most of the volatiles through evaporation. Ensure that the appropriate surface soil depth is being analyzed in accordance with the planning document.
4. Using decontaminated sampling tools, thoroughly mix in place a sufficient amount of soil to fill the remaining sample containers. See Section 6.5 of this procedure for hand auger instruction, as needed.
5. Transfer the sample into those containers utilizing a stainless steel trowel.
6. Cap and securely tighten all sample containers.
7. Affix a sample label to each container. Be sure to fill out each label carefully and clearly, addressing all the categories described in SOP SA-6.3.
8. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.
9. Site restoration – Whenever removing sample materials, always restore the surface. It is our intent to leave the area better than we found it. Do NOT create trip hazards in areas when pedestrian traffic may exist.

6.4 Near-Surface Soil Sampling

Collection of samples from near the surface (depth of 6 to 18 inches) can be accomplished with tools such as shovels, hand auger, soil corers, and stainless steel or pre-cleaned disposable trowels and the equipment listed under Section 6.5 of this procedure.

To obtain near-surface soil samples, the following protocol shall be used:

1. With a clean shovel, make a series of vertical cuts in the soil to the depth required to form a square approximately 1 foot by 1 foot.
2. Lever out the formed plug and scrape the bottom of the freshly dug hole with a decontaminated stainless steel or pre-cleaned disposable trowel to remove any loose soil.

3. Follow steps 1 through 9 of Section 6.3.

6.5 Subsurface Soil Sampling With a Hand Auger

A hand augering system generally consists of a variety of stainless steel bucket bits (approximately 6.5 inches long and 2, 2.75, 3.25, and 4 inches in diameter), series of extension rods (available in 2-, 3-, 4- and 5-inch lengths), and a T-handle connected to extension rods and to the auger bucket. A larger-diameter bucket bit is commonly used to bore a hole to the desired sampling depth and then it is withdrawn. The larger-diameter bit is then replaced with a smaller-diameter bit, lowered down the hole, and slowly turned into the soil to the completion depth (approximately 6 inches). The apparatus is then withdrawn and the soil sample collected.

The hand auger can be used in a wide variety of soil conditions. It can be used to sample soil either from the surface, or to depths in excess of 12 feet. However, the presence of subsurface rocks and landfill material and collapse of the borehole normally limit sampling depth.

To accomplish soil sampling using a hand augering system, the following equipment is required:

- Complete hand auger assembly (variety of bucket bit sizes)
- Stainless steel mixing bowls
- The equipment listed in Section 6.3
- Miscellaneous hand tools as required to assemble and disassemble the hand auger units

CAUTION

Potential hazards associated with hand augering include:

- Muscle strain and sprain due to over twisting and/or over compromising yourself.
- Equipment failure due to excessive stress on the T-handle or rods through twisting. Failure of any of these components will result in a sudden release and potential injury due to that failure.

As in all situations, any intrusive activities that could damage underground utilities shall be proceeded by a Dig/Excavation permit/ticket. Call the Utility Locating service in the area or your Project Health and Safety Officer for more information. When in doubt – **Get the Ticket!**

To obtain soil samples using a hand auger, use the following procedure:

1. Wearing designated PPE, attach a properly decontaminated bucket bit to a clean extension rod and attach the T-handle to the extension rod.
2. Clear the area to be sampled of any surface debris (vegetation, twigs, rocks, litter, etc.).
3. Twist the bucket into the ground while pushing vertically downward on the auger. The cutting shoes fill the bucket as it is advanced into the ground.
4. As the auger bucket fills with soil, periodically remove any unneeded soil.

5. Add rod extensions as necessary to extend the reach of the auger. Also, note (in a field notebook, boring log, and/or on a standardized data sheet) any changes in the color, texture or odor of the soil as a function of depth. The project-specific planning document (SAP, HASP, etc.) describe requirements for scanning the soil with a real-time air monitoring instrument (e.g., PID, FID, etc.) and recording the measurements.

6. After reaching the desired depth (e.g., the top of the interval to be sampled), slowly and carefully withdraw the apparatus from the borehole to prevent or minimize movement of soil from shallower intervals to the bottom of the hole.

7. Remove the soiled bucket bit from the rod extension and replace it with another properly decontaminated bucket bit. The bucket bit used for sampling is to be smaller in diameter than the bucket bit employed to initiate the borehole.

8. Carefully lower the apparatus down the borehole. Care must be taken to avoid scraping the borehole sides.

9. Slowly turn the apparatus until the bucket bit is advanced approximately 6 inches.

10. Discard the top of the core (approximately 1 inch), which represents any loose material collected by the bucket bit before penetrating the sample material.

11. Using a precleaned syringe or EnCore™ samplers, follow the procedure in Section 6.2.1 for collecting a soil sample for volatile compound analysis directly from the bucket bit.
12. Utilizing a properly decontaminated stainless steel trowel or dedicated disposable trowel, remove the remaining sample material from the bucket bit and place into a properly decontaminated stainless steel mixing bowl.

13. Homogenize the sample material as thoroughly as practicable then fill the remaining sample containers. Refer to Section 6.2.2.

14. Follow steps 4 through 7 listed in Section 6.3.

6.5.1 Sampling Using Stainless Steel Soil Corers

A soil corer is a stainless steel tube equipped with a cutting shoe and sample window in the side. The soil corer is advanced into the soil by applying downward pressure (body weight). The soil is unloaded by then forcing a ram towards the cutting shoe, which results in the discharge of the soil core through a window in the sleeve.

Use, application, and sample protocol is the same as for hand augering provided above, but without necessarily rotating the corer while advancing it.

SAFETY REMINDER

Hand augering and soil corer sampling can be physically demanding based on the type of geology and subsurface encumbrances encountered. Soil coring has some added hazards such the corer collapsing under your weight. To reduce the potential for muscle strain and damage, the following measures will be incorporated:

- Stretch and limber your muscles before heavy exertion. This hazard becomes more predominant in the early morning hours (prior to muscles becoming limber) and later in the day (as a result of fatigue).

- Job rotation – Share the duties so that repetitive actions do not result in fatigue and injury.

- Increase break frequencies as needed, especially as ambient conditions of heat and/or cold stress may dictate.

- Do not force the hand tools or use cheater pipes or similar devices to bypass an obstruction. Move to another location near the sampling point. Exerting additional forces on the sampling devices can result in damage and/or failure that could potentially injure someone in the immediate vicinity.

- Do not over compromise yourself when applying force to the soil corer or hand auger. If there is a sudden release, it could result in a fall or muscle injury due to strain.

6.6 Subsurface Soil Sampling with a Split-Barrel Sampler

A split-barrel (split-spoon) sampler consists of a heavy carbon steel or stainless steel sampling tube that can be split into two equal halves to reveal the soil sample (see Attachment B). A drive head is attached to the upper end of the tube and serves as a point of attachment for the drill rod. A removable tapered nosepiece/drive shoe attaches to the lower end of the tube and facilitates cutting. A basket-like sample retainer can be fitted to the lower end of the split tube to hold loose, dry soil samples in the tube when the sampler is removed from the drill hole. This split-barrel sampler is made to be attached to a drill rod and forced into the ground by means of a 140-pound or larger casing driver.

Safety Reminder

It is intended through the Equipment Inspection for Drill Rigs form provided in the HASP that the hammer and hemp rope, where applicable, associated with this activity will be inspected (no physical damage is obvious), properly attached to the hammer (suitable knots or sufficient mechanical devices), and is in overall good condition.

Split-barrel samplers are used to collect soil samples from a wide variety of soil types and from depths greater than those attainable with other soil sampling equipment.

The following equipment is used for obtaining split-barrel samples:

- Drilling equipment (provided by subcontractor).
- Split-barrel samplers (2-inch OD, 1-3/8-inch ID, either 20 inches or 26 inches long); Larger OD samplers are available if a larger volume of sample is needed.
- Drive weight assembly, 140-pound weight, driving head, and guide permitting free fall of 30 inches.
- Stainless steel mixing bowls.
- Equipment listed in Section 6.3.

The following steps shall be followed to obtain split-barrel samples (Steps 1 through 4 are typically performed by the drilling subcontractor):

1. Attach the split-barrel sampler to the sampling rods.

2. Lower the sampler into the borehole inside the hollow stem auger bits.

3. Advance the split-barrel sampler by hammering the length (typically 18 or 24 inches) of the split-barrel sampler into the soil using 140-pound or larger hammer.

4. When the desired depth is achieved, extract the drill rods and sampler from the augers and/or borehole.

5. Detach the sampler from the drill rods.

6. Place the sampler securely in a vise so it can be opened using pipe wrenches.

> ***CAUTION***
> Pipe wrenches are used to separate the split spoon into several components. The driller's helper should not apply excessive force through the use of cheater pipes or push or pull in the direction where, if the wrench slips, hands or fingers will be trapped against an immovable object.

7. Remove the drive head and nosepiece with the wrenches, and open the sampler to reveal the soil sample.

8. Immediately scan the sample core with a real-time air monitoring instrument (e.g., FID, PID, etc.) (as project-specific planning documents dictate). Carefully separate (or cut) the soil core, with a decontaminated stainless steel knife or trowel, at about 6-inch intervals while scanning the center of the core for elevated readings. Also scan stained soil, soil lenses, and anomalies (if present), and record readings.

9. If elevated vapor readings were observed, collect the sample scheduled for volatile analysis from the center of the core where elevated readings occurred. If no elevated readings where encountered, the sample material should be collected from the core's center (this area represents the least disturbed area with minimal atmospheric contact) (refer to Section 6.2.1).

10. Using the same trowel, remove remaining sample material from the split-barrel sampler (except for the small portion of disturbed soil usually found at the top of the core sample) and place the soil into a decontaminated stainless steel mixing bowl.

11. Homogenize the sample material as thoroughly as practicable then fill the remaining sample containers (refer to Section 6.2.2).

12. Follow steps 4 through 7 in Section 6.3.

6.7 Subsurface Soil Sampling Using Direct-Push Technology

Subsurface soil samples can be collected to depths of 40+ feet using DPT. DPT equipment, responsibilities, and procedures are described in SOP SA-2.5.

6.8 Excavation and Sampling of Test Pits and Trenches

6.8.1 Applicability

This subsection presents routine test pit or trench excavation techniques and specialized techniques that are applicable under certain conditions.

CAUTION

During the excavation of trenches or pits at hazardous waste sites, several health and safety concerns arise from the method of excavation. No personnel shall enter any test pit or excavation over 4 feet deep except as a last resort, and then only under direct supervision of a Competent Person (as defined in 29 CFR 1929.650 of Subpart P - Excavations). Whenever possible, all required chemical and lithological samples should be collected using the excavator bucket or other remote sampling apparatus. If entrance is required, all test pits or excavations must be stabilized by bracing the pit sides using specifically designed wooden, steel, or aluminum support structures or through sloping and benching. Personnel entering the excavation may be exposed to toxic or explosive gases and oxygen-deficient environments; therefore, monitoring will be conducted by the Competent Person to determine if it is safe to enter. Any entry into a trench greater than 4 feet deep will constitute a Confined Space Entry and must be conducted in conformance with OSHA standard 29 CFR 1910.146. In all cases involving entry, substantial air monitoring, before entry, appropriate respiratory gear and protective clothing determination, and rescue provisions are mandatory. There must be at least three people present at the immediate site before entry by one of the field team members. This minimum number of people will increase based on the potential hazards or complexity of the work to be performed. The reader shall refer to OSHA regulations 29 CFR 1926.650, 29 CFR 1910.120, 29 CFR 1910.134, and 29 CFR 1910.146. High-hazard entries such as this will be supported by members of the Health Sciences Group professionally trained in these activities.

Excavations are generally not practical where a depth of more than about 15 to 20-feet is desired, and they are usually limited to a few feet below the water table. In some cases, a pumping system may be required to control water levels within the pit, providing that pumped water can be adequately stored or disposed. If soil data at depths greater than 15-feet are required, the data are usually obtained through test borings instead of test pits.

In addition, hazardous wastes may be brought to the surface by excavation equipment. This material, whether removed from the site or returned to the subsurface, must be properly handled according to any and all applicable federal, state, and local regulations.

6.8.2 Test Pit and Trench Excavation

Test pits or trench excavations are constructed with the intent that they will provide an open view of subsurface lithology and/or disposal conditions that a boring will not provide. These procedures describe the methods for excavating and logging test pits and trenches installed to determine subsurface soil and rock conditions. Test pit operations shall be logged and documented (see Attachment C).

Test pits and trenches may be excavated by hand or power equipment to permit detailed descriptions of the nature and contamination of the in-situ materials. The size of the excavation will depend primarily on the following:

- The purpose and extent of the exploration

- The space required for efficient excavation
- The chemicals of concern
- The economics and efficiency of available equipment

Test pits normally have a cross section that is 4 to 10 feet square; test trenches are usually 3 to 6 feet wide and may be extended for any length required to reveal conditions along a specific line. The following table provides guidelines for design consideration based on equipment efficiencies.

Equipment	Typical Widths, in Feet
Trenching machine	0.25 to 1.0
Backhoe/Track Hoe	2 to 6

The lateral limits of excavation of trenches and the position of test pits shall be carefully marked on area base maps. If precise positioning is required to indicate the location of highly hazardous materials, nearby utilities, or dangerous conditions, the limits of the excavation shall be surveyed. Also, if precise determination of the depth of buried materials is needed for design or environmental assessment purposes, the elevation of the ground surface at the test pit or trench location shall also be determined by survey. If the test pit/trench will not be surveyed immediately, it shall be backfilled and its position identified with stakes placed in the ground at the margin of the excavation for later surveying.

The construction of test pits and trenches shall be planned and designed in advance as much as possible. However, the following field conditions may necessitate revisions to the initial plans:

- Subsurface utilities
- Surface and subsurface encumbrances
- Vehicle and pedestrian traffic patterns
- Purpose for excavation (e.g., the excavation of potential ordnance items)

The final depth and construction method shall be collectively determined by the FOL and designated Competent Person. The actual layout of each test pit, temporary staging area, and spoils pile may further be predicated based on site conditions and wind direction at the time the test pit is excavated. Prior to excavation, the area may be surveyed by magnetometer or metal detector or other passive methods specified in SOP HS1.0, Utility Location and Excavation Clearance, to identify the presence of underground utilities or drums. Where possible, the excavator should be positioned upwind and preferably within an enclosed cab.

No personnel shall enter any test pit or excavation except as a last resort, and then only under direct supervision of a Competent Person. If entrance is required, OSHA requirements must be met (e.g., walls must be braced with wooden or steel braces, ladders must be placed for every 25 feet of lateral travel and extended 3 feet above ground surface). A temporary guard rail or vehicle stop must be placed along the surface of the hole before entry in situations where the excavation may be approached by traffic. Spoils will be stockpiled no closer than 2 feet from the sidewall of the excavation. The excavation equipment operator shall be careful not to undercut sidewalls and will, where necessary, bench back to increase stability. The top cover, when considered clean, will be placed separately from the subsurface materials to permit clean cover. It is emphasized that the project data needs should be structured such that required samples can be collected without requiring entrance into the excavation. For example,

samples of leachate, groundwater, or sidewall soil can be collected with telescoping poles or similar equipment.

Dewatering and watering may be required to ensure the stability of the side walls, to prevent the bottom of the pit from heaving, and to keep the excavation stable. This is an important consideration for excavations in cohesionless material below the groundwater table and for excavations left open greater than a day. Liquids removed as a result of dewatering operations must be handled as potentially contaminated materials. Procedures for the collection and disposal of such materials should be discussed in the site-specific project plans.

Where possible excavations and test pits shall be opened and closed within the same working day. Where this is not possible, the following engineering controls shall be put in place to control access:

- Trench covers/street plates
- Fences encompassing the entire excavation intended to control access
- Warning signs warning personnel of the hazards
- Amber flashing lights to demarcate boundaries of the excavation at night

Excavations left open will have emergency means to exit should someone accidentally enter.

6.8.3 Sampling in Test Pits and Trenches

6.8.3.1 General

Log test pits and trenches as they are excavated in accordance with the Test Pit Log presented in Attachment C. These records include plan and profile sketches of the test pit/trench showing materials encountered, their depth and distribution in the pit/trench, and sample locations. These records also include safety and sample screening information.

Entry of test pits by personnel is extremely dangerous, shall be avoided unless absolutely necessary, and can occur only after all applicable health and safety and OSHA requirements have been met as stated above. These provisions will be reiterated as appropriate in the project-specific HASP.

The final depth and type of samples obtained from each test pit will be determined at the time the test pit is excavated. Sufficient samples are usually obtained and analyzed to quantify contaminant distribution as a function of depth for each test pit. Additional samples of each waste phase and any fluids encountered in each test pit may also be collected.

In some cases, samples of soil may be extracted from the test pit for reasons other than waste sampling and chemical analysis, for instance, to obtain geotechnical information. Such information includes soil types, stratigraphy, strength, etc., and could therefore entail the collection of disturbed (grab or bulk) or relatively undisturbed (hand-carved or pushed/driven) samples that can be tested for geotechnical properties. The purposes of such explorations are very similar to those of shallow exploratory or test borings, but often test pits offer a faster, more cost-effective method of sampling than installing borings.

6.8.3.2 Sampling Equipment

The following equipment is needed for obtaining samples for chemical or geotechnical analysis from test pits and trenches:

- Backhoe or other excavating machinery.
- Shovels, picks, hand augers, and stainless steel trowels/disposable trowels.
- Sample container - bucket with locking lid for large samples; appropriate bottle ware for chemical or geotechnical analysis samples.
- Polyethylene bags for enclosing sample containers; buckets.
- Remote sampler consisting of 10-foot sections of steel conduit (1-inch-diameter), hose clamps, and right angle adapter for conduit (see Attachment D).

6.8.3.3 Sampling Methods

The methods discussed in this section refer to test pit sampling from grade level. If test pit entry is required, see Section 6.8.3.4.

- Excavate the trench or pit in several 0.5- to 1.0-foot depth increments. Where soil types support the use of a sand bar cutting plate, use of this device is recommended to avoid potentially snagging utilities with the excavator teeth. It is recommended that soil probes or similar devices be employed where buried items or utilities may be encountered. This permits the trench floor to be probed prior to the next cut.
- After each increment:
  - the operator shall wait while the sampler inspects the test pit from grade level
  - the sampler shall probe the next interval where this is considered necessary. Practical depth increments for lithological evaluations may range from 2 to 4 feet i or where lithological changes are noted.
- The backhoe operator, who will have the best view of the test pit, shall immediately cease digging if:
  - Any fluid phase, including groundwater seepage, is encountered in the test pit
  - Any drums, other potential waste containers, obstructions, or utility lines are encountered
  - Distinct changes of material being excavated are encountered

This action is necessary to permit proper sampling of the test pit and to prevent a breach of safety protocol. Depending on the conditions encountered, it may be required to excavate more slowly and carefully with the backhoe.

For obtaining test pit samples from grade level, the following procedure shall be followed:

- Use the backhoe to remove loose material from the excavation walls and floor to the greatest extent possible.
- Secure the walls of the pit, if necessary. (There is seldom any need to enter a pit or trench that would justify the expense of shoring the walls. All observations and samples should be taken from the ground surface.)

- Samples of the test pit material are to be obtained either directly from the backhoe bucket or from the material after it has been deposited on the ground, as follows:

  a. The sampler or FOL shall direct the backhoe operator to remove material from the selected depth or location within the test pit/trench.

  b. The backhoe operator shall bring the bucket over to a designated location on the sidewall a sufficient distance from the pit (at least 5 feet) to allow the sampler to work around the bucket.

  c. After the bucket has been set on the ground, the backhoe operator shall either disengage the controls or shut the machine down.

  d. When signaled by the operator that it is safe to do, the sampler will approach the bucket.

  e. The soil shall be monitored with a photoionization or flame ionization detector (PID or FID) as directed in the project -specific planning documents.

  f. The sampler shall collect the sample from the center of the bucket or pile in accordance with surface soil sampling procedures of Section 6.3 or 6.4, as applicable. Collecting samples from the center of a pile or bucket eliminates cross-contamination from the bucket or other depth intervals.

- If a composite sample is desired, several depths or locations within the pit/trench will be selected, and the bucket will be filled from each area. It is preferable to send individual sample bottles filled from each bucket to the laboratory for compositing under the more controlled laboratory conditions. However, if compositing in the field is required, each sample container shall be filled from materials that have been transferred into a mixing bucket and homogenized. Note that homogenization/compositing is not applicable for samples to be subjected to volatile organic analysis.

> ***CAUTION***
> Care must be exercised when using the remote sampler described in the next step because of potential instability of trench walls. In situations where someone must move closer than 2 feet to the excavation edge, a board or platform should be used to displace the sampler's weight to minimize the chance of collapse of the excavation edge. Fall protection should also be employed when working near the edges or trenches greater than 6 feet deep. An immediate means to extract people who have fallen into the trench will be immediately available. These means may include ladders or rope anchor points.

- Using the remote sampler shown in Attachment D, samples can be taken at the desired depth from the sidewall or bottom of the pit as follows:

  a. Scrape the face of the pit/trench using a long-handled shovel or hoe to remove the smeared zone that has contacted the backhoe bucket.

  b. Collect the sample directly into the sample jar, by scraping with the jar edge, eliminating the need for sample handling equipment and minimizing the likelihood of cross-contamination.

  c. Cap the sample jar, remove it from the remote sampler assembly, and package the sample for shipment in accordance with SOP SA-6.3.

- Complete documentation as described in SOP SA-6.3 and Attachment C of this SOP.

6.8.3.4 In-Pit Sampling

Under rare conditions, personnel may be required to enter the test pit/trench. This is necessary only when soil conditions preclude obtaining suitable samples from the backhoe bucket (e.g., excessive mixing of soil or wastes within the test pit/trench) or when samples from relatively small discrete zones within the test pit are required. This approach may also be necessary to sample any seepage occurring at discrete levels or zones in the test pit that are not accessible with remote samplers.

In general, personnel shall sample and log pits and trenches from the ground surface, except as provided for by the following criteria:

- There are no practical alternative means of obtaining such data.
- The SSO and Competent Person determine that such action can be accomplished without breaching site safety protocol. This determination will be based on actual monitoring of the pit/trench after it is dug (including, at a minimum, measurements of oxygen concentration, flammable gases, and toxic compounds, in that order). Action levels will be provided in project-specific planning documents.
- A company-designated Competent Person determines that the pit/trench is stable trough soil classification evaluation/inspections or is made stable (by cutting/grading the sidewalls or using shoring) prior to entrance of any personnel. OSHA requirements shall be strictly observed.

If these conditions are satisfied, only one person may enter the pit/trench. On potentially hazardous waste sites, this individual shall be dressed in selected PPE as required by the conditions in the pit. He/she shall be affixed to a harness and lifeline and continuously monitored while in the pit.

A second and possible third individual shall be fully dressed in protective clothing including a self-contained breathing device and on standby during all pit entry operations to support self rescue or assisted self rescue. The individual entering the pit shall remain therein for as brief a period as practical, commensurate with performance of his/her work. After removing the smeared zone, samples shall be obtained with a decontaminated trowel or spoon.

6.8.3.5 Geotechnical Sampling

In addition to the equipment described in Section 6.8.3.2, the following equipment is needed for geotechnical sampling:

- Soil sampling equipment, similar to that used in shallow drilled boring (i.e., thin-walled tube samplers), that can be pushed or driven into the floor of the test pit.
- Suitable driving (e,g., sledge hammer) or pushing (e.g., backhoe bucket) equipment used to advance the sampler into the soil.
- Knives, spatulas, and other suitable devices for trimming hand-carved samples.
- Suitable containers (bags, jars, tubes, boxes, etc.), labels, wax, etc. for holding and safely transporting collected soil samples.
- Geotechnical equipment (pocket penetrometer, torvane, etc.) for field testing collected soil samples for classification and strength properties.

Disturbed grab or bulk geotechnical soil samples may be collected for most soil in the same manner as comparable soil samples for chemical analysis. These collected samples may be stored in jars or plastic-lined sacks (larger samples), which will preserve their moisture content. Smaller samples of this type are usually tested for their index properties to aid in soil identification and classification: larger bulk samples are usually required to perform compaction tests.

Relatively undisturbed samples are usually extracted in cohesive soil using thin-walled tube samplers, and such samples are then tested in a geotechnical laboratory for their strength, permeability, and/or compressibility. The techniques for extracting and preserving such samples are similar to those used in performing Shelby tube sampling in borings, except that the sampler is advanced by hand or backhoe, rather than by a drill rig. Also, the sampler may be extracted from the test pit by excavation around the tube when it is difficult to pull it out of the ground. If this excavation requires entry of the test pit, the requirements described in Section 6.8.3.4 shall be followed. The thin-walled tube sampler shall be pushed or driven vertically into the floor or steps excavated in the test pit at the desired sampling elevations. Extracting tube samples horizontally from the walls of the test pit is not appropriate because the sample will not have the correct orientation.

A sledge hammer or backhoe may be used to drive or push the tube into the ground. Place a piece of wood over the top of the sampler or sampling tube to prevent damage during driving/pushing of the sample. Pushing the sampler with a constant thrust is always preferable to driving it with repeated blows, thus minimizing disturbance to the sample. When using a sledge hammer, it is recommended that the sampler be stabilized using a rope/strap wrench or pipe wrench to remove the person's hands holding the sampler from the strike zone. If the sample cannot be extracted by rotating it at least two revolutions (to shear off the sample at the bottom), hook the sampler to the excavator or backhoe and extract. This means an alternative head will be used as a connection point or that multiple choke hitches will be applied to extract the sampler. If this fails and the excavator can dig deeper without potentially impacting subsurface utilities, excavate the sampler. If this fails or if the excavator cannot be used due to subsurface utilities, hand-excavate to remove the soil from around the sides of the sampler. If hand-excavation requires entry into the test pit, the requirements in Section 6.8.3.4 must be followed. Prepare the sample as described in Steps 9 through 13 in Section 6.2.3, and label, pack and transport the sample in the required manner, as described in SOPs SA-6.3 and SA-6.1.

6.8.4 Backfilling of Trenches and Test Pits

All test pits and excavations must be either backfilled, covered, or otherwise protected at the end of each day. No excavations shall remain open during non-working hours unless adequately covered or otherwise protected.

Before backfilling, the onsite crew may photograph, if required by the project-specific work plan, all significant features exposed by the test pit and trench and shall include in the photograph a scale to show dimensions. Photographs of test pits shall be marked to include site number, test pit number, depth, description of feature, and date of photograph. In addition, a geologic description of each photograph shall be entered in the site logbook. All photographs shall be indexed and maintained as part of the project file for future reference.

After inspection, backfill material shall be returned to the pit under the direction of the FOL. Backfill should be returned to the trench or test pit in 6-inch to 1-foot lifts and compacted with the bucket. Remote controlled tampers or rollers may be lowered into the trench and operated from top side. This procedure will continue to the grade surface. It is recommended that the trench be tracked or rolled in. During excavation, clean soil from the top 2 feet may have been separated to be used to cover the last segments. Where these materials are not clean, it is recommended that clean fill be used for the top cover.

If a low-permeability layer is penetrated (resulting in groundwater flow from an upper contaminated flow zone into a lower uncontaminated flow zone), backfill material must represent original conditions or be impermeable. Backfill could consist of a soil-bentonite mix prepared in a proportion specified by the FOL (representing a permeability equal to or less than original conditions). Backfill can be covered by "clean" soil and graded to the original land contour. Revegetation of the disturbed area may also be required.

6.9 Records

The appropriate sample log sheet (see Attachment A of this SOP) must be completed by the site geologist/sampler for all samples collected. All soil sampling locations should be documented by tying in the location of two or more nearby permanent landmarks (building, telephone pole, fence, etc.) or obtaining GPS coordinates; and shall be noted on the appropriate sample log sheet, site map, or field notebook. Surveying may also be necessary, depending on the project requirements.

Test pit logs (see Attachment C of this SOP) shall contain a sketch of pit conditions. If the project-specific work plan requires photographs, at least one photograph with a scale for comparison shall be taken of each pit. Included in the photograph shall be a card showing the test pit number. Boreholes, test pits, and trenches shall be logged by the field geologist in accordance with SOP GH-1.5.

Other data to be recorded in the field logbook include the following:

- Name and location of job
- Date of boring and excavation
- Approximate surface elevation
- Total depth of boring and excavation
- Dimensions of pit
- Method of sample acquisition
- Type and size of samples
- Soil and rock descriptions
- Photographs if required
- Groundwater levels
- PID/FID/LEL/O_2 meter readings
- Other pertinent information, such as waste material encountered

In addition, site-specific documentation to be maintained by the SSO and/or Competent Person will be required including:

- Calibration logs
- Excavation inspection checklists

- Soil type classification

7.0 REFERENCES

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ATTACHMENT A
SOIL & SEDIMENT SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

Date:	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

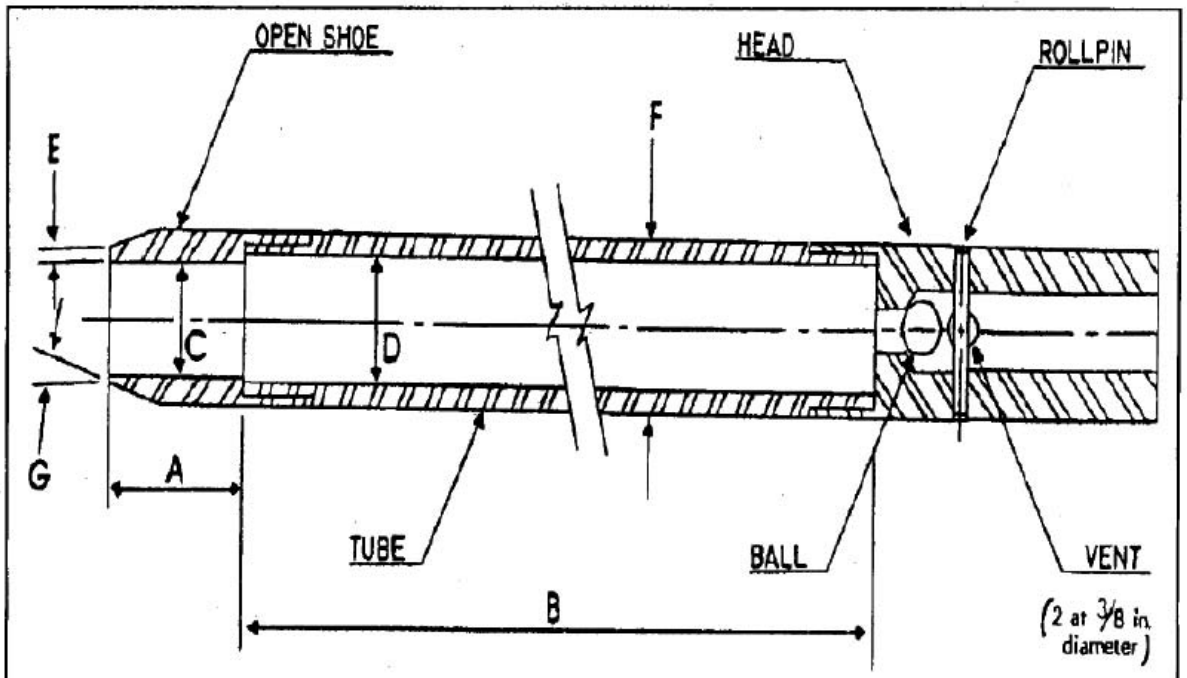
Circle if Applicable:

MS/MSD

Duplicate ID No.:

Signature(s):

ATTACHMENT B
SPLIT-SPOON SAMPLER



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)
G = 16.0° to 23.0°

The 1½ in. (38 mm) inside diameter split barrel may be used with a 16-gage wall thickness split liner. The penetrating end of the drive shoe may be slightly rounded. Metal or plastic retainers may be used to retain soil samples.

ATTACHMENT C
TEST PIT LOG

Tetra Tech NUS, Inc.

TEST PIT LOG

Page ___ of ___

PROJECT NAME: _____ TEST PIT No.: _____
PROJECT NUMBER: _____ DATE: _____
LOCATION: _____ GEOLOGIST: _____

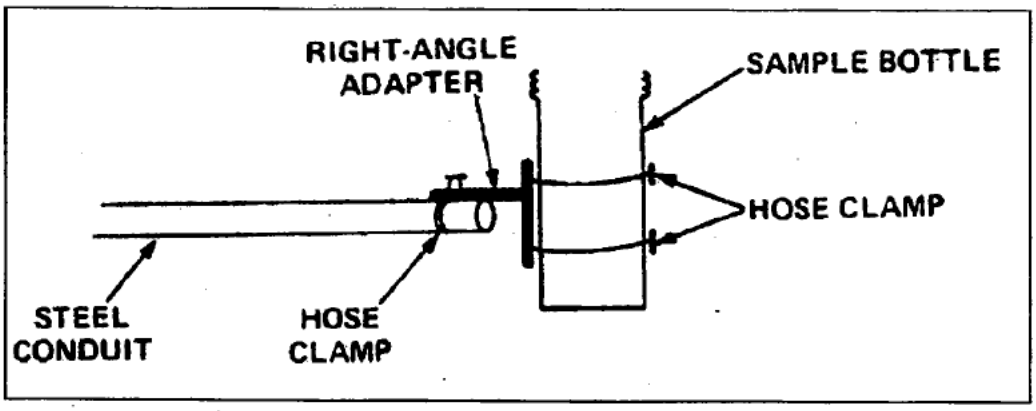
Depth (Ft.)	Lithology Change (Depth/Ft.)	MATERIAL DESCRIPTION Soil/Waste Characteristics (lithology, density, color, etc.)	USCS	Remarks	PID/FID READING Source (ppm)	BZ (ppm)

TEST PIT CROSS SECTION AND / OR PLAN VIEW

REMARKS: _____

PHOTO LOG: _____

ATTACHMENT D
REMOTE SAMPLE HOLDER FOR TEST PIT/TRENCH SAMPLING



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1.0 PURPOSE

The purpose of this procedure is to provide general reference Information on Direct Push Technology (DPT). DPT is designed to collect soil, groundwater, and soil gas samples without using conventional drilling techniques. The advantage of using DPT over conventional drilling includes the generation of little or no drill cuttings, sampling in locations with difficult accessibility, reduced overhead clearance requirements, no fluid introduction during probing, and typical lower costs per sample than with conventional techniques. Disadvantages include a maximum penetration depth of approximately 15 to 40 feet in dense soils (although it may be as much as 60 to 80 feet in certain types of geological environments), reduced capability of obtaining accurate water-level measurements, and the inability to install permanent groundwater monitoring wells. The methods and equipment described herein are for collection of surface and subsurface soil samples and groundwater samples. Soil gas sampling is discussed in SOP SA-2.4.

2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for DPT. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methodology.

3.0 GLOSSARY

Direct Push Technology (DPT) - DPT refers to sampling tools and sensors that are driven directly into the ground without the use of conventional drilling equipment. DPT typically utilizes hydraulic pressure and/or percussion hammers to advance the sampling tools. A primary advantage of DPT over conventional drilling techniques is that DPT results in the generation of little or no investigation derived waste.

Geoprobe® - Geoprobe® is a manufacturer of a hydraulically-powered, percussion/probing machines utilizing DPT to collect subsurface environmental samples. Geoprobe® relies on a relatively small amount of static weight (vehicle) combined with percussion as the energy for advancement of a tool string. The Geoprobe® equipment can be mounted in a multitude of vehicles for access to all types of environmental sites.

HydroPunch™ - HydroPunch™ is a manufacturer of stainless steel and Teflon® sampling tools that are capable of collecting representative groundwater and/or soil samples without requiring the installation of a groundwater monitoring well or conventional soil boring. HydroPunch™ is an example of DPT sampling equipment.

Flame Ionization Detector (FID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing a flame as the energizing source.

Photo Ionization Detector (PID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing ultraviolet radiation as the energizing source.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for selecting and/or reviewing the appropriate DPT drilling procedure required to support the project objectives.

Field Operations Leader (FOL)- The FOL is primarily responsible for performing the DPT in accordance with the project-specific plan.

5.0 SOIL SAMPLING PROCEDURES

5.1 General

The common methodology for the investigation of the vadose zone is soil boring drilling and soil sampling. However, drilling soil borings can be very expensive. Generally the advantage of DPT for subsurface soil sampling is the reduced cost of disposal of drilling cuttings and shorter sampling times.

5.2 Sampling Equipment

Equipment needed for conducting DPT drilling for subsurface soil sampling includes, but is not limited to, the following:

- Geoprobe® Sampling Kit
- Cut-resistant gloves
- 4-foot x 1.5-inch diameter macrocore sampler
- Probe sampling adapters
- Roto-hammer with 1.5-inch bit
- Disposable acetate liners for soil macrocore sampler
- Cast aluminum or steel drive points
- Geoprobe® AT-660 Series Large Bore Soil Sampler, or equivalent
- Standard decontamination equipment and solutions

For health and safety equipment and procedures, follow the direction provided in the Safe Work Permit in Attachment 1, or the more detailed directions provided in the project's Health and Safety Plan.

5.3 DPT Sampling Methodology

There are several methods for the collection of soil samples using DPT drilling. The most common method is discussed in the following section. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project-specific plan.

- Macrocore samplers fitted with detachable aluminum or steel drive points are driven into the ground using hydraulic pressure. If there is concrete or pavement over a sampling location, a Roto-hammer is used to drill a minimum 1.5-inch diameter hole through the surface material. A Roto-hammer may also be used if very dense soils are encountered.

- The sampler is advanced continuously in 4-foot intervals or less if desired. No soil cuttings are generated because the soil which is not collected in the sampler is displaced within the formation.

- The sampler is retracted from the hole, and the 4-foot continuous sample is removed from the outer coring tube. The sample is contained within an inner acetate liner.

- Attach the metal trough from the Geoprobe® Sampling Kit firmly to the tail gate of a vehicle. If a vehicle with a tail gate is not available, secure the trough on another suitable surface.

- Place the acetate liner containing the soils in the trough.

- While wearing cut-resistant gloves (constructed of leather or other suitable material), cut the acetate liner through its entire length using the double-bladed knife that accompanies the Geoprobe® Sampling Kit. Then remove the strip of acetate from the trough to gain access to the collected soils. Do not attempt to cut the acetate liner while holding it in your hand.

- Field screen the sample with an FID or PID, and observe/examine the sample (according to SOP GH-1.3). If appropriate, transfer the sample to sample bottles for laboratory analysis. If additional volume is required, push an additional boring adjacent to the first and composite/mix the same interval. Field compositing is usually not acceptable for sample requiring volatile organics analysis.

- Once sampling has been completed, the hole is backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch is used to cap holes through paved or concrete areas. All holes should be finished smooth to existing grade.

- In the event the direct push van/truck cannot be driven to a remote location or a sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric operated equipment (e.g., jack hammer).

- Sampling equipment is decontaminated prior to collecting the next sample.

6.0 GROUNDWATER SAMPLING PROCEDURES

6.1 General

The most common methodology for the investigation of groundwater is the installation and sampling of permanent monitoring wells. If only groundwater screening is required, the installation and sampling of temporary well points may be performed. The advantage of temporary well point installation using DPT is reduced cost due to no or minimal disposal of drilling cuttings and well construction materials, and shorter installation/times sampling.

Two disadvantages of DPT drilling for well point installation are:

- In aquifers with low yields, well points may have to be sampled without purging or development.
- If volume requirements are high, this method can be time consuming for low yield aquifers.

6.2 Sampling Equipment

Equipment needed for temporary well installation and sampling using DPT includes, but is not limited, to the following:

- 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point
- Connecting rods
- Roto-hammer with 1.5-inch bit
- Mechanical jack
- 1/4-inch OD polyethylene tubing
- 3/8-inch OD polyethylene tubing
- Peristaltic pump
- Standard decontamination equipment and solutions

6.3 DPT Temporary Well Point Installation and Sampling Methodology

There are several methods for the installation and sampling of temporary well points using DPT. The most common methodology is discussed below. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project specific plan.

- A 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point attached to connecting rods is driven into the ground to the desired depth using a rotary electric hammer or other direct push drill rig. If there is concrete or pavement over a sampling location, a Roto-hammer or electric coring machine is used to drill a hole through the surface material.

- The well point will be allowed to equilibrate for at least 15 minutes, after which a measurement of the static water level will be taken. The initial measurement of the water level will be used to assess the amount of water which is present in the well point and to determine the amount of silt and sand infiltration that may have occurred.

- The well point will be developed using a peristaltic pump and polyethylene tubing to remove silt and sand which may have entered the well point. The well point is developed by inserting polyethylene tubing to the bottom of the well point and lifting and lowering the tubing slightly while the pump is operating. The pump will be operated at a maximum rate of approximately 2 liters per minute. After removal of sediment from the bottom of the well point, the well point will be vigorously pumped at maximum capacity until discharge water is visibly clear and no further sediments are being generated. Measurements of pH, specific conductance, temperature, and turbidity shall be recorded every 5 to 10 minutes during the purging process. After two consistent readings of pH, specific conductance, temperature and turbidity (±10 percent), the well may be sampled.

- A sample will be collected using the peristaltic pump set at the same or reduced speed as during well development. Samples (with the exception of the samples to be analyzed for volatile organic compounds, VOCs) will be collected directly from the pump discharge. Sample containers for VOCs will be filled by (first shutting off the pump) crimping the discharge end of the sample tubing when filled, removing the inlet end of the sample tubing from the well, suspending the inlet tubing above the vial, and allowing water to fill each vial by gravity flow.

- Once the groundwater sample has been collected, the connecting rods and well point will be removed from the hole with the direct push rig hydraulics. The hole will be backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch will be used to cap holes through paved or concrete areas. All holes will be finished smooth to existing grade.

- In the event the direct push van/truck cannot be driven to a remote location or sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric-operated equipment (e.g., jack hammer).

- Decontaminate the equipment before moving to the next location.

7.0 RECORDS

A record of all field procedures, tests, and observations must be recorded in the field logbook, boring logs, and sample log sheets, as needed. Entries should include all pertinent data regarding the investigation. The use of sketches and field landmarks will help to supplement the investigation and evaluation.

ATTACHMENT 1
SAFE WORK PERMIT FOR DPT OPERATIONS

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): **Monitoring well drilling and installation through direct push technology**

II. Required Monitoring Instruments: _____

III. Field Crew: _____

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector _____ _____ TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

V. Protective equipment required
- Level D ☒ Level B ☐
- Level C ☐ Level A ☐
- Detailed on Reverse

Respiratory equipment required
- Full face APR ☐
- Half face APR ☐
- SKA-PAC SAR ☐
- Skid Rig ☐
- Escape Pack ☐
- SCBA ☐
- Bottle Trailer ☐
- None ☒

Level D Minimum Requirements: Sleeved shirt and long pants, safety footwear, and work gloves. Safety glasses, hard hats, and hearing protection will be worn when working near or sampling in the vicinity of the DPT rig.

Modifications/Exceptions.

VI. Chemicals of Concern | Action Level(s) | Response Measures

VII. Additional Safety Equipment/Procedures

Hard-hat	☒ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☒ Yes	☐ No
Safety Glasses	☒ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio	☐ Yes	☒ No
Splash Shield	☐ Yes	☒ No	Barricades	☒ Yes	☐ No
Splash suits/coveralls	☐ Yes	☐ No	Gloves (Type - _____)	☐ Yes	☐ No
Steel toe Work shoes or boots	☒ Yes	☐ No	Work/warming regimen	☐ Yes	☐ No

Modifications/Exceptions: Reflective vests for high traffic areas.

VIII. Procedure review with permit acceptors

	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)	☐	☒	Emergency alarms	☐	☐
Daily tail gate meetings	☒	☐	Evacuation routes	☐	☐
Contractor tools/equipment/PPE inspected	☐	☐	Assembly points	☐	☐

IX. Site Preparation

Utility Clearances obtained for areas of subsurface investigation	☐ Yes	☐ No
Physical hazards removed or blockaded	☐ Yes	☐ No
Site control boundaries demarcated/signage	☐ Yes	☐ No

X. Equipment Preparation

	Yes	NA
Equipment drained/depressurized	☐	☒
Equipment purged/cleaned	☐	☒
Isolation checklist completed	☐	☒
Electrical lockout required/field switch tested	☐	☒
Blinds/misalignments/blocks & bleeds in place	☐	☒
Hazardous materials on walls/behind liners considered	☐	☒

XI. Additional Permits required (Hot work, confined space entry). ☐ Yes ☐ No

If yes, complete permit required or contact Health Sciences, Pittsburgh Office

XII. Special instructions, precautions:

_____

Permit Issued by: _____ Permit Accepted by: _____

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide information on sample preservation, packaging, and shipping procedures to be used in handling environmental samples submitted for chemical constituent, biological, or geotechnical analysis. Sample chain-of-custody procedures and other aspects of field documentation are addressed in SOP SA-6.3. Sample identification is addressed in SOP CT-04.

2.0 SCOPE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped off site for chemical analysis.

3.0 GLOSSARY

Hazardous Material - A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated. Under 49 CFR, the term includes hazardous substances, hazardous wastes, marine pollutants, and elevated temperature materials, as well as materials designated as hazardous under the provisions of §172.101 and §172.102 and materials that meet the defining criteria for hazard classes and divisions in Part 173. With slight modifications, IATA has adopted DOT "hazardous materials" as IATA "Dangerous Goods."

Hazardous Waste - Any substance listed in 40 CFR, Subpart D (y261.30 et seq.), or otherwise characterized as ignitable, corrosive, reactive, or toxic (as defined by Toxicity Characteristic Leaching Procedure, TCLP, analysis) as specified under 40 CFR, Subpart C (y261.20 et seq.), that would be subject to manifest requirements specified in 40 CFR 262. Such substances are defined and regulated by EPA.

Marking - A descriptive name, identification number, instructions, cautions, weight, specification or UN marks, or combination thereof required on outer packaging of hazardous materials.

n.o.i - Not otherwise indicated (may be used interchangeably with n.o.s.).

n.o.s. - Not otherwise specified.

Packaging - A receptacle and any other components or materials necessary for compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, and multi-unit tank-car tanks to perform a containment function in conformance with the minimum packaging requirements of 49 CFR 173.24(a) & (b).

Placard - Color-coded, pictorial sign which depicts the hazard class symbol and name and which is placed on the side of a vehicle transporting certain hazardous materials.

Common Preservatives:

- Hydrochloric Acid - HCl
- Sulfuric Acid - H_2SO_4
- Nitric Acid - HNO_3
- Sodium Hydroxide - NaOH

Other Preservatives

- Zinc Acetate
- Sodium Thiosulfate - $Na_2S_2O_3$

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing 1 gram-atom of replaceable hydrogen or its equivalent.

Reportable Quantity (RQ) - For the purposes of this SOP, means the quantity specified in column 3 of the Appendix to DOT 49 CFR §172.101 for any material identified in column 1 of the appendix. A spill greater than the amount specified must be reported to the National Response Center.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the location and time of collection.

4.0 RESPONSIBILITIES

Field Operations Leader - Directly responsible for the bottling, preservation, labeling, packaging, shipping, and custody of samples up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record (per SOP SA-6.3), implementing the packaging and shipping requirements, and maintaining custody of samples until they are relinquished to another custodian or to the shipper.

5.0 PROCEDURES

Sample identification, labeling, documentation, and chain-of-custody are addressed by SOP SA-6.3.

5.1 Sample Containers

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, whereas many organic chemicals may dissolve various types of plastic containers. Attachments A and B show proper containers (as well as other information) per 40 CFR 136. In general, the sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample warms during transport. However, for collection of volatile organic compounds, head space shall be omitted. The analytical laboratory will generally provide certified-clean containers for samples to be analyzed for chemical constituents. Shelby tubes or other sample containers are generally provided by the driller for samples requiring geotechnical analysis. Sufficient lead time shall be allowed for a delivery of sample container orders. Therefore, it is critical to use the correct container to maintain the integrity of the sample prior to analysis.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded. Because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or a missing Teflon liner (if required for the container), shall be discarded.

5.2 Sample Preservation

Many water and soil samples are unstable and therefore require preservation to prevent changes in either the concentration or the physical condition of the constituent(s) requiring analysis. Although complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological

changes that inevitably take place after the sample is collected. Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration/ freezing (certain biological samples only).

5.2.1 Overview

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the field or be added in the field (in a clean environment). Only high purity reagents shall be used for preservation. In general, aqueous samples of low-concentration organics (or soil samples of low- or medium-concentration organics) are cooled to 4°C. Medium-concentration aqueous samples, high-hazard organic samples, and some gas samples are typically not preserved. Low-concentration aqueous samples for metals are acidified with HNO_3, whereas medium-concentration and high-hazard aqueous metal samples are not preserved. Low- or medium-concentration soil samples for metals are cooled to 4°C, whereas high-hazard samples are not cooled.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

The FOL is responsible for ensuring that an accurate Chemical Inventory is created and maintained for all hazardous chemicals brought to the work site (see Section 5 of the TtNUS Health and Safety Guidance Manual). Furthermore, the FOL must ensure that a corresponding Material Safety Data Sheet (MSDS) is collected for every substance entered on the site Chemical Inventory, and that all persons using/handling/ disposing of these substances review the appropriate MSDS for substances they will work with. The Chemical Inventory and the MSDSs must be maintained at each work site in a location and manner where they are readily-accessible to all personnel.

5.2.2 Preparation and Addition of Reagents

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade or purer and shall be diluted to the required concentration with deionized water before field sampling commences. To avoid uncontrolled reactions, be sure to Add Acid to water (not vice versa). A dilutions guide is provided below.

Acid/Base	Dilution	Concentration	Estimated Amount Required for Preservation
Hydrochloric Acid (HCl)	1 part concentrated HCl: 1 part double-distilled, deionized water	6N	5-10 mL
Sulfuric Acid (H_2SO_4)	1 part concentrated H_2SO_4: 1 part double-distilled, deionized water	18N	2 - 5 mL
Nitric Acid (HNO_3)	Undiluted concentrated HNO_3	16N	2 - 5 mL
Sodium Hydroxide (NaOH)	400 grams solid NaOH dissolved in 870 mL double-distilled, deionized water; yields 1 liter of solution	10N	2 mL

The amounts required for preservation shown in the above table assumes proper preparation of the preservative and addition of the preservative to one liter of aqueous sample. This assumes that the sample is initially at pH 7, is poorly buffered, and does not contain particulate matter; as these conditions vary, more preservative may be required. Consequently, the final sample pH must be checked using narrow-range pH paper, as described in the generalized procedure detailed below:

- Pour off 5-10 mL of sample into a dedicated, clean container. Use some of this sample to check the initial sample pH using wide range (0-14) pH paper. Never dip the pH paper into the sample; always apply a drop of sample to the pH paper using a clean stirring rod or pipette.

- Add about one-half of the estimated preservative required to the original sample bottle. Cap and invert gently several times to mix. Check pH (as described above) using medium range pH paper (pH 0-6 or pH 7.5-14, as applicable).

- Cap sample bottle and seal securely.

Additional considerations are discussed below:

- To test if ascorbic acid must be used to remove oxidizing agents present in the sample before it can be properly preserved, place a drop of sample on KI-starch paper. A blue color indicates the need for ascorbic acid addition.

  If required, add a few crystals of ascorbic acid to the sample and retest with the KI-starch paper. Repeat until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 grams of ascorbic acid per each liter of sample volume.

  Continue with proper base preservation of the sample as described above.

- Samples for sulfide analysis must be treated by the addition of 4 drops (0.2 mL) of 2N zinc acetate solution per 100 ml of sample.

  The 2N zinc acetate solution is made by dissolving 220 grams of zinc acetate in 870 mL of double-distilled, deionized water to make 1 liter of solution.

  The sample pH is then raised to 9 using the NaOH preservative.

- Sodium thiosulfate must be added to remove residual chlorine from a sample. To test the sample for residual chlorine use a field test kit specially made for this purpose.

  If residual chlorine is present, add 0.08 grams of sodium thiosulfate per liter of sample to remove the residual chlorine.

  Continue with proper acidification of the sample as described above.

For biological samples, 10% buffered formalin or isopropanol may also be required for preservation. Questions regarding preservation requirements should be resolved through communication with the laboratory before sampling begins.

5.3 Field Filtration

At times, field-filtration may be required to provide for the analysis of dissolved chemical constituents. Field-filtration must be performed prior to the preservation of samples as described above. General procedures for field filtration are described below:

- The sample shall be filtered through a non-metallic, 0.45-micron membrane filter, immediately after collection. The filtration system shall consist of dedicated filter canister, dedicated tubing, and a peristaltic pump with pressure or vacuum pumping squeeze action (since the sample is filtered by mechanical peristalsis, the sample travels only through the tubing).

- To perform filtration, thread the tubing through the peristaltic pump head. Attach the filter canister to the discharge end of the silicon tubing (note flow direction arrow); attach the aqueous sample container to the intake end of the silicon tubing. Turn the peristaltic pump on and perform filtration. Run approximately 100 ml of sample through the filter and discard prior to sample collection.

- Continue by preserving the filtrate (contained in the filter canister), as applicable and generally described above.

5.4 Sample Packaging and Shipping

Only employees who have successfully completed the TtNUS "Shipping Hazardous Materials" training course are authorized to package and ship hazardous substances. These trained individuals are responsible for performing shipping duties in accordance with this training.

Samples collected for shipment from a site shall be classified as either environmental or hazardous material samples. Samples from drums containing materials other than Investigative Derived Waste (IDW) and samples obtained from waste piles or bulk storage tanks are generally shipped as hazardous materials. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples (if there is any doubt, a sample shall be considered hazardous and shipped accordingly.)

- Protect the health and safety of transport and laboratory personnel receiving the samples (special precautions are used by the shipper and at laboratories when hazardous materials are received.)

Detailed procedures for packaging environmental samples are outlined in the remainder of this section.

5.4.1 Environmental Samples

Environmental samples are packaged as follows:

- Place properly identified sample container, with lid securely fastened, in a plastic bag (e.g. Ziploc baggie), and seal the bag.

- Place sample in a cooler constructed of sturdy material which has been lined with a large, plastic bag (e.g. "garbage" bag). Drain plugs on coolers must be taped shut.

- Pack with enough cushioning materials such as bubble wrap (shoulders of bottles must be iced if required) to minimize the possibility of the container breaking.

- If cooling is required (see Attachments A and B), place ice around sample container shoulders, and on top of packing material (minimum of 8 pounds of ice for a medium-size cooler).

- Seal (i.e., tape or tie top in knot) large liner bag.

- The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing the vials for VOC analysis. The COC form should then state how many coolers are included with that shipment.

- Close and seal outside of cooler as described in SOP SA-6.3. Signed custody seals must be used.

Coolers must be marked as containing "Environmental Samples." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling is required; there are no DOT restrictions on mode of transportation.

6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater, 15th Edition. APHA, Washington, D.C.

International Air Transport Association (latest issue). Dangerous Goods Regulations, Montreal, Quebec, Canada.

U.S. Department of Transportation (latest issue). Hazardous Materials Regulations, 49 CFR 171-177.

U.S. EPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, U.S. EPA-EMSL, Cincinnati, Ohio.

ATTACHMENT A

GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample Type and Concentration			Container[1]	Sample Size	Preservation[2]	Holding Time[2]
WATER						
Organics (GC&GC/MS)	VOC	Low	Borosilicate glass	2 x 40 mL	Cool to 4°C HCl to ≤ 2	14 days[9]
	Extractables SVOCs and pesticide/PCBs)	(Low	Amber glass	2x2 L or 4x1 L	Cool to 4°C	7 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticide/PCBs)	(Medium	Amber glass	2x2 L or 4x1 L	None	7 days to extraction; 40 days after extraction
Inorganics	Metals	Low	High-density polyethylene	1 L	HNO_3 to pH ≤2	6 months (Hg-28 days)
		Medium	Wide-mouth glass	16 oz.	None	6 months
	Cyanide	Low	High-density polyethylene	1 L	NaOH to pH>12	14 days
	Cyanide	Medium	Wide-mouth glass	16 oz.	None	14 days
Organic/ Inorganic	High Hazard		Wide-mouth glass	8 oz.	None	14 days
SOIL						
Organics (GC&GC/MS)	VOC		EnCore Sampler	(3) 5 g Samplers	Cool to 4°C	48 hours to lab preservation
	Extractables SVOCs and pesticides/PCBs)	(Low	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticides/PCBs)	(Medium	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
Inorganics	Low/Medium		Wide-mouth glass	8 oz.	Cool to 4°C	6 months (Hg - 28 days) Cyanide (14 days)
Organic/Inorganic	High Hazard		Wide-mouth glass	8 oz.	None	NA
Dioxin/Furan	All		Wide-mouth glass	4 oz.	None	35 days until extraction; 40 days after extraction
TCLP	All		Wide-mouth glass	8 oz.	None	7 days until preparation; analysis as per fraction
AIR						
Volatile Organics	Low/Medium		Charcoal tube – 7 cm long, 6 mm OD, 4 mm ID	100 L air	Cool to 4°C	5 days recommended

1 All glass containers should have Teflon cap liners or septa.
2 See Attachment E. Preservation and maximum holding time allowances per 40 CFR 136.

ATTACHMENT B

ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

Parameter Number/Name	Container[1]	Preservation[2][3]	Maximum Holding Time[4]
INORGANIC TESTS:			
Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia - Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Biochemical Oxygen Demand (BOD)	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Chemical Oxygen Demand (COD)	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Chloride	P, G	None required	28 days
Chlorine, Total Residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	P, G	Cool, 4°C; NaOH to pH 12; 0.6 g ascorbic acid[5]	14 days[6]
Fluoride	P	None required	28 days
Hardness	P, G	HNO_3 to pH 2; H_2SO_4 to pH 2	6 months
Total Kjeldahl and Organic Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Nitrate - Nitrogen	P, G	None required	48 hours
Nitrate-Nitrite - Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Nitrite - Nitrogen	P, G	Cool, 4°C	48 hours
Oil & Grease	G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Total Organic Carbon (TOC)	P, G	Cool, 4°C; HCl or H_2SO_4 to pH 2	28 days
Orthophosphate	P, G	Filter immediately; Cool, 4°C	48 hours
Oxygen, Dissolved-Probe	G Bottle & top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle & top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Phosphorus, Total	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Residue, Total	P, G	Cool, 4°C	7 days
Residue, Filterable (TDS)	P, G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, Settleable	P, G	Cool, 4°C	48 hours
Residue, Volatile (Ash Content)	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific Conductance	P, G	Cool, 4°C	28 days
Sulfate	P, G	Cool, 4°C	28 days

ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES
PAGE TWO

Parameter Number/Name	Container[1]	Preservation[2][3]	Maximum Holding Time[4]
INORGANIC TESTS (Cont'd):			
Sulfide	P, G	Cool, 4°C; add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P, G	None required	Analyze immediately
Turbidity	P, G	Cool, 4°C	48 hours
METALS:[7]			
Chromium VI (Hexachrome)	P, G	Cool, 4°C	24 hours
Mercury (Hg)	P, G	HNO_3 to pH 2	28 days
Metals, except Chromium VI and Mercury	P, G	HNO_3 to pH 2	6 months
ORGANIC TESTS:[8]			
Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% $Na_2S_2O_3$[5] HCl to pH 2 [9]	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4°C; 0.008% $Na_2S_2O_3$[5] adjust pH to 4-5 [10]	14 days
Phenols[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
Benzidines[11], [12]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction[13]
Phthalate esters[11]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitrosamines[11], [14]	G, Teflon-lined cap	Cool, 4°C; store in dark; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
PCBs[11]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitroaromatics & Isophorone[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]; store in dark	7 days until extraction; 40 days after extraction
Polynuclear Aromatic Hydrocarbons (PAHs)[11],[14]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]; store in dark	7 days until extraction; 40 days after extraction
Haloethers[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
Dioxin/Furan (TCDD/TCDF)[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction

ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES
PAGE THREE

(1) Polyethylene (P): generally 500 ml or Glass (G): generally 1L.
(2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.
(3) When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172).
(4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer periods, and has received a variance from the Regional Administrator.
(5) Should only be used in the presence of residual chlorine.
(6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments are made to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.
(7) Samples should be filtered immediately on site before adding preservative for dissolved metals.
(8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.
(9) Sample receiving no pH adjustment must be analyzed within 7 days of sampling.
(10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.
(11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for 7 days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benzidine).
(12) If 1,2-diphenylthydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benzidine.
(13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.
(14) For the analysis of diphenylnitrosamine, add 0.008% $Na_2S_2O_3$ and adjust pH to 7-10 with NaOH within 24 hours of sampling.
(15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O_3$.

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs, and reports generally initiated and maintained for documenting Tetra Tech NUS, Inc. (TtNUS) field activities.

2.0 SCOPE

Documents presented within this SOP (or equivalents) shall be used for all TtNUS field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager (PM) - The PM is responsible for obtaining hardbound controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all field documentation used in site activities (i.e., records, field reports, sample data sheets, field notebooks, and the site logbook) in the project's central file upon the completion of field work.

Field Operations Leader (FOL) - The FOL is responsible for ensuring that the site logbook, notebooks, and all appropriate and current forms and field reports included in this SOP (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time frame.

General personnel qualifications for field documentation activities include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for documentation, handling, packaging, and shipping.

5.0 PROCEDURES

5.1 SITE LOGBOOK

5.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major on-site activities are documented. At a minimum, record or reference the following activities/events (daily) in the site logbook:

- All field personnel present
- Arrival/departure times and names of site visitors
- Times and dates of health and safety training
- Arrival/departure times of equipment
- Times and dates of equipment calibration

- Start and/or completion of borehole, trench, monitoring well installation activities, etc.
- Daily on-site activities
- Sample pickup information
- Health and safety issues (level of protection, personal protective equipment [PPE], etc.)
- Weather conditions

Maintain a site logbook for each project and initiate it at the start of the first on-site activity (e.g., site visit or initial reconnaissance survey). Make entries every day that on-site activities take place involving TtNUS or subcontractor personnel. Upon completion of the fieldwork, provide the site logbook to the PM or designee for inclusion in the project's central file.

Record the following information on the cover of each site logbook:

- Project name
- TtNUS project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2) but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, either record the measurements and equipment used in the site logbook or reference the field notebook in which the measurements are recorded (see Attachment A).

Make all logbook, notebook, and log sheet entries in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, cross out the entry with a single strike mark, initial, and date it. At the completion of entries by any individual, the logbook pages used must be signed and dated by the person making the entries. The site logbook must also be signed by the FOL at the end of each day.

5.1.2 Photographs

Sequentially number movies, slides, or photographs taken of a site or any monitoring location to correspond to logbook/notebook entries. Enter the name of the photographer, date, time, site location, site description, and weather conditions in the logbook/notebook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook/notebook. If possible, such techniques shall be avoided because they can adversely affect the accuracy of photographs. Chain-of-custody procedures depend on the subject matter, type of camera (digital or film), and the processing it requires. Follow chain-of-custody procedures for film used for aerial photography, confidential information, or criminal investigation. After processed, consecutively number the slides of photographic prints and label them according to the logbook/notebook descriptions. Docket the site photographs and associated negatives and/or digitally saved images to compact disks into the project's central file.

5.2 FIELD NOTEBOOKS

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a

separate field notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a field notebook.

5.3 FIELD FORMS

All TtNUS field forms (see list in Section 6.0 of this SOP) can be found on the company's intranet site (http://intranet.ttnus.com) under Field Log Sheets. Forms may be altered or revised for project-specific needs, subject to client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOPs.

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 Sample Log Sheet

Sample log sheets are used to record specified types of data while sampling. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. Complete a sample log sheet for each sample obtained, including field quality control (QC) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B. Complete the required information on the adhesive labels and apply them to every sample container. Obtain sample labels from the appropriate program/project source, request that they be electronically generated in house, or request them the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record

The chain-of-custody record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used as follows for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site:

- Retain one carbonless copy of the completed chain-of custody form in the field.
- Send one copy is sent to the PM (or designee)
- Send the original to the laboratory with the associated samples. Place the original (top, signed copy) of the chain-of custody form inside a large Ziploc®-type bag taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one chain-of custody form, send the form with the cooler containing vials for volatile organic compound (VOC) analysis or the cooler with the air bill attached. Indicate on the air bill how many coolers are included with that shipment.

An example of a chain-of-custody form is provided as Attachment C. After the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed chain-of custody form (any discrepancies between the sample labels and chain-of custody form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the TtNUS PM). The chain-of custody form is signed and copied. The laboratory will retain the copy, and the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Chain-of-Custody Seal

Attachment D is an example of a custody seal. The custody seal is an adhesive-backed label that is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. Sign and date custody seals

and affix them across the lid and body of each cooler (front and back) containing environmental samples (see SOP SA-6.1). Obtain custody seals from the laboratory (if available) or purchase them from a supplier.

5.3.1.5 Geochemical Parameters Log Sheets

Complete Field Analytical Log Sheets to record geochemical and/or natural attenuation field test results.

5.3.2 Hydrogeological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

Complete a Groundwater Level Measurement Sheet for each round of water level measurements made at a site.

5.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. Use a Pumping Test Data Sheet to facilitate this task by standardizing the data collection format for the pumping well and observation wells, and allowing the time interval for collection to be established in advance.

5.3.2.3 Packer Test Report Form

Complete a Packer Test Report Form for each well at which a packer test is conducted.

5.3.2.4 Boring Log

Complete a Summary Log of Boring, or Boring Log for each soil boring performed to document the materials encountered, operation and driving of casing, and locations/depths of samples collected. In addition, if volatile organics are monitored on cores, samples, cuttings from the borehole, or breathing zone, (using a photoionization detector [PID] or flame ionization detector [FID]), enter these readings on the boring log at the appropriate depth. When they become available, enter the laboratory sample number, concentrations of key contaminants, or other pertinent information in the "Remarks" column. This feature allows direct comparison of contaminant concentrations with soil characteristics.

5.3.2.5 Monitoring Well Construction Details Form

Complete a Monitoring Well Construction Details Form for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock, stick-up or flush mount), different forms are used.

5.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician.

5.3.2.7 Miscellaneous Monitoring Well Forms

Miscellaneous monitoring well forms that may be required on a project-specific basis include the Monitoring Well Materials Certificate of Conformance and Monitoring Well Development Record. Use a Monitoring Well Materials Certificate of Conformance to document all materials utilized during each monitoring well installation. Use a Monitoring Well Development Record to document all well development activities.

5.3.2.8 Miscellaneous Field Forms – Quality Assurance and Checklists

Miscellaneous field forms/checklists forms that may be required on a project-specific basis include the following:

- Container Sample and Inspection Sheet – use this form when a container (drum, tank, etc.) is sampled and/or inspected.
- QA Sample Log Sheet – use this form when a QA sample such as an equipment rinsate blank, source blank, etc. is collected.
- Field Task Modification Request (FTMR) – use this form to document deviations from the project planning documents. The FOL is responsible for initiating the FTMRs. Maintain copies of all FTMRs with the on-site planning documents, and place originals in the final evidence file.
- Field Project Daily Activities Checklist and Field Project Pre-Mobilization Checklist – used these during both the planning and field effort to ensure that all necessary tasks are planned for and completed. These two forms are not requirements but are useful tools for most field work.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring, or test equipment is necessary to ensure the proper operation and response of the equipment, to document the accuracy, precision, or sensitivity of the measurements, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log, which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. Maintain an Equipment Calibration Log for each electronic measuring device used in the field; make entries for each day the equipment is used or in accordance with manufacturer recommendations.

5.4 FIELD REPORTS

The primary means of recording on-site activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation but are not easily used for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain on site for extended periods of time and are thus not accessible for timely review by project management. Other reports useful for tracking and reporting the progress of field activities are described below.

5.4.1 Daily Activities Report

To provide timely oversight of on-site contractors, complete and submit Daily Activities Reports (DARs) as described below.

5.4.1.1 Description

The DAR documents the activities and progress for each day's field work. Complete this report on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring that involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors. The DAR form can be found on the TtNUS intranet site.

5.4.1.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.1.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the DAR to the FOL for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DARs are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the PM.

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

In addition to those described herein, other summary reports may also be contractually required.

All TtNUS field forms can be found on the company's intranet site at http://intranet.ttnus.com under Field Log Sheets.

6.0 LISTING OF FIELD FORMS ON THE TtNUS INTRANET SITE

- Boring Log
- Container Sample and Inspection Sheet
- Daily Activities Checklist
- Daily Activities Record
- Equipment Calibration Log
- Field Task Modification Request
- Field Analytical Log sheet - Geochemical Parameters
- Groundwater Level Measurement Sheet
- Groundwater Sample Log Sheet
- Hydraulic Conductivity Test Data Sheet
- Low Flow Purge Data Sheet
- Bedrock Monitoring Well Construction (Stick Up)
- Bedrock Monitoring Well Construction Flush Mount
- Bedrock Monitoring Well Construction Open Hole
- Confining Layer Monitoring Well Construction
- Monitoring Well Development Record

- Monitoring Well Materials Certificate of Conformance
- Overburden Monitoring Well Construction Flush Mount
- Overburden Monitoring Well Construction Stick Up
- Packer Test Report Form
- Pumping Test Data Sheet
- QA Sample Log Sheet
- Soil/Sediment Sample Log Sheet
- Surface Water Sample Log Sheet
- Test Pit Log
- Field Project Pre-Mobilization Checklist

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: _____ DATE: _____

SITE LEADER: _____
PERSONNEL:

TtNUS	DRILLER	SITE VISITORS
_____	_____	_____
_____	_____	_____
_____	_____	_____

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.
2. Drilling activities at well ____ resumes. Rig geologist was _____. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well _____.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _____.
4. Well _____ drilled. Rig geologist was _____. See Geologist's Notebook, No. 2, page ____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _____.
8. Test pit _____ dug with cuttings placed in dump truck. Rig geologist was _____. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit ___ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.

_____

Field Operations Leader

ATTACHMENT B
SAMPLE LABEL

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090	Project: Site: Location:		
Sample No:			Matrix:
Date:	Time:	Preserve:	
Analysis:			
Sampled by:	Laboratory:		

ATTACHMENT C
CHAIN-OF-CUSTODY RECORD FORM

TETRA TECH NUS, INC. CHAIN OF CUSTODY | NUMBER 3413 | PAGE ____ OF _____

PROJECT NO:	FACILITY:	PROJECT MANAGER	PHONE NUMBER	LABORATORY NAME AND CONTACT:
SAMPLERS (SIGNATURE)		FIELD OPERATIONS LEADER	PHONE NUMBER	ADDRESS
		CARRIER/WAYBILL NUMBER		CITY, STATE

STANDARD TAT ☐
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

CONTAINER TYPE PLASTIC (P) or GLASS (G)
PRESERVATIVE USED
TYPE OF ANALYSIS

DATE YEAR	TIME	SAMPLE ID	LOCATION ID	TOP DEPTH (FT)	BOTTOM DEPTH (FT)	MATRIX (GW, SO, SW, SD, QC, ETC.)	COLLECTION METHOD GRAP (G) COMP (C)	No. OF CONTAINERS										COMMENTS

1. RELINQUISHED BY	DATE	TIME	1. RECEIVED BY	DATE	TIME
2. RELINQUISHED BY	DATE	TIME	2. RECEIVED BY	DATE	TIME
3. RELINQUISHED BY	DATE	TIME	3. RECEIVED BY	DATE	TIME

COMMENTS

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (FIELD COPY) PINK (FILE COPY)

4/02R
FORM NO. TtNUS-001

ATTACHMENT D
CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL	**CUSTODY SEAL**
Date	**Date**
Signature	**Signature**

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1.0 PURPOSE

Decontamination is the process of removing and/or neutralizing site contaminants that have contacted and/or accumulated on equipment. The purpose of this Standard Operating Procedure (SOP) is to protect site personnel, the general public, and the environment while preserving or maintaining sample integrity. It is further intended through this procedure to describe the steps necessary for proper decontamination of drilling equipment, earth-moving equipment , chemical sampling equipment and field operation and analytical equipment.

2.0 SCOPE AND APPLICABILITY

This procedure applies to all equipment used to provide access to/acquire environmental samples that may have become contaminated through direct contact with contaminated media including air, water, and soil. This equipment includes drilling and heavy equipment and chemical sampling and field analytical equipment. Where technologically and economically feasible, single-use sealed disposable equipment will be employed to minimize the potential for cross-contamination. This SOP also provides general reference information on the control of contaminated materials.

Decontamination methods and equipment requirements may differ from one project to another. General equipment items are specified in Section 6.0, but project-specific equipment must be obtained to address the project-specific decontamination procedures presented in Section 7.0 and applicable subsections.

3.0 GLOSSARY

Alconox/Liquinox - A brand of phosphate-free laboratory-grade detergent.

Decontamination Solution - A solution selected/identified in the Health and Safety Plan or Project-Specific Quality Assurance Plan. The solution is selected and employed as directed by the project chemist/health and safety professional.

Deionized Water (DI) - Tap water that has been treated by passing through a standard deionizing resin column. This water may also pass through additional filtering media to attain various levels of analyte-free status. The DI water should meet College of American Pathologists (CAP) and National Committee for Clinical Laboratory Standards (NCCLS) specifications for reagent-grade Type I water.

Potable Water - Tap water from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

Pressure Washing - Process employing a high-pressure pump and nozzle configuration to create a high-pressure spray of potable water. High-pressure spray is employed to remove solids from equipment.

Solvent – A liquid in which solid chemicals or other liquids are dissolved. The solvent of choice is pesticide-grade isopropanol. Use of other solvents (methanol, acetone, or hexane) may be required for particular projects or for a particular purpose (e.g., removal of concentrated waste) and must be justified in the project planning documents. For example, it may be necessary to use hexane when analyzing for trace levels of pesticides, PCBs, or fuels. In addition, because many of these solvents are not miscible in water, the equipment should be air dried prior to use. Solvents should not be used on PVC equipment or well construction materials.

Steam Pressure Washing - A cleaning method employing a high-pressure spray of heated potable water to remove various organic/inorganic chemicals from equipment.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) requirements.

Decontamination Personnel - Individuals assigned the task of decontamination. It is the responsibility of these individuals to understand the use and application of the decontamination process and solutions as well as the monitoring of that process to ensure that it is working properly. This is accomplished through visual evaluation, monitoring instrument scanning of decontaminated items, and/or through the collection of rinsate blanks to verify contaminant removal.

Field Operations Leader (FOL) - Responsible for the implementation of project-specific planning documents. This includes on-site verification that all field activities are performed in compliance with approved SOPs or as otherwise dictated by the approved project plan(s). The FOL is also responsible for the completion and accuracy of all field documentation.

Site Safety Officer (SSO) - Exercises shared responsibility with the FOL concerning decontamination effectiveness. All equipment arriving on site (as part of the equipment inspection), leaving the site, and moving between locations is required to go through a decontamination evaluation. This is accomplished through visual examination and/or instrument screening to determine the effectiveness of the decontamination process. Improper or incomplete decontamination is sufficient to restrict equipment from entering the site, exiting the site, or moving to a new location on the site until the objectives are successfully completed.

General personnel qualifications for decontamination activities include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate decontamination procedures.

5.0 HEALTH AND SAFETY

In addition to the health and safety issues and reminders specified in subsections of this SOP, the following considerations and requirements must be observed as SOPs for field equipment decontamination activities:

- If any solvents or hazardous chemicals (e.g., isopropyl alcohol) are to be used in equipment decontamination activities, the FOL must first obtain the manufacturer's/supplier's Material Safety Data Sheet (MSDS) and assure that it is reviewed by all users (prior to its use), added to the site Hazardous Chemical Inventory, and maintained on site as part of the project Hazard Communication Program.
- Review and observe specific health and safety requirements (e.g., personal protective equipment [PPE]) specified in the project-specific health and safety plan for this activity.

6.0 EQUIPMENT LIST

- Wood for decontamination pad construction, when applicable (see Section 7.1).

- Tools for constructing decontamination pad frame, when applicable (see Section 7.1).
- Visqueen sheeting or comparable material to cover decontamination pad frame, when applicable (see Section 7.1).
- Wash/drying racks for auger flights and drill/drive rods, when applicable (see Section 7.2).
- PPE as specified in the project health and safety plan.
- Soap and water for washing and rinsing.
- Deionized water for final rinsing.
- Solvents (e.g., pesticide-grade isopropanol) for rinsing (see applicable portions of Section 7.2).
- Tubs, buckets, etc. for containerizing rinse water (see applicable portions of Section 7.2).
- Sample bottles for collecting rinsate blanks (see Section 7.2).
- Calibrated photoionization detector (PID) or flame ionization detector (FID) to monitor decontaminated equipment for organic vapors generated through the existence of residual contamination or the presence of decontamination solvent remaining after the piece was rinsed.
- Aluminum foil or clear clean plastic bag for covering cleaned equipment (see applicable portions of Section 7.2).
- Paper towels or cloths for wiping.
- Brushes, scrapers, or other hand tools useful for removing solid materials from equipment.
- Clear plastic wrap for covering or wrapping large decontaminated equipment items (see Section 7.2.2).
- Drum-moving equipment for moving filled waste drums (optional) (see Section 7.3).
- Drum labels for waste drums (see Attachment A).

7.0 PROCEDURES

The process of decontamination is accomplished through the removal of contaminants, neutralization of contaminants, or isolation of contaminants. To accomplish this activity, preparation is required including site preparation, equipment selection, and evaluation of the decontamination requirements and processes. Site contaminant types, concentrations, and media types are primary drivers in the selection of the types of decontamination and where it will be conducted. For purposes of this SOP, discussion is limited to decontamination procedures for general environmental investigations.

Decontamination processes will be performed at the location(s) specified in project-specific planning documents. Typical decontamination locations include the following:

- Temporary decontamination pads/facilities
- Sample locations
- Centralized decontamination pad/facilities

- Combination of some or all of the above

The following discussion includes general considerations for the decontamination process. Specific construction and implementation procedures will be as specified in the project-specific planning documents and/or may be as dictated by site-specific conditions as long as the intent of the requirements in the planning documents is met. This intent is to contain any residual fluids and solids generated through the decontamination process.

7.1 Decontamination Pad Design/Construction Considerations

7.1.1 Temporary Decontamination Pads

Temporary decontamination pads may be constructed at satellite locations within the site area in support of temporary work areas. These structures are generally constructed to support the decontamination of heavy equipment such as drill rigs and earth-moving equipment but can be employed for smaller articles.

The purpose of the decontamination pad is to contain wash waters and potentially contaminated soil generated during decontamination procedures. Therefore, construction of these pads should take into account the following considerations:

- Site location – The decontamination site selected should be far enough from the work site to maximize decontamination effectiveness while minimizing travel distance. The location of the decontamination site shall be selected to provide, in the judgment of the FOL or FOL designee, compliance with as many of the following characteristics as practicable:

  - Well removed from pedestrian/vehicle thoroughfares.

  - Avoidance of areas where control/custody cannot be maintained.

  - Avoidance of areas where potential releases of contaminated media or decontamination fluids may be compounded through access to storm water transport systems, streams, or other potentially sensitive areas.

  - Avoidance of potentially contaminated areas.

  - Avoidance of areas too close to the ongoing operation, where cross-contamination may occur.

  The selected decontamination site should include the following, where possible:

  - Areas where potable water and electricity are provided.

> ***Safety Reminder***
>
> When utilizing electrical power sources, either hard-wired or portable-generated sources, ensure that:
>
> - All power is routed through a Ground Fault Circuit Interrupter (GFCI).
>
> - All power cords are in good condition (no physical damage), rated for the intended energy load, and designated for outdoor use.
>
> In situations where accomplishing these elements is not possible, it will be necessary to implement a site electrical grounding program.

- Areas where support activities such as removing decontamination waters soil and sediment are possible without entering an active exclusion zone.

- Areas that offer sufficient size to carry out the specific decontamination sequence.

- Decontamination pad (decon pad) – The decon pad shall be constructed to meet the following characteristics:

  - Size – The size of the pad should be sufficient to accept the equipment to be decontaminated as well as permitting free movement around the equipment by the personnel conducting the decontamination. The size should permit these movements utilizing pressure/steam washer wands and hoses and minimizing splash due to work in close quarters.

  - Slope – An adequate slope will be constructed to permit the collection of water and potentially contaminated soil within a trough or sump constructed at one end. The collection point for wash waters should be of adequate distance that the decontamination workers do not have to walk through the wash waters while completing their tasks. Because the pad will be sloped, place a light coating of sand over the plastic to minimize potential slips and falls. See the text about liners below.

  - Sidewalls – The sidewalls shall be at least 6 inches in height (or as high as possible if 6 inches is not achievable) to provide adequate containment for wash waters and soil. If splash represents a potential problem, splash guards should be constructed to control overspray. Sidewalls may be constructed of wood, inflatables, sand bags, etc. to permit containment. Splash guards are typically wood frames with Visqueen coverings to control overspray.

  - Liner – Depending on the types of equipment and decontamination method to be used, the liner should be of sufficient thickness to provide a puncture-resistant barrier between the decontamination operation and the unprotected environment. Care should be taken to examine the surface area prior to placing the liner to remove sharp articles (sticks, stones, debris) that could puncture the liner. Liners are intended to form an impermeable barrier. The thickness may vary from a minimum recommended thickness of 10 mil to 30 mil. The desired thickness may be achieved through layering materials of lighter construction. It should be noted that various materials (rubber, polyethylene sheeting) become slippery when wet. To minimize this potential hazard associated with a sloped liner, a light coating of sand shall be applied to provide traction as necessary.

  - Wash/drying racks – Auger flights, drill/drive rods, and similar equipment require racks positioned off of the ground to permit these articles to be washed, drained, and dried while secured from falling during this process.

For decontamination of direct-push technology (DPT) equipment, the pad may be as simple as a mortar tub containing buckets of soapy water for washing and an empty bucket to capture rinse waters. Decontamination may be conducted at the rear of the rig to permit rapid tool exchange.

- Maintenance – Maintain the decontamination area by:

  - Periodically clearing the work area of standing water, soil, and debris, and coiling hoses to aid in eliminating slip, trip, and fall hazards. In addition, these articles will reduce potential backsplash and cross-contamination.

- Regularly changing the decontamination fluids to ensure proper cleaning and prevent cross-contamination.

- PPE – Periodically evaluate the condition of, and maintain the decontamination equipment, including regular cleaning of face shields and safety glasses. This is critical to ensuring the safety of decontamination personnel and the integrity of the decontamination process, and it will ensure that equipment is functioning properly.

7.1.2 Decontamination Activities at Drill Rigs/DPT Units

During subsurface sampling activities including drilling and DPT activities, decontamination of drive rods, Macro Core Samplers, split spoons, etc. is typically conducted at an area adjacent to the operation. Decontamination is generally accomplished using a soap/water wash and rinse utilizing buckets and brushes. This area requires sufficient preparation to accomplish the decontamination objectives.

Buckets shall be placed within mortar tubs or similar secondary containment tubs to prevent splash and spills from reaching unprotected environmental media. Drying racks shall be employed as directed for temporary pads to permit parts to dry and be evaluated prior to use/reuse. Methodology regarding this activity is provided in Section 7.2.

7.1.3 Decontamination Activities at Remote Sample Locations

When sampling at remote locations, sampling equipment such as trowels and pumps/tubing should be evacuated of potentially contaminated media to the extent possible. This equipment should be wrapped in plastic for transport to the temporary/centralized decontamination location for final cleaning and disposition. Flushing and cleaning of single-use equipment such as disposable trowels, tubing, and surgeon's gloves may allow disposal of this equipment after visible soil and water remnants have been removed.

7.2 Equipment Decontamination Procedures

The following represents procedures to be employed for the decontamination of equipment that may have contacted and/or accumulated contamination through site investigation activities.

7.2.1 Monitoring Well Sampling Equipment

7.2.1.1 Groundwater sampling equipment – This includes pumps inserted into monitoring wells such as bladder pumps, Whale pumps, and Redi-Flo pumps and reusable bailers, etc.

1. Evacuate to the extent possible, any purge water within the pump/bailer.

2. Scrub using soap and water and/or steam clean the outside of the pump/bailer and, if applicable, the pump tubing.

3. Insert the pump and tubing/bailer into a clean container of soapy water. Pump/run a sufficient amount of soapy water through the pump/bailer to flush out any residual well water. After the pump is flushed, circulate soapy water through the pump to ensure that the internal components are thoroughly flushed.

4. Remove the pump and tubing/bailer from the container

5. Rinse external pump components using tap water.

6. Insert the pump and tubing/bailer into a clean container of tap water. Pump/run a sufficient amount of tap water through the pump/bailer to evacuate all of the soapy water (until clear).

> ***CAUTION***
> Do not rinse PE, PVC, and associated tubing with solvents –
> Use the procedures defined in the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 7 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

7. If groundwater contains or is suspected to contain oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment to be cleaned with pesticide-grade isopropanol.

8. Pass deionized water through the hose to flush out the tap water and solvent residue as applicable.

9. Drain residual deionized water to the extent possible.

10. Allow components of the equipment to air dry.

11. For bladder pumps, disassemble the pump and wash the internal components with soap and water, then rinse with tap water, isopropanol, and deionized water and allow to dry. After the parts are dry, conduct a visual inspection and a monitoring instrument scan to ensure that potential contaminants and all decontamination solvent have been removed. Collect a rinsate blank in accordance with the project-specific planning documents to ensure that the decontamination process is functioning as intended. The typical frequency of collection for rinsate blanks is 1 per 20 field samples. In addition, wipe samples or field tests such as UV light may be used.

12. Wrap pump/bailer in aluminum foil or a clear clean plastic bag for storage.

> ***SAFETY REMINDER***
> Remember when handling powered equipment to disconnect the power source and render the equipment to a zero energy state (both potential and kinetic) before opening valves, disconnecting lines, etc.

7.2.1.2 Electronic Water Level Indicators/Sounders/Tapes

During water level measurements, rinsing the extracted tape and probe with deionized water and wiping the surface of the extracted tape between locations is acceptable. However, periodic full decontamination should be conducted as follows:

1. Wash with soap and water
2. Rinse with tap water
3. Rinse with deionized water

> ***NOTE***
> In situations where oil, grease, free product, other hard to remove materials are encountered, probes and exposed tapes should be washed in hot soapy water. If probes or tapes cannot be satisfactorily decontaminated (they are still stained, discolored, etc.), they should be removed from service.

7.2.1.3 Miscellaneous Equipment

Miscellaneous equipment including analytical equipment (water quality testing equipment) shall be cleaned per manufacturers' instructions. This generally includes wiping the sensor housing and rinsing with tap and deionized water.

Coolers/shipping containers employed to ship samples are received from the laboratory in a variety of conditions including marginal to extremely poor. Coolers shall be evaluated prior to use for the following:

- Structural integrity – Coolers missing handles or having breaks in the outer housing should be removed and not used. Notify the laboratory that the risk of shipping samples in the cooler(s) provided is too great and request a replacement unit.

- Cleanliness – As per protocol, only volatile organic samples are accompanied by a trip blank. If a cooler's cleanliness is in question (visibly dirty/stained) or if there are noticeable odors, the cooler should be decontaminated prior to use as follows:

  1. Wash with soap and water
  2. Rinse with tap water
  3. Dry

If these measures fail to clean the cooler to an acceptable level, remove the unit from use as a shipping container and ask the cooler provider (e.g., the analytical laboratory) to provide a replacement unit.

7.2.2 Downhole Drilling Equipment

This includes any portion of the drill rig that is over the borehole, including auger flights, drill stems, rods, and associated tooling that would extend over the borehole. The following procedure is to be employed prior to initiating the drilling/sampling activity, then between locations:

> ***CAUTION***
> Exercise care when using scrapers to remove soil and debris from downhole drilling equipment. Inadvertent slips of scrapers have resulted in cuts, scrapes, and injured knuckles, so use scrapers carefully when removing soil from these items.

1. Remove loose soil using shovels, scrapers, etc.

2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment being decontaminated.

> ***CAUTION***
> In Step 3, do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

3. Rinse the equipment with tap water, where applicable (steam cleaning and pressure washing incorporate rinsing as part of the process).

4. If the equipment has directly or indirectly contacted contaminated sample media and is known or suspected of being contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse equipment with pesticide-grade isopropanol

5. To the extent possible, allow components to air dry.

6. If the decontaminated equipment is to be used immediately after decontamination, screen it with a calibrated photoionization detector (PID)/flame ionization detector (FID) to ensure that all contaminants and possible decontamination solvents (if they were used) have been adequately removed.

7. Wrap or cover equipment in clear plastic until it is time to be used.

SAFETY REMINDER

Even when equipment is disconnected from power sources, dangers such as the following may persist:

Falls - An auger flight standing on its end may fall and injure someone. Secure all loose articles to prevent heavy articles from falling onto people or equipment.

Burns - Steam cleaner water is heated to more than 212 ˚F and exhibits thermal energy that can cause burns. Prevent contact of skin with hot water or surfaces.

High water pressure - Pressure washer discharge can have 2,000 to 4,000 psi of water pressure. Water under this amount of pressure can rupture skin and other human tissues. Water at 4,000 psi exiting a 0˚ tip can be dangerous because of its relatively high cutting power. The exit velocity and cutting power of the water are reduced when exiting a 40˚ fan tip, but damage to soft tissues is still possible.

In general, follow the rules below to avoid injury, equipment damage, or incomplete decontamination:

1. Read the operating manual and follow the manufacturers' recommended safety practices before operating pressure washers and steam cleaners.

2. Never point the pressure washer or steam cleaner at another person or use to clean your boots or other parts of your body. Water lacerations and burns may appear to be minor at first but can be life threatening. Do not attempt to hold small parts in your hand while washing them with high-temperature or high-pressure water.

3. Always wear PPE as specified in the HASP such as:

   - Hard hat, safety glasses, splash shield, impermeable apron or splash suit, and hearing protection. Remember that excessive noise is a hazard when operating gas-powered engines and electrically driven pressure washers. PPE will be identified in your project specific planning documents.

4. Inspect each device before use. An inspection checklist will be provided in the project-specific planning documents. If it is a rented device, safety measures are typically provided by the vendor. In all cases, if you are not familiar with the operation of a pressure washer/steam cleaner, do not operate it until you obtain and thoroughly review operating instructions and recommended safety practices.

5. Do not modify equipment unless the manufacturer has approved the modifications.

7.2.3 Soil/Sediment Sampling Equipment

This section applies to soil sampling equipment including but not limited to hand augers, stainless steel trowels/spoons, bowls, dredges, scoops, split spoons, Macro Core samplers, etc.

1. Remove all loose soil from the equipment through manual means.

2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment.

3. Rinse the equipment with tap water.

> ***CAUTION***
> Do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

4. If the equipment is contaminated or suspected to be contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment with pesticide-grade isopropanol.

5. Rinse the equipment with deionized water.

6. To the extent possible, allow components to air dry.

7. If the equipment is to be used immediately after decontamination, screen it with a calibrated PID/FID to ensure that all solvents (if they were used) and trace contaminants have been adequately removed.

8. After the equipment has dried, wrap it in aluminum foil for storage until use.

Dredges employed in sediment sampling are typically decontaminated as follows:

- Remove the sediment sample from the sampling device

- If sufficient associated surface water is available at the sampling site, place the dredge in the water and flush to remove visible sediment.

- Extract the dredge and wash it in soap and water per the project-specific planning documents.

> ***CAUTION***
> When handling dredges, the primary safety concern is trapping fingers or extremities in the larger dredge samplers within the jaws or pinch points of the mechanical jaws. Keep hands, fingers, and extremities away from these pinch and compression points. Either handle the device by the rope or preferably lock the jaws in place to control the potential for closing during maintenance and/or cleaning.

7.3 Contact Waste/Materials

During the course of field investigations, disposable/single-use equipment becomes contaminated. These items include tubing, trowels, PPE (gloves, overboots, splash suits, etc.), and broken sample containers.

With the exception of the broken glass, single-use articles should be cleaned (washed and rinsed) of visible materials and disposed as normal refuse. The exception to this rule is that extremely soiled materials that cannot be cleaned shall be containerized for disposal in accordance with applicable federal, state, and local regulations.

7.3.1 Investigation-Derived Wastes - Decontamination Wash Waters and Sediments

NOTE
Requirements for waste storage may differ from one facility to the next. Facility-specific directions for waste storage areas will be provided in project-specific documents, or separate direction will be provided by the Project Manager.

1. Assume that all investigation-derived waste (IDW) generated from decontamination activities contains the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. Waste solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.

2. Where possible, use filtering systems to extend the use of water within a closed system wash unit to recycle water and to reduce possible waste amounts.

NOTE
Containerized waste rinse solutions are best stored in 55-gallon drums (or equivalent containers) that can be sealed until ultimate disposal at an approved facility.

3. Label waste storage containers appropriately labeled (see Attachment A).

4. Ensure that the IDW storage area is configured to meet the following specifications to permit access to the containers and to conduct spill/leak monitoring, sampling, and extraction when the disposal route is determined:

   - Enclose areas accessible by the general public using construction fencing and signs.

   - Stored materials in 55-gallon drums on pallets with four (or fewer) drums per pallet.

   - Maintain the retaining bolt and label on the outside of storage containers where readily visible.

   - Provide at least 4 feet of room between each row of pallets to allow access to containers for sampling, drum removal, and spill response.

   - As directed in project-specific planning documents, maintain an IDW Inventory List and provide the list to the site Point of Contact at the termination of each shift.

   - Maintain spill response equipment at the IDW storage area in case it is required for immediate access.

- Where possible, use equipment for moving containers. Where not possible, obtain help to manipulate containers.

CAUTION

Each container of water can weigh up to 490 pounds. Each 55-gallon drum of wet soil can weigh more than 750 pounds. Fill drums and temporary containers to 80 percent capacity to minimize spill and handling difficulties. Use drum carts to move filled drums.

See safe lifting techniques provided in Section 4.4 of the Tetra Tech NUS, Inc. Health and Safety Guidance Manual.

When placing drums, keep your fingers out of pinch and smash points such as between the drums. In some cases such as well development and/or purge water, you can place the drums to be filled on the pallet and transport materials in smaller easier to handle containers.

7.4 Decontamination Evaluation

Upon decontamination of equipment, determine the effectiveness of the decontamination process in the following manner:

- Visual evaluation – A visual evaluation will be conducted to ensure the removal of particulate matter. This shall be done to ensure that the washing/rinsing process is working as intended.

- Instrument Screening – A properly calibrated PID/FID should be used to evaluate the presence of site contaminants and solvents used in the cleaning process. The air intake of the instrument shall be passed over the article to be evaluated. Avoid placing the instrument probe into residual waters. A PID/FID reading greater than the daily established background level requires a repeat of the decontamination process, followed by rescreening with the PID/FID. This sequence must be repeated until no instrument readings greater than the daily established background level are observed. It should be noted that the instrument scan is only viable if the contaminants are detectable within the instrument's capabilities.

NOTE

When required by project-specific planning documents, collection of rinsate blanks (see next step) shall be completed without exception unless approval to not collect these samples is obtained from the Project Manager.

- Collection of Rinsate Blanks – It is recommended that rinsate samples be collected to:

  - Evaluate the decontamination procedure representing different equipment applications (pumps versus drilling equipment) and different decontamination applications.

  - Single-use disposable equipment – The number of samples should represent different types of equipment as well as different lot numbers of single-use articles.

  - The collection and the frequency of collection of rinsate samples are as follows unless specified differently in the project-specific planning documents:

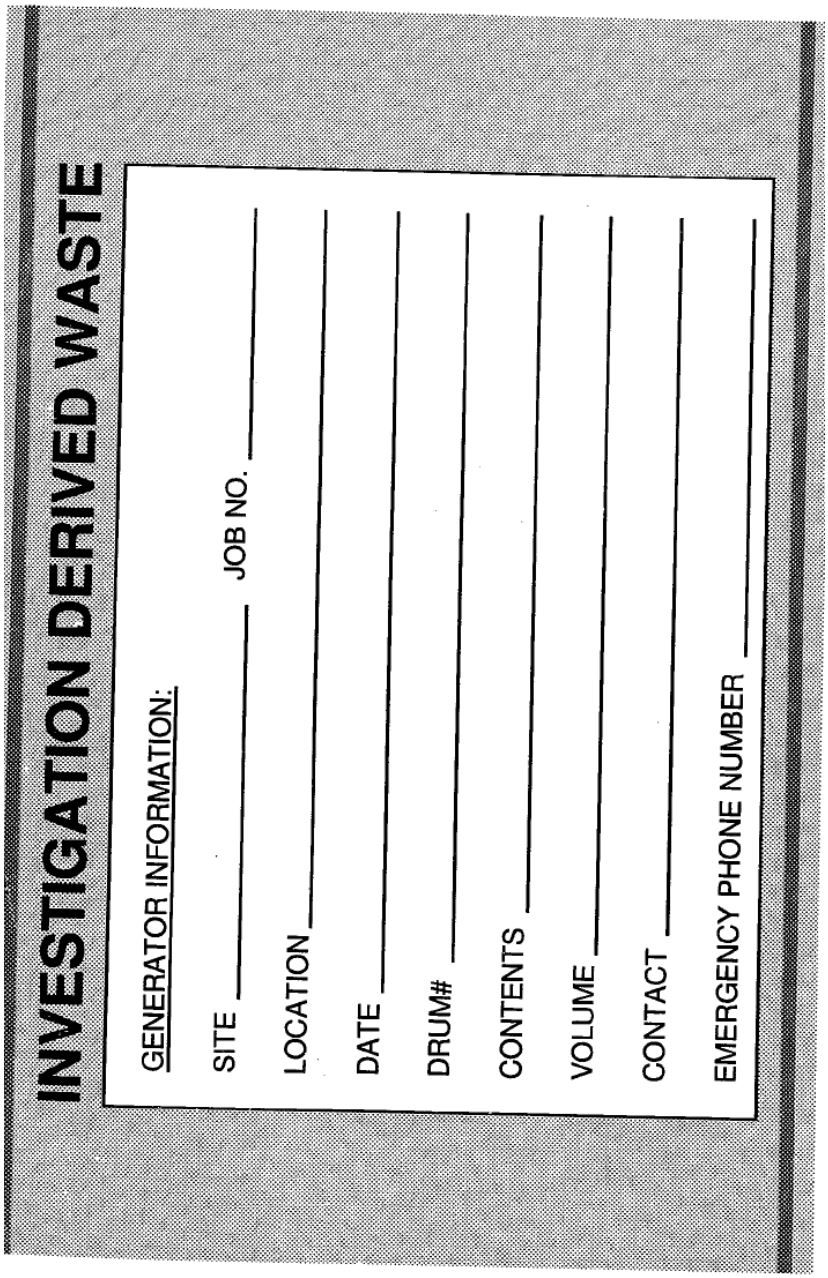
    - Per decontamination method
    - Per disposable article/batch number of disposable articles

NOTE

It is recommended that an initial rinsate sample be collected early in the project to ensure that the decontamination process is functioning properly and to avoid using a contaminated batch of single-use articles. It is recommended that a follow-up sample be collected later during the execution of the project to ensure that those conditions do not change.

Rinsate samples collection may be driven by types of and/or levels of contaminant. Difficult to remove contaminants, oils/greases, some PAHs/PCBs, etc. may also support the collection of additional rinsates due to the obvious challenges to the decontamination process. This is a field consideration to be determined by the FOL.

Attachment A
iDW Label



APPENDIX C

FIELD LOG SHEETS

ATTACHMENT C
CHAIN-OF-CUSTODY RECORD FORM

TETRA TECH NUS, INC. CHAIN OF CUSTODY | NUMBER 3413 | PAGE ____ OF _____

PROJECT NO:	FACILITY:	PROJECT MANAGER	PHONE NUMBER	LABORATORY NAME AND CONTACT:
SAMPLERS (SIGNATURE)		FIELD OPERATIONS LEADER	PHONE NUMBER	ADDRESS
		CARRIER/WAYBILL NUMBER		CITY, STATE

STANDARD TAT ☐
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

CONTAINER TYPE PLASTIC (P) or GLASS (G)
PRESERVATIVE USED
TYPE OF ANALYSIS

DATE YEAR	TIME	SAMPLE ID	LOCATION ID	TOP DEPTH (FT)	BOTTOM DEPTH (FT)	MATRIX (GW, SO, SW, SD, QC, ETC.)	COLLECTION METHOD GRAP (G) COMP (C)	No. OF CONTAINERS									COMMENTS

1. RELINQUISHED BY	DATE	TIME	1. RECEIVED BY	DATE	TIME
2. RELINQUISHED BY	DATE	TIME	2. RECEIVED BY	DATE	TIME
3. RELINQUISHED BY	DATE	TIME	3. RECEIVED BY	DATE	TIME

COMMENTS

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (FIELD COPY) PINK (FILE COPY)

4/02R
FORM NO. TtNUS-001

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME : _____ INSTRUMENT NAME/MODEL: _____

SITE NAME: _____ MANUFACTURER: _____

PROJECT No.: _____ SERIAL NUMBER: _____

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration	Post-calibration	Pre-calibration	Post-calibration		

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: _____ **Project No.:** _____

Location: _____ **Personnel:** _____

Weather Conditions: _____ **Measuring Device:** _____

Tidally Influenced: Yes ____ No ____ **Remarks:** _____

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Total Well Depth (feet)*	Water Level Indicator Reading (feet)*	Thickness of Free Product (feet)*	Groundwater Elevation (feet)*	Comments

* All measurements to the nearest 0.01 foot

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: _____ **WELL ID.:** _____

PROJECT NUMBER: _____ **DATE:** _____

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	pH (S.U.)	S. Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celcius)	ORP mV	Salinity % or ppt	Comments

SIGNATURE(S): _____

PAGE___OF___

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Well: _____ Depth to Bottom (ft.): _____ Responsible Personnel: _____
Site: _____ Static Water Level Before (ft.): _____ Drilling Co.: _____
Date Installed: _____ Static Water Level After (ft.): _____ Project Name: _____
Date Developed: _____ Screen Length (ft.): _____ Project Number: _____
Dev. Method: _____ Specific Capacity: _____
Pump Type: _____ Casing ID (in.): _____

Time	Estimated Sediment Thickness (Ft.)	Cumulative Water Volume (Gal.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units _____)	Turbidity (NTU)	Remarks (odor, color, etc.)

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME : _____ INSTRUMENT NAME/MODEL: _____

SITE NAME: _____ MANUFACTURER: _____

PROJECT No.: _____ SERIAL NUMBER: _____

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration	Post-calibration	Pre-calibration	Post-calibration		

Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Project Site Name: _____
Project No.: _____

[] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date:			
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

Tetra Tech NUS, Inc.

SURFACE WATER SAMPLE LOG SHEET

Project Site Name: _____
Project No.: _____

[] Stream
[] Spring
[] Pond
[] Lake
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (^{0}C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other
Date:								
Time:								
Depth:								
Method:								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

ATTACHMENT C

QUALITY ASSURANCE PROJECT PLAN

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ACRONYMS

°C	degrees Celcius
%R	Percent recovery
COC	Chain-of-custody
CVAA	Cold vapor atomic absorption
DO	Dissolved oxygen
FID	Flame ionization detector
FOL	Field Operations Leader
FSP	Field Sampling Plan
FTMR	Field task modification request
GC/MS	Gas Chromatography/Mass Spectrometer
HPLC	High Performance Liquid Chromatography
HR/GC/MS	High Resolution Gas Chromatography Mass Spectrometry
ICP	Inductively Coupled Plasma
IDW	Investigation-derived waste
LCS	Laboratory Control Sample
MDL	Method detection limit
MS	Matrix spike
MSD	Matrix spike duplicate
mg/kg	Milligram per kilogram
mg/L	Milligram per liter
NELAP	National Environmental Laboratory Accreditation Program
NIST	National Institute of Science and Technology
NTU	Nephelometric turbidity unit
PAHs	Polycyclic Aromatic Hydrocarbons
PARCC	Precision, accuracy, representativeness, comparability, and completeness
PDF	Portable document format
PDS	Post-digestion spike
PID	Photoionization detector
PM	Project Manager
PPE	Personal protective equipment
QL	Quantitation Limit
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RI/FS	Remedial Investigation/Feasibility Study
RPD	Relative percent difference

SDG	Sample delivery group
SOP	Standard Operating Procedure
TPH	Total Petroleum Hydrocarbons
USEPA	United States Environmental Protection Agency
µg/L	microgram per liter
VOC	Volatile organic compound
WP	Work Plan

1.0 PROJECT DESCRIPTION

1.1 INTRODUCTION

This Quality Assurance Project Plan (QAPP) outlines the organization, objectives, planned activities and Quality Assurance/Quality Control (QA/QC) procedures associated with sampling and analysis activities at Kilgore Manufacturing Company Facility (the Site) located in Westerville, Ohio. This QAPP addresses specific protocols for sample collection, sample handling and storage, chain of custody, laboratory and field analyses, data validation, and data reporting.

1.1.1 PROJECT OBJECTIVE

The objective of this Remedial Investigation/Feasibility Study (RI/FS) is to collect additional data for evaluation of specific suspected source areas and for development of risk assessments, prior to conducting excavation removal action if risk warrants.

1.1.2 QAPP Preparation Guidelines

This QAPP has been prepared in accordance with the general requirements and content outlined in United States Environmental Protection Agency (USEPA) Guidance for Quality Assurance Project Plans, EPA QA/G-5 (USEPA, 2002). A variation of the QA/G-5 format was implemented by providing a separate Work Plan (WP), Field Sampling Plan (FSP) and QAPP in accordance with the statement of work. QA/G-5 allows deviations from the QA/G-5 format and Tetra Tech, Inc. (Tetra Tech) has also found it to be more user friendly both in development and implementation to separate the WP, FSP and QAPP.

1.2 SITE DESCRIPTION

A site description, including the location and general description, site history, land use, water sources and usage, population, physiography and topography, geology, soils, hydrogeology, hydrology, ecology, and meteorology is provided in Section 2.0 of the WP.

1.3 PROJECT TARGET PARAMETERS AND INTENDED DATA USES

This section discusses the field and laboratory analytical information to be generated during the course of this investigation. Field parameters and intended data uses are discussed in Section 1.3.1. Laboratory parameters and intended data uses are discussed in Section 1.3.2.

1.3.1 Field Parameters

Field parameters include those associated with the completion of soil borings, installation and development of monitoring wells, and groundwater sampling and analysis. Field measurements include only those measurements completed using field instrumentation.

Field measurements of total volatile organic compounds (VOCs) will be completed using a photoionization detector (PID). These measurements will be used as screening tools to determine the following: (1) appropriate subsurface sample horizons to be submitted for laboratory analysis; (2) relative spatial distribution of VOC contamination; (3) locations that require additional investigative work; (4) breathing zone conditions of site workers; and (5) gross levels of VOC contamination in investigation-derived waste (IDW). In addition to the obvious health and safety advantages, PID measurements aid in the decision-making process during data collection activities and are not intended to be a substitute for conventional analytical methodologies. Rather, they are used as screening tools to enable conventional analytical methods to be used more effectively.

Field parameters including pH, specific conductivity, turbidity, dissolved oxygen (DO), and temperature will be collected for all aqueous phase samples. These measurements will be used to support monitoring well development and purging of stagnant water from well casings. Specific conductivity and pH can also be used as general indicators of water quality. It is anticipated that a Horiba® Model U-22 combination water-quality meter, or equivalent will be used as per the manufacturer's calibration instructions. All five parameters are measured simultaneously, and the instrument is capable of storing the data in memory, printing the stored data, or presenting it for viewing directly on the instrument panel. Calibration will be performed/checked daily.

1.3.2 Laboratory Parameters

All samples will be analyzed using USEPA Test Methods for Evaluating Solid Wastes, Volumes 1A through 1C: Laboratory Manuals Physical/Chemical Methods, SW-846 (USEPA, 1983), hereafter refered to as SW-846.

1.3.2.1 Soil Analysis

Soil samples submitted to the laboratory will be analyzed for: metals using SW-846 methods 6010C and 7471A; and explosives using SW-846 method 8330A. Select soil samples will be analyzed for VOCs using SW-846 method 8260B with preparatory method 5035A; Polycyclic Aromatic Hydrocarbons (PAHs) using SW-846 method 8270D with selective ion monitoring (SIM); Total Organic Carbon (TOC) via the Walkley Black method; pH via SW-846 9045C; Dioxins/Furans via SW-846 8290A; and Total Petroleum

Hydrocarbons (TPH) Range C6-C12, TPH Range (C10-C20), TPH Range (C20-C34) all via SW-846 8015D.

1.3.2.2 Groundwater Analysis

Groundwater samples will be analyzed for: metals using SW-846 methods 6010C and 7471A; and explosives using SW-846 method 8330A. Select groundwater samples will be analyzed for VOCs using SW-846 method 8260B; PAHs using SW-846 method 8270D with SIM; and perchlorate using SW-846 6850.

1.3.2.3 Surface Water Analysis

Surface water samples will be analyzed for: total and dissolved metals using SW-846 methods 6010C and 7471A and explosives using SW-846 method 8330A.

1.3.2.4 Drainage Channel Soil Analysis

Drainage channel soil samples will be analyzed for: metals using SW-846 methods 6010C and 7471A and explosives using SW-846 method 8330A.

Table 1-1 provides a summary of the analytical methods, and Tables 1-2 summarizes the quantitation limits (QLs) and Method Detection Limits (MDLs) for both soil and water samples. QLs and MDLs are further discussed in Section 7.2 of this QAPP.

1.4 DATA QUALITY OBJECTIVES

Data Quality Objectives are presented in Section 4 of the WP.

1.5 SAMPLE NETWORK DESIGN AND RATIONALE

Sample network design and rationale will be provided in Section 5.0 of the FSP.

TABLE 1-1

ANALYTICAL METHODS SUMMARY
QUALITY ASSURANCE PROJECT PLAN
FORMER KILGORE MANUFACTURING FACILITY, WESTERVILLE, OHIO

Parameter	Preparation Method	Analytical Method
Aqueous Matrices		
VOCs	SW-846 5030B[1]	SW-846 8260B
PAHs	SW-846 3510C or 3520C	SW-846 8270C
Metals	SW-846 3005A	SW-846 6010B/7470A
Explosives	SW-846 8330A	SW-846 8330A
Perchlorate	SW-846 6850	SW-846 6850
Solid Matrices		
VOCs	SW-846 5035	SW-846 8260B
PAHs	SW-846 3550	SW-846 8270C
TPH Range C6-12	TBD	SW-846 8015D
TPH Range C10-20	TBD	SW-846 8015D
TPH Range C20-34	TBD	SW-846 8015D
Dioxin/Furans	SW-846 8290A	SW-846 8290A
Metals	SW-846 3050B	SW-846 6010B/7471A
Explosives	SW-846 8330A	SW-846 8330A
Perchlorate	SW-846 6850	SW-846 6850
TOC	NA	Walkley Black
pH	NA	SW-846 9045C

1 USEPA, 1986. Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods. SW-846, 3rd ed. with updates up to and including Update III and IV.

TBD - To be determined. Laboratory will provide method according to their SOP upon procurement of services for these analysis.

TABLE 1-2

PROJECT ACTION LIMITS AND LABORATORY QUANTITATION AND METHOD DETECTION LIMITS FOR SURFACE WATER SAMPLES
FORMER KILGORE MANUFACTURING FACILITY, WESTERVILLE, OHIO

CAS No.	Chemical	Ecological PAL (mg/kg)	Ecological PAL Reference	Human Health PAL (mg/kg)	Human Health Reference	Test America QL mg/kg	Test America MDL mg/kg
	TAL Metals (mg/kg)						
7429-90-5	ALUMINUM	pH	Eco SSL	7700	RSL-R	5	1.3
7440-36-0	ANTIMONY	0.27	Eco SSL	0.66	RB-SSL	0.2	0.024
7440-38-2	**ARSENIC**	18	Eco SSL	**0.0013**	**RB-SSL**	**0.5**	**0.062**
7440-39-3	BARIUM	330	Eco SSL	300	RB-SSL	0.1	0.046
7440-41-7	BERYLLIUM	21	Eco SSL	16	RSL-R	0.1	0.047
7440-43-9	CADMIUM	0.36	Eco SSL	1.4	RB-SSL	0.1	0.0078
7440-70-2	CALCIUM	---		---		100	40
7440-47-3	CHROMIUM	26	Eco SSL	---		0.2	0.04
7440-48-4	COBALT	13	Eco SSL	0.49	RB-SSL	0.1	0.0038
7440-50-8	COPPER	28	Eco SSL	51	RB-SSL	0.2	0.043
7439-89-6	IRON	pH	Eco SSL	640	RB-SSL	5	1
7439-92-1	LEAD	11	Eco SSL	40	RB-SSL	0.1	0.013
7439-97-6	**MERCURY**	**0.00051**	**EPA PRG**	**0.03**	**RB-SSL**	**0.2**	**0.012**
7439-95-4	MAGNESIUM	---		---		100	2.1
7439-96-5	MANGANESE	220	Eco SSL	57	RB-SSL	0.1	0.047
7440-02-0	NICKEL	38	Eco SSL	48	RB-SSL	0.1	0.021
7440-09-7	POTASSIUM	---		---		100	1.1
7782-49-2	SELENIUM	0.52	Eco SSL	0.95	RB-SSL	0.5	0.09
7440-22-4	SILVER	4.2	Eco SSL	1.6	RB-SSL	0.1	0.016
7440-23-5	SODIUM	---		---		100	2.4
7440-24-6	STRONTIUM	---		770	RB-SSL	1	0.063
7440-28-0	THALLIUM	1	EPA PRG	---		0.1	0.013
7440-62-2	VANADIUM	7.8	Eco SSL	39	RSL-R	0.5	0.041
7440-66-6	ZINC	46	Eco SSL	680	RB-SSL	2	0.2
	TCL VOCs (mg/kg)						
75-34-3	**1,1- DICHLOROETHANE**	20.1	EPA R5	**0.00069**	**RB-SSL**	**0.005**	**0.0003**
71-55-6	1,1,1-TRICHLOROETHANE	29.8	EPA R5	3.2	RB-SSL	0.005	0.0005
79-00-5	**1,1,2- TRICHLOROETHANE**	28.6	EPA R5	**0.000078**	**RB-SSL**	**0.005**	**0.0003**
79-34-5	1,1,2,2- TETRACHLORETHANE	0.127	EPA R5	---		0.005	0.0003
76-13-1	1,1,2-TRICHLORO-1,2,2-TRIFLUORO-ETHANE	---		150	RB-SSL	0.005	0.00013
75-35-4	1,1-DICHLOROETHENE	8.28	EPA R5	0.12	RB-SSL	0.005	0.00052
95-50-1	1,2- DICHLOROBENZENE	20	EPA PRG	0.36	RB-SSL	0.005	0.00036
107-06-2	**1,2- DICHLOROETHANE**	21.2	EPA R5	**0.000042**	**RB-SSL**	**0.005**	**0.00034**
87-61-6	1,2,3-TRICHLOROBENZENE	20	EPA PRG	0.087	RB-SSL	0.005	0.00038
120-82-1	1,2,4-TRICHLOROBENZENE	20	EPA PRG	0.0068	RB-SSL	0.005	0.00027
96-12-8	**1,2-DIBROMO-3-CHLOROPROPANE**	0.0352	EPA R5	**0.00000014**	**RB-SSL**	**0.01**	**0.0013**
106-93-4	**1,2-DIBROMOETHANE**	1.23	EPA R5	**0.0000018**	**RB-SSL**	**0.005**	**0.0005**
78-87-5	**1,2-DICHLOROPROPANE**	32.7	EPA R5	**0.00013**	**RB-SSL**	**0.005**	**0.00069**
541-73-1	1,3-DICHLOROBENZENE	37.7	EPA R5	---		0.005	0.00035
106-46-7	**1,4- DICHLOROBENZENE**	20	EPA PRG	**0.00041**	**RB-SSL**	**0.005**	**0.00066**

TABLE 1-2

PROJECT ACTION LIMITS AND LABORATORY QUANTITATION AND METHOD DETECTION LIMITS FOR SURFACE WATER SAMPLES
FORMER KILGORE MANUFACTURING FACILITY, WESTERVILLE, OHIO

CAS No.	Chemical	Ecological PAL (mg/kg)	Ecological PAL Reference	Human Health PAL (mg/kg)	Human Health Reference	Test America QL mg/kg	Test America MDL mg/kg
123-91-1	**1,4-DIOXANE**	2.05	EPA R5	**0.0013**	**RB-SSL**	**0.25**	**0.1**
78-93-3	2-BUTANONE	89.6	EPA R5	1.5	RB-SSL	0.25	0.0014
591-78-6	**2-HEXANONE**	12.6	EPA R5	**0.011**	**RB-SSL**	**0.02**	**0.00063**
108-10-1	4-METHYL-2-PENTANONE	443	EPA R5	0.45	RB-SSL	0.02	0.00054
67-64-1	ACETONE	2.5	EPA R5	4.5	RB-SSL	0.02	0.0063
71-43-2	**BENZENE**	0.255	EPA R5	**0.00021**	**RB-SSL**	**0.005**	**0.00023**
74-97-5	BROMOCHLOROMETHANE	---		---		0.005	0.00028
75-27-4	**BROMODICHLOROMETHANE**	0.54	EPA R5	**0.000032**	**RB-SSL**	**0.005**	**0.00028**
75-25-2	BROMOFORM	15.9	EPA R5	**0.0023**	**RB-SSL**	**0.005**	**0.00033**
74-83-9	BROMOMETHANE	0.235	EPA R5	**0.0022**	**RB-SSL**	**0.005**	**0.00054**
75-15-0	CARBON DISULFIDE	0.0941	EPA R5	0.31	RB-SSL	0.005	0.00044
56-23-5	**CARBON TETRACHLORIDE**	2.98	EPA R5	**0.00017**	**RB-SSL**	**0.005**	**0.00037**
108-90-7	CHLOROBENZENE	40	EPA PRG	0.062	RB-SSL	0.005	0.00033
75-00-3	CHLOROETHANE	---		5.9	RB-SSL	0.005	0.00086
67-66-3	**CHLOROFORM**	1.19	EPA R5	**0.000053**	**RB-SSL**	**0.005**	**0.00029**
74-87-3	CHLOROMETHANE	10.4	EPA R5	0.049	RB-SSL	0.005	0.00041
156-59-2	CIS-1,2- DICHLOROETHENE	0.78373	EPA R5	0.11	RB-SSL	0.005	0.00036
10061-01-5	**CIS-1,3- DICHLOROPROPENE**	0.39786	EPA R5	**0.00015**	**RB-SSL**	**0.005**	**0.00034**
110-82-7	CYCLOHEXANE	---		13	RB-SSL	0.01	0.00033
124-48-1	**DIBROMOCHLOROMETHANE**	2.05	EPA R5	**0.000039**	**RB-SSL**	**0.005**	**0.00055**
75-71-8	DICHLORODIFLUOROMETHANE	39.5	EPA R5	0.61	RB-SSL	0.005	0.0005
100-41-4	**ETHYLBENZENE**	5.16	EPA R5	**0.0017**	**RB-SSL**	**0.005**	**0.00026**
98-82-8	ISOPROPYLBENZENE	---		1.1	RB-SSL	0.005	0.00016
79-20-9	METHYL ACETATE	---		7.5	RB-SSL	0.01	0.0014
1634-04-4	**METHYL TERT-BUTYL ETHER**	---		**0.0028**	**RB-SSL**	**0.02**	**0.00043**
108-87-2	METHYLCYCLOHEXANE	---		---	RB-SSL	0.01	0.00031
75-09-2	**METHYLENE CHLORIDE**	4.05	EPA R5	**0.0012**	**RB-SSL**	**0.005**	**0.00067**
100-42-5	STYRENE	300	EPA PRG	1.8	RB-SSL	0.005	0.00015
127-18-4	**TETRACHLOROETHENE**	9.92	EPA R5	**0.000049**	**RB-SSL**	**0.005**	**0.00052**
108-88-3	TOLUENE	200	EPA PRG	1.6	RB-SSL	0.005	0.00027
95-94-6	O-XYLENE	---		1.2	RB-SSL	0.005	0.00035
179601-23-1	m,p-XYLENE	---		---		0.01	0.0012
156-60-5	TRANS-1,2- DICHLOROETHENE	0.784	EPA R5	0.031	RB-SSL	0.005	0.00041
10061-02-6	TRANS-1,3-DICHLOROPROPENE	0.39786	EPA R5	1.7	RSL-R	0.005	0.00054
79-01-6	**TRICHLOROETHENE**	12.4	EPA R5	**0.00072**	**RB-SSL**	**0.005**	**0.00042**
75-69-4	TRICHLOROFLUOROMETHANE	16.4	EPA R5	0.83	RB-SSL	0.005	0.00034
75-01-4	**VINYL CHLORIDE**	0.646	EPA R5	**0.0000056**	**RB-SSL**	**0.005**	**0.00039**
Explosives	**(mg/kg)**						
99-35-4	1,3,5-TRINITROBENZENE	0.376	EPA R5	3.9	RB-SSL	0.25	0.02
99-65-0	**1,3-DINITROBENZENE**	0.655	EPA R5	**0.0033**	**RB-SSL**	**0.25**	**0.05**
121-14-2	**2,4-DINITROTOLUENE**	1.28	EPA R5	**0.00029**	**RB-SSL**	**0.25**	**0.02**

TABLE 1-2

PROJECT ACTION LIMITS AND LABORATORY QUANTITATION AND METHOD DETECTION LIMITS FOR SURFACE WATER SAMPLES
FORMER KILGORE MANUFACTURING FACILITY, WESTERVILLE, OHIO

CAS No.	Chemical	Ecological PAL (mg/kg)	Ecological PAL Reference	Human Health PAL (mg/kg)	Human Health Reference	Test America QL mg/kg	Test America MDL mg/kg
606-20-2	**2,6-DINITROTOLUENE**	**0.0328**	**EPA R5**	**0.05**	**RB-SSL**	**0.25**	**0.03**
98-95-3	**NITROBENZENE**	1.31	EPA R5	**0.000079**	**RB-SSL**	**0.25**	**0.05**
118-96-7	**2,4,6-TRINITROTOLUENE**	---		**0.013**	**RB-SSL**	**0.25**	**0.02**
35572-78-2	**2-AMINO-4,6-DINITROTOLUENE**	---		**0.056**	**RB-SSL**	**0.25**	**0.1**
88-72-2	**2-NITROTOLUENE**	---		**0.00029**	**RB-SSL**	**0.25**	**0.08**
99-08-1	**3-NITROTOLUENE**	---		**0.0034**	**RB-SSL**	**0.25**	**0.07**
1946-51-0	**4-AMINO-2,6-DINITROTOLUENE**	---		**0.056**	**RB-SSL**	**0.25**	**0.02**
99-99-0	**4-NITROTOLUENE**	---		**0.0039**	**RB-SSL**	**0.25**	**0.08**
2691-41-0	HMX	---		2.3	RB-SSL	0.25	0.03
479-45-8	TETRYL	---		1.4	RB-SSL	0.25	0.05
121-82-4	**RDX**	---		**0.00023**	**RB-SSL**	**0.25**	**0.04**
78-11-5	PETN	---		---		0.5	0.16
88-89-1	PICRIC ACID	---		---		1	0.25
14797-73-0	PERCHLORATE	---		5.5	RSL-R	5	0.26
PAHs	**(mg/kg)**						
90-12-0	1-METHYLNAPHTHALENE	---		0.012	RB-SSL	0.0067	0.0033
91-57-6	2-METHYLNAPHTHALENE	29	Eco SSL	0.75	RB-SSL	0.0067	0.0033
83-32-9	ACENAPHTHENE	29	Eco SSL	22	RB-SSL	0.0067	0.0033
208-96-8	ACENAPHTHYLENE	29	Eco SSL	22	RB-SSL	0.0067	0.0033
120-12-7	ANTHRACENE	29	Eco SSL	360	RB-SSL	0.0067	0.0033
56-55-3	BENZO(A)ANTHRACENE	1.1	Eco SSL	0.01	RB-SSL	0.0067	0.0033
50-32-8	**BENZO(A)PYRENE**	1.1	Eco SSL	**0.0035**	**RB-SSL**	**0.0067**	**0.0033**
205-99-2	BENZO(B)FLUORANTHENE	1.1	Eco SSL	0.035	RB-SSL	0.0067	0.0033
191-24-2	BENZO(G,H,I)PERYLENE	1.1	Eco SSL	120	RB-SSL	0.0067	0.0033
207-08-9	BENZO(K)FLUORANTHENE	1.1	Eco SSL	0.35	RB-SSL	0.0067	0.0033
218-01-9	CHRYSENE	1.1	Eco SSL	1.1	RB-SSL	0.0067	0.0033
53-70-3	DIBENZO(A,H)ANTHRACENE	1.1	Eco SSL	0.011	RB-SSL	0.0067	0.0033
206-44-0	FLUORANTHENE	29	Eco SSL	160	RB-SSL	0.0067	0.0033
86-73-7	FLUORENE	29	Eco SSL	27	RB-SSL	0.0067	0.0033
193-39-5	INDENO(1,2,3-CD)PYRENE	1.1	Eco SSL	0.12	RB-SSL	0.0067	0.0033
91-20-3	**NAPHTHALENE**	29	Eco SSL	**0.00047**	**RB-SSL**	**0.0067**	**0.0033**
85-01-8	PHENANTHRENE	29	Eco SSL	120	RB-SSL	0.0067	0.0033
129-00-0	PYRENE	1.1	Eco SSL	120	RB-SSL	0.0067	0.0033
Dioxins/Furans							
3268-87-9	1,2,3,4,6,7,8,9-OCDD	0.015		0.015	RSL-R		
39001-02-0	1,2,3,4,6,7,8,9-OCDF	0.015		0.015	RSL-R		
35822-46-9	1,2,3,4,6,7,8-HPCDD	0.00045		0.00045	RSL-R		
67562-39-4	1,2,3,4,6,7,8-HPCDF	0.00045		0.00045	RSL-R		
55673-89-7	1,2,3,4,7,8,9-HPCDF	0.00045		0.00045	RSL-R		
39227-28-6	1,2,3,4,7,8-HXCDD	0.000045		0.000045	RSL-R		
70648-26-9	1,2,3,4,7,8-HXCDF	0.000045		0.000045	RSL-R		

TABLE 1-2

PROJECT ACTION LIMITS AND LABORATORY QUANTITATION AND METHOD DETECTION LIMITS FOR SURFACE WATER SAMPLES
FORMER KILGORE MANUFACTURING FACILITY, WESTERVILLE, OHIO

CAS No.	Chemical	Ecological PAL (mg/kg)	Ecological PAL Reference	Human Health PAL (mg/kg)	Human Health Reference	Test America QL mg/kg	Test America MDL mg/kg
57653-85-7	1,2,3,6,7,8-HXCDD	0.000045		0.000045	RSL-R		
57117-44-9	1,2,3,6,7,8-HXCDF	0.000045		0.000045	RSL-R		
19408-74-3	1,2,3,7,8,9-HXCDD	0.000045		0.000045	RSL-R		
72918-21-9	1,2,3,7,8,9-HXCDF	0.000045		0.000045	RSL-R		
40321-76-4	1,2,3,7,8-PECDD	0.0000045		0.0000045	RSL-R		
57117-41-6	1,2,3,7,8-PECDF	0.00015		0.00015	RSL-R		
60851-34-5	2,3,4,6,7,8-HXCDF	0.000045		0.000045	RSL-R		
57117-31-4	2,3,4,7,8-PECDF	0.000015		0.000015	RSL-R		
1746-01-6	2,3,7,8-TCDD	0.0000045		0.0000045	RSL-R		
51207-31-9	2,3,7,8-TCDF	0.000045		0.000045	RSL-R		
37871-00-4	TOTAL HPCDD	NC		NC	RSL-R		
38998-75-3	TOTAL HPCDF	NC		NC	RSL-R		
34465-46-8	TOTAL HXCDD	NC		NC	RSL-R		
55684-94-1	TOTAL HXCDF	NC		NC	RSL-R		
36088-22-9	TOTAL PECDD	NC		NC	RSL-R		
30402-15-4	TOTAL PECDF	NC		NC	RSL-R		
41903-57-5	TOTAL TCDD	NC		NC	RSL-R		
55722-27-5	TOTAL TCDF	NC		NC	RSL-R		
TPH							
	TPH Range C6-12	1000		1000			
	TPH Range C10-20	2000		2000			
	TPH Range C20-34	5000		5000			

EPA PRG = Efroymson, R.A., G.W. Suter II, B.E. Sample, and D.S. Jones. 1997. Preliminary Remediation Goals for Ecological Endpoints, ES/ER/TM-162/R2, Oak Ridge National Laboratory, August.

EPA R5 - USEPA 2003. Ecological Screening Levels. USEPA Region 5 August

Eco SSL = USEPA 2005. Guidance for Developing Ecological Soil Screening Levels.
Office of Solid Waste and Emergency and Response. OSWER Directive 92857-55. February

RSL- R = USEPA Regions 3, 6, and 9. (May, 2010). Regional Screening Levels for Chemical Contaminants at Superfund Sites- Residential Soil Values."

RB- SSL = USEPA Regions 3, 6, and 9. (May, 2010). Regional Screening Levels for Chemical Contaminants at Superfund Sites- Soil Screening Level Values."

Bolded compounds indicate PAL values that are less than the laboratory QL.
Bolded and Shaded compounds have QLs and MDLs that do not meet the PAL.

2.0 PROJECT ORGANIZATION

Project personnel and organization are discussed in detail in Section 11.0 of the WP.

3.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA

The overall QA objective is to develop and implement procedures for field sampling, chain of custody, laboratory analysis, and reporting that will provide results achieving the objectives of the planned work as well as establishing a data set that is legally defensible in a court of law. Specific procedures for sampling, chain of custody, laboratory instrument calibration, laboratory analysis, reporting of data, internal QC, audits, preventive maintenance of field equipment, and corrective action are described in other sections of this QAPP.

The PARCC parameters (precision, accuracy, representativeness, comparability, and completeness) are qualitative and/or quantitative statements regarding the quality characteristics of the data used to support project objectives and ultimately, environmental decisions. These parameters are discussed in the remainder of this section. QC samples used to evaluate performance and their frequencies of use are described in Section 8.1 (field QC samples) and Section 8.2 (laboratory QC samples). Specific routine procedures used to assess the quantitative parameters (precision, accuracy, and completeness) are provided in Section 12.0.

3.1 PRECISION

3.1.1 Definition

Precision is a measure of the amount of variability and bias inherent in a data set. Precision describes the reproducibility of measurements of the same parameter for samples under similar conditions. The equation for determining precision is provided in Section 12.2.

3.1.2 Field Precision Objectives

Field duplicate precision monitors the consistency with which environmental samples were obtained and analyzed. Field duplicate results for solid matrix samples are considered to be precise if the relative percent difference (RPD) is less than or equal to 50 percent. Field duplicate results for aqueous matrix samples are considered to be precise if the RPD is less than or equal to 30 percent. Field precision is assessed through the collection and measurement of field duplicates at a rate of one duplicate per 10 environmental samples or one duplicate per sampling day per matrix, whichever is greater.

3.1.3 Laboratory Precision Objectives

Laboratory precision QC samples [i.e., laboratory duplicates for inorganic chemicals and matrix spike duplicates (MSDs) for organic chemicals] will be analyzed with a minimum frequency of 5 percent

(i.e., 1 QC sample per 20 environmental samples). Laboratory precision is measured by comparing RPD values with laboratory-derived precision control limits. Precision control limits are updated periodically hence the limits that current at the time of sample analysis will be used to evaluate data. These limits will be presented in each analytical data package along with sample results.

3.2 ACCURACY

3.2.1 Definition

Accuracy is the degree of agreement between an observed value and an accepted reference value. This parameter is assessed by measuring spiked samples [e.g., surrogate spikes or matrix spikes (MSs)] or well-characterized samples of certified analyte concentrations [e.g., Laboratory Control Samples (LCS)] and by measuring blanks. Accuracy measurements are designed to detect biases resulting from the sample handling and analysis procedures. The equations for determining accuracy of an individual MS and a surrogate spike or LCS for this project are provided in Section 12.1. For blank samples, acceptance criteria are designed to limit the tolerable amount of contamination while recognizing that non-zero results for blanks are likely, if only because of random error in the measurement process. The bias computations for individual MSs, LCSs, and method blanks will be used to control the analysis process by triggering corrective actions as specified in Table 3-1.

3.2.2 Field Accuracy Objectives

Accuracy requirements for field measurements are typically ensured through control over the sample collection and handling and through routine instrument calibration. Accuracy is also typically monitored through the use of blanks to detect cross-contamination and by monitoring adherence to procedures that prevent sample contamination or degradation. Accuracy also shall be assured quantitatively through adherence to all sample handling, preservation and holding time requirements.

3.2.3 Laboratory Accuracy Objectives

Accuracy in the laboratory is measured through the comparison of a spiked sample or LCS result to a known or calculated value and is expressed as a percent recovery (%R). It is also assessed by monitoring the analytical recovery of select surrogate compounds added to samples that are analyzed by organic chromatographic methods. MS and surrogate compound analyses measure the combined accuracy effects of the sample matrix, sample preparation, and sample measurement. LCSs are used to assess the accuracy of laboratory operations with minimal sample matrix effects. Post-digestion spikes (PDSs) are used to assess the accuracy of the analytical measurement on the sample extract or digestate. Each spike sample shall be spiked with representative project target analytes for the analysis

being performed to ensure that accuracy measures are obtained for each target analyte. Spiking concentrations shall equal or approximate the default concentrations detailed in the applicable sample preparation or analysis standard operating procedures (SOPs). LCS and MS analyses are performed at a frequency no less than 1 per 20 associated samples of like matrix.

Laboratory accuracy is assessed by comparing calculated %R values with laboratory-derived accuracy control limits. Accuracy control limits are updated periodically hence the limits that current at the time of sample analysis will be used to evaluate data. These limits will be presented in each analytical data package along with sample results.

3.3 COMPLETENESS

3.3.1 Definition

Completeness is a measure of the amount of usable, valid, analytical data obtained compared to the amount expected to be obtained. Completeness is typically expressed as a percentage.

The ideal objective for completeness is 100 percent (i.e., every sample planned to be collected is collected; every sample submitted for analysis yields valid data). However, samples can be rendered unusable during shipping or preparation (e.g., bottles broken or extracts accidentally destroyed), errors can be introduced during analysis (e.g., loss of instrument sensitivity, introduction of ambient laboratory contamination), or strong matrix effects can become apparent (e.g., extremely low MS recovery). These instances result in data that do not meet QC criteria. Based on these considerations, 95 percent is considered an acceptable target for the data completeness objective. If critical data points are lost, resampling and/or reanalysis may be required.

One hundred percent of the laboratory data will be validated in accordance with method-specific criteria and the USEPA Contract Laboratory Program National Functional Guidelines for Organic and Inorganic Data Review EPA-540/R-99-008, October 1999 and EPA 540-R-04-004, October 2004, respectively, to the extent practicable. Dioxin/furan data will be validated according to USEPA National Functional Guidelines for Chlorinated Dibenzo-p-Dioxins and Chlorinated Dibenzofurans Data Review, September 2005. Data rejected as a result of the validation process will be treated as incomplete data.

3.3.2 Field Completeness Objectives

Field completeness is a measure of the amount of valid field measurements obtained from all the field measurements taken in the project. The equation for completeness is presented in Section 12.3. Field data completeness is expected to be 95 percent.

3.3.3 Laboratory Completeness Objectives

Laboratory completeness is a measure of the amount of valid laboratory measurements obtained from all the laboratory measurements made in support of a given project. The equation for completeness is presented in Section 12.3. Laboratory completeness is expected to be at least 95 percent.

3.4 REPRESENTATIVENESS

3.4.1 Definition

Representativeness is an expression of the degree to which the data accurately and precisely depict the actual characteristics of a population or environmental condition existing at an individual sampling point. Use of standardized sampling, handling, analytical, and reporting procedures ensures that the final data accurately represent actual site conditions.

3.4.2 Measures to Ensure Representativeness of Field Data

Representativeness is dependent on the proper design of the sampling program and will be satisfied by ensuring that the WP is followed and that proper sampling techniques are used.

3.4.3 Measures to Ensure Representativeness of Laboratory Data

Representativeness in the laboratory is ensured by using the proper analytical procedures, meeting sample holding times, and analysis of field duplicate samples.

3.5 COMPARABILITY

3.5.1 Definition

Comparability is defined as the confidence with which one data set can be compared to another (e.g., between sampling points; between sampling events). Comparability is achieved by using standardized sampling and analysis methods and data reporting formats (including use of consistent units of measure and reporting of solid matrix sample results on a dry-weight basis). Additionally, consideration is given to seasonal conditions and other environmental variations that could exist to influence data results.

3.5.2 Measures to Ensure Comparability of Field Data

Comparability is dependent on the proper design of the sampling program and will be satisfied by ensuring that the WP is followed and that proper sampling techniques are used. It is also dependent on recording field measurements using the correct units. Field measurements will include pH, specific conductance, temperature, turbidity, DO. The units used for these field measurements are as follows:

- pH is measured to the nearest 0.1 standard pH unit.
- Specific conductance is measured in μmhos (the inverse of the ohm).
- Temperature is measured in degrees Celsius (°C).
- Turbidity is measured in nephelometric turbidity units (NTUs).
- DO is measured in milligrams per liter (mg/L).

3.5.3 Measures to Ensure Comparability of Laboratory Data

Analytical data will be comparable when similar sampling and analytical methods are used and documented. Results will be reported in units that ensure comparability with previous data and with current State and federal standards and guidelines. Detection/reporting limits are discussed in Section 7.2 of this QAPP. The units used for these laboratory measurements are as follows:

- VOCs, PAHs, explosives, TPH, and perchlorate will be reported in micograms per liter (µg/L) for groundwater, and surface water samples and in milligrams per kilogram (mg/kg) for soil and drainage ditch samples.
- Dioxins/Furans will be reported in ng/kg for soil samples.

3.6 LEVEL OF QUALITY CONTROL EFFORT

Trip blank, equipment blank, field duplicate, standard reference materials, and MS samples will be analyzed to assess the quality of the data resulting from the field sampling and analytical programs. In addition, duplicate field measurements will be completed for temperature, DO, pH, specific conductance, and turbidity, as applicable.

External QC samples (i.e., field QC samples) consist of field duplicates, trip blanks, and equipment (rinsate) blanks. Each of these types of field QC samples will undergo the same preservation, analysis, and reporting procedures as the related environmental samples. Each type of field QC sample is discussed below. Internal field QC checks are discussed in Section 8.1 of this QAPP. A summary of the types and frequencies of QC checks (both internal and external) is presented in Table 3-1.

Field duplicates are either two samples collected independently at a sampling location (e.g., surface water) or a single sample homogenized and split into two portions. Where VOCs are to be analyzed, the VOC sample aliquots are containerized first to avoid loss of constituents, then the remaining sample matrix is homogenized. Field duplicates are collected and analyzed for chemical constituents to measure the precision of the sampling and analysis methods employed. The general level of the QC effort will be one field duplicate for every 10 or fewer investigative samples or one duplicate per matrix per sampling day, whichever is greater. Field duplicates will be collected for all analyses.

Temperature blanks are vials of water inserted into each sample cooler prior to shipment from the field. The temperature of the temperature blank is measured prior to shipment and upon receipt at the laboratory to assess whether samples were properly cooled during transit.

Trip blanks, consisting of distilled water, will be submitted to the laboratory to provide the means to assess the quality of the data resulting from the field sampling program. Trip blanks pertain to VOCs only. Trip blanks are used to assess the potential for contamination with VOCs resulting from contaminant migration into sample bottles/jars during sample shipment and storage. Trip blanks are prepared by the laboratory prior to the sampling event, shipped to the site with the sample containers, and kept with the investigative samples throughout the sampling event. They are then packaged for shipment with other VOC samples and sent for analysis. There should be one trip blank included in each sample shipping container that contains samples for VOC analysis. At no time after trip blank preparation are the trip blank sample containers opened before they reach the laboratory.

Equipment (rinsate) blanks are obtained under representative field conditions by collecting the rinse water generated by running analyte-free water through sample collection equipment after decontamination and prior to use. One rinsate blank will be collected per each type of sampling equipment used (i.e., bailer, split-barreled sampler, hand tools, etc.) per day that sampling is conducted at a minimum frequency of 10 percent. A sampling event is matrix specific; therefore, an equipment blank must be collected for each matrix sampled. If pre-cleaned, dedicated, or disposable sampling equipment is used, one rinsate blank must be collected as a "batch blank." Rinsate blanks are not applicable for the wipe samples.

Matrix Spikes (MSs) are environmental samples to which known quantities of analytes are added prior to sample preparation (digestion or extraction). These samples provide information about the heterogeneity of the samples as well as the effect of the sample matrix on the sample digestion and measurement methodology.

MSs will contain as many representative analytes as practicable. For many analyses, the spiking list will consist of most or all the target analytes.

If MS recovery is not within applicable control limits, the laboratory will assess the batch to determine whether the spike results are attributable to a matrix effect or are the result of other problems in the analytical process. If all the batch QC elements that are not affected by the sample matrix are in control (e.g., method blank, LCS, calibration checks) and if no evidence shows that spiking was not properly performed, the poor spike recovery may be attributed to matrix effects. In this case, the associated data will be flagged, but repreparation and reanalysis will not be required. If any of the batch QC elements that are not affected by the sample matrix are out of control, or if any evidence shows that spiking may have been improperly performed, the MS sample will be reprocessed through the entire analytical sequence. If insufficient sample is available or if holding times have passed, the laboratory will flag the associated data. Details of non-compliant and laboratory duplicate results will be included in the sample delivery group (SDG) narrative.

Matrix Spike Duplicates (MSDs) are duplicates of MSs and are used for estimating the precision of organic analyses. They are used instead of duplicate samples because native environmental samples frequently do not exhibit detectable levels of organic target compounds, which otherwise prevents the calculation of RPD values.

The level of QC effort provided by the contracted laboratory will be equivalent to the level of QC effort specified by this QAPP and the analytical method of analysis. The level of QC effort for testing of all analyses will conform to SW-846 methodology. The level of QC effort for testing of the remaining analyses will conform to those listed in the analytical method.

TABLE 3-1

NON-CALIBRATION QC SAMPLE USAGE FREQUENCIES, ACCEPTANCE LIMITS, AND CORRECTIVE ACTIONS
QUALITY ASSURANCE PROJECT PLAN
FORMER KILGORE MANUFACTURING FACILITY, WESTERVILLE, OHIO

QC Sample Type	Collection Frequency	Acceptance Limits	Corrective Action
Field Duplicate	1 per 10 investigative samples collected.	Aqueous = 30% RPD Soil/Sediment = 50% RPD	Qualify data according to data validation requirements.
Equipment Rinsate Blank	1 per 10 investigative samples collected, with a minimum of one per day of sampling, per non-disposable sampling device/instrument. For pre-cleaned, dedicated, and/or disposable equipment (i.e., disposable plastic trowels, etc.), one rinsate blank will be collected and analyzed at a frequency of one per lot or "batch blank" for a specific equipment type.	< QL (soil and water).	Identify source of contamination, if possible. Qualify data according to validation criteria. Qualify use of data if contamination appears to have adversely affected its usability.
Trip Blanks	1 per cooler containing samples for volatile organics analysis.	< QL (soil and water).	Identify source of volatiles contamination, if possible. Qualify data according to validation criteria. Qualify use of data if contamination appears to have adversely affected its usability.
Internal Standard	At least one internal standard per sample for GC/MS analyses.	Retention times stable to ±30 seconds; area counts stable to within factor of 2.	Laboratory to re-extract and reanalyze. Contractor action taken per validation protocols, and Section 13.3.
Laboratory Duplicate	1 per 20 environmental samples analyzed for inorganic target analytes.	Laboratory derived limits (soil and water).	Laboratory to reanalyze. Contractor action taken per validation protocols, and Section 13.3.
Laboratory Method Blank	1 per 20 environmental samples or per preparation batch, whichever is more frequent.	< QL (soil and water).	Laboratory must reanalyze if detection is 5 times greater than the Quantitation limit. Action taken per validation protocols, and Section 13.3.
Matrix Spike (1)	1 per 20 environmental samples.	Laboratory derived limits (soil and water).	Laboratory to confirm matrix interference by reanalysis and evaluation of all other quality control data. Contractor action taken per validation protocols, and Section 13.3.

TABLE 3-1

NON-CALIBRATION QC SAMPLE USAGE FREQUENCIES, ACCEPTANCE LIMITS, AND CORRECTIVE ACTIONS
QUALITY ASSURANCE PROJECT PLAN
FORMER KILGORE MANUFACTURING FACILITY, WESTERVILLE, OHIO

QC Sample Type	Collection Frequency	Acceptance Limits	Corrective Action
Matrix Spike Duplicate(1)	1 per 20 environmental samples analyzed for organic target analytes.	Laboratory derived limits (soil and water).	Laboratory to confirm matrix interference by reanalysis and evaluation of all other quality control data. Contractor action taken per validation protocols, and Section 13.3.
Post-digestion Spike	Only if out-of-control matrix spike exists (metals only).	100 ± 20% recovery.	Contractor action taken per validation protocols, and Section 13.3.
Surrogate	At least one per sample for organic chromatographic analyses (GC/MS).	Laboratory derived limits (soil and water).	Laboratory must re-extract and reanalyze. Contractor action taken per validation protocols, and Section 13.3.
Temperature Blank	One blank per sample cooler.	0 to 6 °C	Laboratory to call contractor for direction. Contactor action taken per validation protocols, and Section 13.3.

1 Matrix spikes and matrix spike duplicates are not analyzed in the field, but additional sample material must be collected in the field to ensure that the laboratory has enough material for spiking and duplicate analysis.

RPD Relative Percent Difference
FOL Field Operations Leader
GC/MS Gas Chromatography/Mass Spectrometer
°C Degrees Celsius

4.0 SAMPLING PROCEDURES

Sampling procedures for field activities are presented in Section 5.0 of the FSP. SOPs for relevant field activities are presented in Appendix B of the FSP.

5.0 CUSTODY PROCEDURES

Documented sample custody is one of several factors necessary for the admissibility of environmental data as evidence in a court of law. Custody procedures help to satisfy the two major requirements for admissibility: relevance and authenticity. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files. Final evidence files, including all original laboratory reports and purge files, are maintained under document control in a secure area. A sample or evidence file is under custody when any one of the following conditions is satisfied:

- The item is in the actual physical possession of an authorized person.
- The item is in view of the person after being in his or her possession.
- The item was placed in a secure area to prevent tampering.
- The item is in a designated and identified secure area with access restricted to authorized personnel only.

The chain-of-custody (COC) form is a multi-part, standardized form used to summarize and document pertinent sample information, such as sample identification and type, sample matrix, date and time of collection, preservation, and requested analyses. Furthermore, through the sequential signatures of various sample custodians (e.g., sampler, airbill number, laboratory sample custodian) the COC form documents sample custody and tracking. Laboratory custody procedures will ensure that sample integrity is not compromised from the time of receipt at the laboratory until final data are reported to Tetra Tech. This requires that the laboratory control all sample handling and storage conditions and circumstances. Custody procedures apply to all environmental and associated field QC samples obtained as part of the data collection system.

5.1 FIELD CUSTODY PROCEDURES

The Field Operations Leader (FOL), or designee, is responsible for the care and custody of the samples collected until they are relinquished to the laboratory or entrusted to a commercial courier. COC forms are completed to the fullest extent possible for each sample cooler used for shipment. The forms are legibly completed with waterproof ink, and are signed and dated by the sampler. COC forms will include the following information: project name, sample number, time collected, matrix, designated analyses, type of sample, preservative, and name of sampler. Pertinent notes or comments are also indicated on the COC form.

Information similar to that contained on the COC form is provided on the sample label, which is securely attached to the sample bottle. Sample labels will include, at a minimum, the following information: sample

number, date and time of collection, analysis required for the sample aliquot in the associated sample container and a space for the laboratory sample number. The list of samples to be collected is presented in Section 5.0 of the FSP.

Site conditions during sampling and the care with which samples are handled may factor into the degree to which samples represent the media from which they are collected. This, in turn, could affect the ability of decision-makers to make accurate and timely decisions concerning the contamination status of the site. As appropriate, logbooks are assigned to, and maintained by, key field team personnel. The logbooks are used to record daily conditions and activities such as weather conditions, dates and times of significant events, level of personal protective equipment (PPE) used, boring activities, actual sample collection locations, photographs taken, problems encountered during field activities, chemical screening results, and corrective actions taken to overcome problems. In addition, the names of site visitors and the purposes of their visits shall be recorded. Field logbook assignments shall be recorded in the site logbook or other central file whose location is known by the FOL and Project Manager (PM). During field activities, the FOL is responsible for the maintenance and security of all field records. At the completion of field activities, the FOL will forward all field records to the Tetra Tech PM. All field sample records will eventually be docketed into the final evidence file.

A temperature blank shall be included in each cooler containing samples for use by the laboratory upon receipt. Each cooler shall be taped shut with strapping tape in at least two places to prevent tampering. Custody seals shall be attached so that the seals must be broken to open the cooler. Samples for chemical analysis will be sent (for next-day receipt) to the laboratory within 24 hours of collection.

The following procedures will be used when transferring custody of samples. As previously noted, individual custody records will accompany each sample cooler. The methods of shipment, courier name, and other pertinent information will be entered in the remarks section of the custody record. When transferring samples, the individuals relinquishing and receiving the samples will sign, date, and note the time on the COC record. The original record (top copy of the multi-part form) will accompany the shipments, and the field sampler will retain a copy. This record documents the sample custody transfer from the sampler to the laboratory, often through another person or agency (common courier). After COC records have been placed within sealed shipping coolers, the signed courier airbills will serve to document COC. When samples arrive at the laboratory, internal laboratory sample custody procedures will be followed (see Section 5.2).

5.2 LABORATORY CUSTODY PROCEDURES

Upon laboratory receipt of a shipment of samples, the laboratory’s sample custodian will verify that the correct number of coolers has been received. The custodian will examine each cooler's custody seals to

verify that they are intact and that the integrity of the environmental samples has been maintained. The custodian will then open each cooler and measure its internal temperature by measuring the temperature of the temperature blank. The temperature reading will be documented. The sample custodian will then sign the COC form and examine the contents of the cooler. Identification of broken sample containers or discrepancies between the COC form and sample labels will be recorded. The laboratory will retain the original field COC forms, providing copies of the forms with the final data package deliverable. All problems or discrepancies noted during sample receipt will be promptly reported to the Tetra Tech PM. Samples will be logged into the laboratory information management system.

5.3 FINAL EVIDENCE FILES

The Tetra Tech Central File will be the repository for all documents that constitute evidence relevant to sampling and analysis activities described in this QAPP. Tetra Tech will be the custodian of the evidence file and will maintain the contents of these files, including all relevant records, reports, logs, field notebooks, pictures, subcontractor reports, and data reviews in a secure, limited-access location and under custody of the Tetra Tech quality assurance manager. The control file will include at a minimum:

- Field logbooks
- Field data and data deliverables
- Photographs and negatives
- Drawings
- Laboratory data deliverables
- Data validation reports
- Data assessment reports
- Progress reports, QA reports, interim project reports, etc.
- All custody documentation (tags, forms, airbills, etc.)
- Sample log sheets
- Field task modification request forms
- Corrective actions documentation.

Upon completion of the contract, all files associated with this investigation will be relinquished to the custody of Otterbein College.

6.0 CALIBRATION PROCEDURES AND FREQUENCY

All instrumentation used to perform chemical measurements must be properly calibrated prior to use to obtain valid and usable results. The requirement to properly calibrate instruments prior to use applies equally to field instruments as it does to fixed laboratory instruments.

6.1 FIELD INSTRUMENT CALIBRATION

Field instrument calibration will be conducted as per manufacturers' instructions. The calibrations of each instrument will be documented on the appropriate log sheet (Appendix C of the FSP).

6.2 LABORATORY INSTRUMENT CALIBRATION

Calibration procedures for a specific laboratory instrument will consist of initial calibration (generally three to six points), initial calibration verification (inorganic methods only), and continuing calibration verification. In all cases, the initial calibration will be verified using an independently prepared calibration verification solution. The frequency of calibration will be performed according to the requirements of the specific methods.

All standards used to calibrate analytical instruments must be obtained from National Institute of Science and Technology (NIST) or through a reliable commercial supplier with a proven record for quality standards. All commercially supplied standards must be traceable to NIST reference standards, where possible, and appropriate documentation will be obtained from the supplier. In cases where documentation is not available, the laboratory will analyze the standard and compare the results to an USEPA-supplied known or previous NIST-traceable standard.

All calibration data, including dates and times of analyses, standards used, and other pertinent information, must be documented in laboratory logbooks or on analysis run logs.

The calibration procedures and frequencies used by the laboratory will comply with the applicable SW-846 analytical method.

7.0 ANALYTICAL AND MEASUREMENT PROCEDURES

Field measurements and analytical procedures are presented in this section.

7.1 FIELD MEASUREMENT PROCEDURES

Water quality parameters consisting of pH, specific conductance, turbidity, DO, and temperature will be measured prior to the collection of groundwater samples. Measurements will be performed in accordance with manufacturer's instructions.

7.2 LABORATORY ANALYTICAL AND MEASUREMENT PROCEDURES

Table 1-1 provides a summary of the laboratory preparation and analytical methods to be used during this investigation.

7.2.1 List of Project Target Compounds and Detection Limits

A list of the laboratory target analytes and QLs and MDLs for all analyses is provided in Table 1-2. All data will be reported to the MDL. An analyte's QL is based on the associated MDL with adjustments made to ensure that the precision and accuracy requirements of the method are attainable. QLs and MDLs will be adjusted on a sample-by-sample basis as necessary, based on dilutions, sample volume, sample clean-up, and percent moisture. Positive results below the QL but greater than the MDL will be reported by the laboratory and flagged as estimated, "J" for organics or "B" for inorganics.

7.2.2 List of Associated Quality Control Samples

The overall level of noncalibration QC effort for field work is described in Section 3.6. Field and laboratory QC samples to be analyzed, as well as details on QC sample usage, are provided in Section 8.0.

8.0 INTERNAL QUALITY CONTROL CHECKS

Field-related QC checks were discussed in Section 3.0 of this QAPP. This section provides additional information regarding internal QC checks for the field and the laboratory.

8.1 FIELD QUALITY CONTROL CHECKS

QC procedures for pH, specific conductance, temperature, DO, and turbidity will include calibrating the instruments as described in Tetra Tech SOPs. Assessment of field sampling precision and bias will be made by collection of field duplicates and equipment blanks for laboratory analysis. Collection of the field QC samples (or external QC checks) will be in accordance with the procedures provided in the appropriate Tetra Tech SOPs at the frequency discussed in Section 3.6 and Table 3-1 of this QAPP.

8.2 LABORATORY QUALITY CONTROL CHECKS

The laboratory will have a QC program that ensures the reliability and validity of the analyses performed at the laboratory. Internal QC procedures for analyses will comply with applicable analytical method requirements. Accutest Southeast will be the laboratory performing analyses at this site.

Several internal laboratory QC checks are briefly discussed in the remainder of this section.

Laboratory method blanks are prepared and analyzed in accordance with the analytical method employed to determine whether contaminants originating from laboratory sources have been introduced and have affected environmental sample analyses. A method blank generally consists of an aliquot of analyte-free water (or purified sodium sulfate for soil samples) that is subjected to the same preparation and analysis procedures as the environmental samples undergoing analysis. With the exception of recognized volatile common laboratory contaminants (i.e., methylene chloride, acetone, and 2-butanone) detected through use of the SW-846 8260B, method blanks must not contain levels of target analytes greater than the reported detection limits [i.e., greater than 2.5 times the reporting limit for methylene chloride and greater than 5 times the quantitation limit for acetone, and 2-butanone]. If method blank contamination is found to exist above allowable limits, corrective actions contained in the laboratory SOPs must be followed. Under no circumstances are laboratory method blank contaminant values to be subtracted from environmental sample analysis results.

Laboratory method blanks are performed at the frequency specified in the analytical method. However, in general, organic analyses method blanks are analyzed at a frequency of one per extraction or analysis batch up to a maximum of 20 samples. In general, inorganic analysis method blanks are analyzed at a

frequency of one method blank per batch of samples processed at the same time, up to a maximum of 20 samples.

MS analysis for organic fraction analyses is performed in duplicate (MSD) as a measure of laboratory precision. For inorganic analyses, one MS analysis and one **laboratory duplicate** analysis will be performed for every 20 environmental samples per matrix per site. With the exception of VOC MSD analyses, laboratory duplicates are prepared by thoroughly mixing and splitting a sample aliquot into two portions and analyzing each portion following the same analytical procedures used for the environmental sample analyses. For VOC MSD analyses, a second sample aliquot is used for analysis to avoid VOC constituent loss through the homogenization process. The field crew provides extra volumes of sample matrices designated for laboratory QC analyses, as required. Control limits for MS and laboratory duplicate analyses are evaluated against statistically derived laboratory-specific limits.

Surrogates or System Monitoring Compounds are organic compounds (typically brominated, fluorinated, or isotopically labeled) that are similar in nature to the compounds of concern and that are not likely to be present in environmental media. Surrogates are spiked into each sample, standard, and method blank prior to analysis and are used only in organic chromatographic analysis procedures as a check of method effectiveness. Surrogate recoveries are evaluated against statistically derived laboratory-specific limits.

LCSs serve to monitor the overall performance of each step during the analysis, including the sample preparation. LCS analysis will be performed in accordance with the analytical method. Aqueous LCS results must fall within the statistically derived laboratory-specific control limits. Solid LCS results must fall within the control limits established by the supplier of the LCS standard, where applicable, or established by the laboratory. Aqueous and solid LCSs shall be analyzed utilizing the same sample preparations, analytical methods, and QA/QC procedures as employed for the samples.

Internal standard performance criteria ensure that GC/MS analysis sensitivity and response are stable during every analytical run. Internal standard area counts for samples and blanks must not vary by more than a factor of two (- 50 to + 100 percent) from the associated 12-hour calibration standard. The retention time of the internal standards in samples and blanks must not vary by more than ±30 seconds from the retention time of the associated 12-hour calibration standard.

Post Digestion Spikes (PDSs) are similar to MSs except that the sample digestate, rather than the original soil sample, is spiked. These spikes are analyzed only for metal target analytes if the matrix spike recovery falls outside control limits. Comparing %Rs for PDSs and MSs helps to identify where in the analytical process accuracy problems are occurring. PDSs will contain all target analytes of interest

and will be used to assist in determining whether unacceptable MS recoveries are a result of matrix effects.

Additional internal laboratory QC checks include mass tuning for Gas Chromatography/Mass Spectrometry (GC/MS) analysis.

9.0 DATA REDUCTION, VALIDATION, AND REPORTING

This section describes the procedures to be used for data reduction, validation, and reporting for samples collected during this investigation. All data generated during the course of the proposed activities will be maintained in hardcopy and/or portable document format (PDF) form in the Tetra Tech central project files.

In addition to the central files, photocopies of all hardcopy/PDF data (as well as electronic data) will be maintained in the Tetra Tech's Chemistry/Toxicology/Risk Assessment Department database records files. Upon completion of the contract, all files will be relinquished to the Otterbein College as per Contract requirements.

9.1 DATA REDUCTION

Data reduction will be completed for both field measurement and laboratory-generated analytical data. Field data reduction will be relatively limited versus the degree of laboratory data reduction required for the project. Reduction of both field data and laboratory data are discussed in the remainder of this section.

9.1.1 Field Data Reduction

Field data will be generated as a result of real-time measurement of organic vapor concentrations via a PID (for health and safety monitoring and to support selection of samples for shipment to the laboratory), through onsite water quality testing for general indicator parameters including pH, specific conductivity, turbidity, DO, and temperature.

Field measurements of organic vapor concentrations (parts per million on a volume-to-volume basis relative to methane or benzene) and data collected as a result of the use of field test kits will be recorded in the site logbook and incorporated into the project-specific reports. General water-quality indicator parameter data will also be recorded in the site logbook and on sample logsheets immediately after the measurements are taken. If an error is made in the logbook, the error will be legibly crossed out (single-line strikeout), initialed and dated by the field member, and corrected in a space adjacent to the original (erroneous) entry.

9.1.2 Laboratory Data Reduction

Laboratory data reduction of analytical results generated via SW-846 methods will be completed as specified in the analytical methods.

Field QC sample results will be included in the database for this site. Specifically, the analytical results for trip blanks, rinsate blanks, and ambient condition blanks will be provided. The results for field QC blanks will be considered during the course of data validation (in concert with laboratory method blanks) to eliminate false positive results according to the 5- and 10-times rules specified in the USEPA Contract Laboratory Program National Functional Guidelines for Organic and Inorganic Data Review EPA-540/ R-99-008, October 1999 and EPA 540-R-04-004, October 2004, respectively. The results for laboratory QC samples such as method blanks will not be presented in the master database. In addition, only the original (unspiked) sample results for MS/MSD samples will be provided in the database.

9.2 DATA VALIDATION

Validation of field measurements and laboratory analytical data are discussed in this section. Validation of field data will be limited to real-time "reality" checks, whereas laboratory analytical data will be validated in accordance with current USEPA guidance.

9.2.1 Field Measurement Data Validation

Field measurements will not be subjected to a formal data validation process. However, field technicians will ensure that the equipment used for field measurement is performing accurately via compliance with the Tetra Tech SOPs. All field data entered into the electronic database will be independently reviewed for transcription errors.

9.2.2 Laboratory Data Validation

100 percent of the laboratory data will be validated. Validation of analytical data will be completed by the Tetra Tech. Final review and approval of validation deliverables will be completed by the Tetra Tech's Data Validation Coordinator.

The analytical results will be validated based on the analytical methods. Validation of these data will conform to method-specific criteria, and the USEPA Contract Laboratory Program National Functional Guidelines for Organic and Inorganic Data Review EPA-540/R-99-008, October 1999 and EPA 540-R-04-004, October 2004, respectively, to the extent practicable. Dioxin data will be validated according to USEPA National Functional Guidelines for Chlorinated Dibenzo-p-Dioxins and Chlorinated Dibenzofurans Data Review, September 2005.

9.3 DATA REPORTING

9.3.1 Field Measurement Data Reporting

All records regarding field measurements (i.e., field logbooks, sampling logbooks, and sample log sheets) will be placed in the Tetra Tech central files upon completion of the field effort. Field measurement data will typically be reported in an appendix to the project-specific report and may also be reported in summary fashion if they are indicative of the presence of contamination (e.g., high specific conductance readings). Tetra Tech's Information Management Resources Department will typically hold responsibility for field data reporting subject to oversight by the Department Manager.

9.3.2 Laboratory Data Reporting

Data reported by the laboratory will be in accordance with a contract laboratory program-type reporting format (to the extent practicable). All pertinent QC data including raw data and summary forms for blanks, standards analysis, calibration information, etc. will be provided. Case narratives will be provided for each sample delivery group (SDG).

All environmental and field QC sample results (trip blanks, duplicates, rinsate blanks, ambient condition blanks) will be included in each project-specific report as an appendix. The database will include pertinent sampling information such as sample number, sampling date, general location, depth, and survey coordinates (if applicable). Sample-specific detection limits will be reported for nondetected analytes. Units will be clearly summarized in the database and will conform to those identified in Section 3.5. The analytical data may also be reported in summary fashion within the body of the project-specific report text in tabular and graphic fashion.

Data will be handled electronically pursuant to the electronic deliverable requirements that must be specified in the Tetra Tech's agreement with the analytical laboratory. This agreement should require the analytical laboratory to provide data as a PDF of the hardcopy and in electronic form (database or text files). The original electronic diskettes and the original hardcopy/PDF analytical data are maintained in the Tetra Tech central project files as received.

Validation will be completed using the hardcopy/PDF data. Upon completion of validation of a SDG and review by the Data Validation Coordinator, the validation qualifiers will be entered in the electronic database and will be subjected to independent review for accuracy. During this review process, the electronic database printout will also be contrasted with the hardcopy/PDF data (i.e., Form Is) to ensure that the hardcopy/PDF data and electronic data are consistent.

The Tetra Tech's Information Management Resource Department will typically hold responsibility for laboratory data reporting subject to oversight by the Department Manager. Key data handling personnel within the Department include the Department Manager and the Database Supervisor (Information Management Resource Department) and the Data Validation Coordinator (Chemistry Department). However, a summary of the validation results (actions taken and completeness, precision, and accuracy) will be provided in the project-specific reports, and example data validation reports and analytical data packages will be provided upon request.

10.0 PERFORMANCE AND SYSTEM AUDITS

Performance and system audits will be performed periodically to ensure that work is being implemented in accordance with the approved project plans and in an overall satisfactory manner. Examples of pertinent audits are as follows:

- The FOL will supervise and check daily that the field measurements are made accurately, equipment is thoroughly decontaminated, samples are collected and handled properly, and fieldwork is documented accurately and neatly.

- Performance and system audits for the laboratory will be performed regularly in accordance with the National Environmental Laboratory Accreditation Program (NELAP) and by the laboratory's QA staff in accordance with the laboratory QA plan.

- External field or laboratory audits may be performed at the discretion of USEPA Region 5 and/or Ohio EPA.

- Data validators will review (on a timely basis) the chemical analytical data packages submitted by the laboratory. The data validators will check that the data were obtained through use of the approved methodology, the appropriate level of QC effort and reporting were conducted, and the results are in conformance with QC criteria. On the basis of these factors, the data validator will generate a report describing data limitations, which will be reviewed internally by the Data Validation Coordinator prior to submittal to the Tetra Tech PM.

- A formal audit of the field sampling procedures may be conducted by the contractor's quality assurance manager or designee in addition to the auditing that is an inherent part of the daily project activities. The purpose of this audit is to ensure that sample collection, handling, and shipping protocols, as well as equipment decontamination and field documentation procedures, are being performed in accordance with the approved project plans and SOPs.

- The contractor's PM will maintain contact with the FOL and Data Validation Coordinator to ensure that management of the acquired data proceeds in an organized and expeditious manner.

- The QA officer or appropriate designee of the laboratory performs routine internal audits of the laboratory. Performance and system audits of laboratories are coordinated through the NELAP by an independent QA contractor. It is the responsibility of the NELAP and its contractor to ensure that the audited lab comply with good laboratory practices and the general requirements of all analytical

services provided by the laboratories. Tetra Tech will employ Test America for analytical services at the Former Kilgore Manufacturing Facility. Test America has current NELAP accreditation for all the parameters and methods outlined in this QAPP.

11.0 PREVENTIVE MAINTENANCE PROCEDURES

Measuring equipment used in environmental monitoring or analysis shall be maintained in accordance with the manufacturers' operation and maintenance manuals. Equipment and instruments shall be calibrated in accordance with the procedures and at the frequencies discussed in Section 6.0 (Calibration Procedures and Frequency) and in Tetra Tech SOPs (field measurement equipment). Preventive maintenance for field and laboratory equipment is discussed in the remainder of this section.

11.1 FIELD EQUIPMENT PREVENTIVE MAINTENANCE

Preventive maintenance of field equipment is described in Tetra Tech SOPs. Tetra Tech's Equipment Manager and the instrument operator will be responsible for ensuring that equipment is operating properly prior to use and that routine maintenance is performed and documented. Any problems encountered while operating the instrument will be recorded in the field logbook including a description of the symptoms and corrective actions taken. If problem equipment is detected or should require service, the equipment should be logged, tagged, and segregated from equipment in proper working order. Use of the instrument will not resume until the problem is resolved.

11.2 LABORATORY INSTRUMENT PREVENTIVE MAINTENANCE

Proper maintenance of laboratory instruments and equipment is essential to ensuring their readiness when needed. Dependent on manufacturer's recommendations, maintenance intervals are established for each instrument. All instruments must be labeled with a model number and serial number, and a maintenance logbook must be maintained for each instrument. Personnel must be alert to the maintenance status of the equipment they are using at all times.

11.2.1 Major Instruments

Table 11-1 provides a summary of preventive maintenance procedures for laboratory equipment that will be used for analysis of these samples.

Maintenance of instruments may also be covered under service contracts with external firms. Such contracts provide for periodic routine maintenance to help guard against unexpected instrument downtime. These contracts also typically provide for quick response for unscheduled service calls when malfunctions are observed by the operator.

The use of manufacturer-recommended grades or better of supporting supplies and reagents is also a form of preventive maintenance. For example, gases used in the various gas chromatograph instruments

are of sufficient grade to minimize fouling of the instrument. The routine use of septa, chromatographic columns, ferrules, furnace tubes, and other supporting supplies from reputable manufacturers will assist in averting unnecessary periods of instrument downtime.

11.2.2 Refrigerators/Ovens

The temperatures of refrigerators used for sample storage will be monitored once daily. The acceptable range for refrigerator temperatures is above 0 to 6°C. The temperatures will be recorded in the refrigerator temperature log. Maintenance of the log will be the responsibility of the sample custodian or designee. The log will contain the following information:

- Date
- Temperature
- Initials of person performing the check

Assignment of responsibilities for temperature monitoring to specific personnel does not preclude the participation of other laboratory personnel. If unusual temperature fluctuations are noted, it is the responsibility of the observer to immediately notify the person in charge of the discrepancy before the condition of the samples is compromised.

Unstable or fluctuating temperatures may be indicative of malfunctions in the cooling system. On the other hand, the instability may be due to frequent opening of the door. Regardless of the cause, such an observation must be investigated, and modifications to access procedures or repairs to equipment must be made to prevent jeopardizing the integrity of the samples.

TABLE 11-1

TYPICAL PREVENTIVE MAINTENANCE FOR ANALYTICAL INSTRUMENTS
QUALITY ASSURANCE PROJECT PLAN
FORMER KLIGORE MANUFACTURING FACILITY, WESTERVILLE, OHIO

Instrument	Preventive Maintenance	Maintenance Frequency
GC/MS	Volatiles: Bake oven, replace septum, check carrier gas. Semivolatiles: Replace septum, clean injection port, replace liner, bake oven, check carrier gas, clean source. Replace solvent washes and clean syringe.	As required. As required. Daily.
HR/GC/MS	Check pressure and gas supply daily. Bake out column, change septa, liner, seal as needed, cut column as needed. Check foreline pump fluid level and ballast. Change the PFK septum. Check the E/T ratio and the air peak ratios. Clean source as needed.	Prior to initial calibration or as necessary. Prior to initial calibration or as necessary.
HPLC	Change filter frits. Change column prefilters. Change pump seals.	Monthly. As needed. As needed
ICP	Change sample introduction tubing, clean nebulizer, clean spray chamber, clean torch, manual profile, and automatic profile optics.	As required.
CVAA	Change sample introduction tubing, change drying cell, re-zero detector.	As required.

HR – High Resolution
GC – Gas Chromatograph
MS – Mass Spectroscopy
ICP – Inductively Coupled Plasma
CVAA – Cold Vapor Atomic Absorption
HPLC – High Performance Liquid Chromatography

12.0 SPECIFIC ROUTINE PROCEDURES USED TO ASSESS DATA PRECISION, ACCURACY, AND COMPLETENESS

Compliance with quantitative QC objectives for laboratory accuracy and precision as outlined in Tables 3-1 will be evaluated during data validation (Section 9.0). Compliance with completeness objectives for field and laboratory data may be computed. Sections 12.1 and 12.2 present equations to be used for computing accuracy and precision values, respectively. Section 12.3 describes the means and presents the equation for determining completeness. Section 12.4 addresses the overall data assessment process.

In general, data validation requires that data be evaluated batch by batch based on the results of quality indicators for the respective batches. Section 12.4 presents additional data quality considerations that may be evaluated after data validation. These considerations are designed to incorporate data quality factors that extend beyond evaluation of the simple quantitative estimators for precision, accuracy, and completeness.

12.1 ACCURACY ASSESSMENT

The accuracy of chemical analyses is assessed through the use of surrogate spikes, MSs, PDSs, LCSs, calibration check standards, internal standards, and blanks. Blanks are used to infer the potential for positive biases because of contamination. To assure the accuracy of the analytical procedures, at least one of every 20 environmental samples will be spiked with known amounts of target analytes (i.e., MSs) prior to preparation for analysis. The spiked samples will be analyzed, and the concentrations of each target analyte observed in the spiked sample will be compared to the reported value of the analyte in the unspiked sample to determine the %R of the analyte. Control charts are plotted by the laboratory for each target analyte and are kept on matrix- and analyte-specific bases. The %R for a spiked sample is calculated using the following formula:

$$\%R = \frac{\text{Amount in Spiked Sample} - \text{Amount in Sample}}{\text{Known Amount Added}} \text{ X } 100\,\%$$

As discussed in Section 3.2.3, LCSs and surrogate spikes are also analyzed to assess accuracy. The %R calculation for LCSs and surrogate spikes is as follows:

$$\%R = \frac{\text{Experimental Concentration}}{\text{Certified or Known Concentration}} \text{ X } 100\,\%$$

12.2 PRECISION ASSESSMENT

As presented in Section 3.1.3, laboratory duplicate samples (for inorganic analyses) and MSD samples (for organic analyses) will be prepared and analyzed at a minimum frequency of one per every 20 environmental samples per matrix. As described in Section 3.1.2, field duplicate samples also will be collected at a minimum frequency of one per 10 environmental samples per matrix. The RPD between a sample or MS (Sample 1) and its duplicate or MSD (Sample 2) is calculated for chemical analyses using the following formula:

$$\text{RPD} = \frac{|\text{Amount in Sample 1} - \text{Amount in Sample 2}|}{0.5\,(\text{Amount in Sample 1} + \text{Amount in Sample 2})} \text{ X } 100\ \%$$

12.3 COMPLETENESS ASSESSMENT

Completeness for this project is determined based on the number of sample results for each target analyte and each sample type that are usable as determined through data validation and data assessment. Data values rejected during data validation (indicated by an “R” or “UR” flag) will be considered unusable unless additional review and documentation by one or more technical team members demonstrates that the rejection was erroneous. To monitor completeness, the number of usable, valid results for each soil type and analyte will be counted and compared to the completeness objectives in Sections 3.3.2 and 3.3.3.

Percent completeness will be calculated using the following equation:

$$\%\,\text{Completeness} = \frac{(\text{Number of Valid Measurements})}{(\text{Number of Measurements Planned})} \text{ x } 100\%$$

Because the many parameters to be measured for a project are interrelated in many different ways, a single completeness criterion cannot be established for the project. Instead, the ability to attain project objectives will be evaluated at the end of each sampling round by how effectively the necessary decisions and data evaluations can be made.

12.4 DATA ASSESSMENT

The assessment of data obtained from an investigation is a critical part of determining the next step in data collection and decision making. It must be determined whether the data are of appropriate type, quality, quantity, and representativeness to support the project objectives. The effect of the loss of data deemed unacceptable for use, for whatever reason, will be evaluated.

12.4.1 Reconciliation with Data Quality Objectives

Field data will be examined immediately after generation for errors. Laboratory data will be examined upon receipt from the laboratory in a series of evaluations. The first step will be a data verification and validation as described in Section 9.0.

After data validation, the data will be reconciled with data quality objectives to determine whether sufficient data of acceptable quality are available for decision making. In addition to the evaluations described in Sections 12.1 through 12.3, a series of inspections and statistical analyses may be performed to estimate several of the data set characteristics. The statistical evaluations will include simple summary statistics for target analytes, such as the maximum concentration, minimum concentration, number of samples exhibiting no detectable analyte, the number of samples exhibiting detectable analytes, and the proportion of samples with detectable and undetectable analytes. These inspections and statistical analyses will be designed to do the following:

- Identify deviations, if any, from the field sampling SOPs (inspection).
- Identify deviations, if any, from the QAPP, FSP, and WP (inspection).
- Identify deviations, if any, from the data validation process (inspection).
- Identify and explain the impacts of elevated detection limits (inspection).
- Identify unusable data (i.e., data qualified as “R”) (inspection).
- Evaluate project assumptions such as “groundwater flow is to the northwest” (inspection).
- Evaluate adherence to investigation objectives and decision rules (inspection and statistics, as applicable).
- Ensure completion of corrective actions (inspection).
- Evaluate effects of deviations from planned procedures and processes on the interpretation and utility of the data (inspection and statistics, as applicable).
- Identify the existence of remaining data gaps (inspection/statistics).

For statistical comparisons and mathematical manipulations, analytes that are not detected at the applicable sample-specific reporting limits will be represented by a concentration equal to one-half the sample-specific reporting limits.

If necessary, investigation objectives may be revised in anticipation of additional data collection.

The suitability of any given statistical test will be assessed based on the completeness of the data sets and the conditions observed at the site. For example, when a single data value is available for soils or water samples at a given sampling location, statistical tests cannot be conducted for that individual sampling location. However, pooling of data across sampling locations may be possible and, if logical to do so, may be implemented at the discretion of the Tetra Tech PM. For example, when evaluating constituents of potential concern, multiple soil sample results of a given depth and grain size within a depositional environment may be pooled for statistical comparison to the background data set from soil of the same depth, grain size, and depositional environment. Statistical testing will generally be conducted at the 5-percent significance level. Statistical testing at other significance levels may also be warranted to provide perspective on the results of testing 5-percent significance. If other significance levels are used, they will be supported with rationales for their use.

13.0 CORRECTIVE ACTION

It is required that any and all personnel noting conditions adverse to quality report these conditions immediately to the Tetra Tech PM and quality assurance manager. These parties, in turn, are charged with performing root-cause analyses and implementing appropriate corrective action in a timely manner. It is ultimately the responsibility of the quality assurance manager to document all findings and corrective actions taken and to monitor the effectiveness of the corrective measures performed.

13.1 FIELD CORRECTIVE ACTION

Field nonconformances or conditions adverse to quality must be identified and corrected as quickly as possible so that work integrity or quality of product is not compromised. The need for corrective action may arise based on deviations from project plans and procedures, adverse field conditions, or other unforeseen circumstances. Corrective action needs may become apparent during the performance of daily work tasks or as a consequence of internal or external field audits.

Corrective action may include resampling and may involve amending previously approved field procedures. If warranted by the severity of the problem (e.g., if a change in the approved project-specific WP or SOPs is required), Otterbein College and Ohio EPA will be notified in writing via a field task modification request (FTMR), and approvals will be obtained. The FOL is responsible for initiating FTMRs; an FTMR will be initiated for all deviations from the project plan documents, as applicable. An FTMR form is provided as Figure 13-1. Copies of all FTMRs will be maintained with the onsite project planning documents and will be placed in the final evidence file.

Minor modifications to field activities such as a slight offset of a boring location will be initiated at the discretion of the FOL, subject to onsite approval by facility personnel. Approval for major modifications (e.g., elimination of a sampling point) must be obtained via an FTMR.

13.2 LABORATORY CORRECTIVE ACTION

In general, laboratory corrective actions are warranted whenever an out-of-control event or potential out-of-control event is noted. The specific corrective action taken depends on the specific analysis and the nature of the event. Generally, the following occurrences alert laboratory personnel that corrective action may be necessary:

- QC data are outside established warning or control limits.
- Method blank analyses yield concentrations of target analytes greater than acceptable levels.

- Undesirable trends are detected in spike recoveries or in duplicate RPDs.
- There is an unexplained change in compound detection capability.
- Inquiries concerning data quality are received.
- Deficiencies are detected by laboratory QA staff audits or from performance evaluation sample test results.

Corrective actions are documented for non-routine out-of-control situations on a corrective action form. Figure 13-2 provides a blank of a typical corrective action form. A routine out-of-control situation is defined as one that is noted in the corrective action section of the method-specific SOP. Each SOP defines the routine out-of-control situations and the appropriate corrective action procedures for these situations. All out-of-control situations not addressed in the SOP must be treated as non-routine and documented in the corrective action logbook.

Using the corrective action form, any employee may notify the laboratory QA/QC Officer of a problem. The QA/QC Officer initiates the corrective action by relating the problem to the appropriate laboratory manager and/or internal coordinator, who then investigates or assigns responsibility for investigating the problem and its cause. After the cause is determined, an appropriate corrective action is approved by the QA/QC Officer. Its implementation is verified and documented on the corrective action form and is further documented through audits.

Information contained on corrective action forms is kept confidential within the laboratory and is generally limited to the individuals involved. Severe problems and difficulties may warrant special reports to the laboratory president, who will ensure that the appropriate corrective actions are taken.

13.3 CORRECTIVE ACTION DURING DATA VALIDATION AND DATA ASSESSMENT

As a means of oversight, the quality assurance manager may audit a percentage of the data validation, assessment, and evaluation deliverables generated/performed.

The need for corrective action may become apparent during data validation, interpretation, or presentation activities, or problems may be identified as a result of oversight findings. The performance of rework, instituting a change in work procedures, or providing additional/refresher training are possible corrective actions relevant to data evaluation activities. The Tetra Tech PM will be responsible for approving the implementation of corrective action.

13.4 CORRECTIVE ACTION FOR ADMINISTRATIVE ACTIVITIES

Findings identified through office procedures and file audits may also necessitate the performance of corrective actions. Corrective actions involving file management and office procedures usually consist of correction of an isolated nonconformance or the performance of activities necessary to conform with clarified guidance.

FIGURE 13-1

FIELD TASK MODIFICATION REQUEST FORM
QUALITY ASSURANCE PROJECT PLAN
FORMER KILGORE MANUFACTURING FACILITY

_____

Client Identification Project Number TMR Number

To_____Location_____Date_____

Description:

_____
_____
_____
_____

Reason for Change:

_____
_____
_____
_____

Recommended Disposition:

_____
_____
_____
_____

_____

Field Operations Leader (Signature, if applicable) Date

Disposition:

_____
_____
_____
_____

_____

Project Manager (Signature, if required) Date

_____

Distribution:
Program Manager
Quality Assurance Officer
Project Manager
Field Operations Leader

Others as required_____
_____
_____
_____

FIGURE 13-2

ANALYTICAL LABORATORY CORRECTIVE ACTION FORM
QUALITY ASSURANCE PROJECT PLAN
FORMER KILGORE MANUFACTURING FACILITY

Name:_____ Date:_____

Problem:

Samples Affected:

_____

Action Taken:

Name_____ Date:_____

_____

Action Taken:

Name_____ Date:_____

_____

Proof of Return to Control:

Supervisor:_____ QA/QC Officer:_____

Date:_____ Date:_____

14.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

QA reports to management will be provided in two primary formats during the course of this investigation. Data validation letter reports will be prepared on a SDG-specific basis and will summarize QA/QC issues for the laboratory data. Monthly progress reports will be provided by the Tetra Tech PM.

14.1 CONTENTS OF PROJECT QUALITY ASSURANCE REPORTS

The data validation reports address all major and minor laboratory noncompliances, as well as noted sample matrix effects. In the event that major problems occur with the analytical laboratory (e.g., holding time exceedances or calibration noncompliances, etc.), the Data Validation Coordinator notifies the Tetra Tech PM, the Program Manager, and the Laboratory Services Coordinator. Such notifications (if necessary) are typically provided via internal memoranda and are placed in the project file. Such reports contain a summary of the noncompliance, a synopsis of the impact on individual projects, and recommendations regarding corrective action and compensational adjustments. Corrective actions are initiated at the program level.

The FOL will provide the Tetra Tech PM with weekly reports regarding accomplishments, deviations from the WP, upcoming activities, and a QA summary during the course of the field investigation. In addition, quarterly project review meetings are held for all active Tetra Tech projects. Issues discussed at the project review meeting include all aspects of budget and schedule compliance and QA/QC problems.

14.2 INDIVIDUALS RECEIVING/REVIEWING QUALITY ASSURANCE REPORTS

Data validation QA reports are provided to the Tetra Tech PM for inclusion in the project files. In the event that major problems are observed for a given laboratory, the Laboratory Services Coordinator is provided with copies of the QA report. Weekly field progress reports are provided to the Tetra Tech PM.

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ATTACHMENT D

HEALTH AND SAFETY PLAN

Health and Safety Plan

for the

Remedial Investigation/Feasibility Study

at

Former Operations Area

of

Kilgore Manufacturing

Otterbein University
Westerville, Ohio

November 2010

HEALTH AND SAFETY PLAN

FOR THE

REMEDIAL INVESTIGATION/FEASIBILITY STUDY

AT

FORMER KILGORE MANUFACTURING SITE
WESTERVILLE, OHIO

Prepared for:
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1 South Grove Street
Westerville, Ohio 430081

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NOVEMBER 2010

PREPARED UNDER THE SUPERVISION OF:	APPROVED FOR SUBMITTAL BY:
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ACRONYMS AND ABBREVIATIONS

AHA	Activity Hazard Analysis
APP	Accident Prevention Plan
BZ	Breathing Zone
CFR	Code of Federal Regulations
CIH	Certified Industrial Hygienist
COC	Contaminant of Concern
CRZ	Contamination Reduction Zone
CSP	Certified Safety Professional
DEET	meta-N,N-diethyl toluamide
DMM	Discarded Military Munitions
DOT	Department of Transportation
DPT	Direct Push Technology
FOL	Field Operations Leader
GPS	Global Positioning System
HASP	Health and Safety Plan
HSA	Hollow Stem Auger
HSM	Health and Safety Manager
IDW	Investigation-Derived Waste
MC	Munitions Constituents
MEC	Munitions and Explosives of Concern
mm	Millimeter
MRP	Munitions Response Program
MSDS	Material Safety Data Sheet
OSHA	Occupational Safety and Health Administration
PHSO	Project Health and Safety Officer
PM	Project Manager
POC	Point of Contact
PPE	personal protective equipment
SOP	Standard Operating Procedure
SSO	Site Safety Officer
TBD	To Be Determined
Tetra Tech	Tetra Tech NUS, Inc.
TNT	trinitrotoluene
UXO	Unexploded Ordnance

1.0 INTRODUCTION

This Health and Safety Plan (HASP) is specifically written for the various activities that are to be conducted at the Former Kilgore Manufacturing Site, in Westerville, Ohio. At this site the production of explosives and incendiary materials such as flares, fuses, hand grenades, landmines and flame throwers occurred. The objective of this investigation is to perform a Remedial Investigation/Feasibility Study (RI/FS), additional precautions must be taken. Because the possibility exists to encounter unexploded ordnance (UXO) or munitions and explosives of concern (MEC) other safety measures, such as UXO screening, may be required.

This HASP is to be used in conjunction with the Tetra Tech Health and Safety Guidance Manual. The Guidance Manual provides detailed information pertaining to hazard recognition and control, and Tetra Tech SOPs. This HASP and the contents of the Guidance Manual were developed to comply with the requirements stipulated in 29 CFR 1910.120 (OSHA's Hazardous Waste Operations and Emergency Response Standard). An Accident Prevention Plan (APP) is included as Attachment I of this document. The HASP, the APP and the Guidance Manual must be present at the site.

This HASP has been developed using the latest available information regarding known or suspected chemical contaminants and potential physical hazards associated with the proposed work and site activities. This HASP will be modified if new information becomes available. Changes to the HASP will be requested through the Tetra Tech Health and Safety Manager (HSM) and the Project Manager (PM). It is the responsibility of the PM to notify the affected personnel of changes to this HASP.

2.0 EMERGENCY ACTION PLAN

2.1 INTRODUCTION

This section has been developed as part of a planning effort to direct and guide field personnel in the event of an emergency. In the event of on-site emergencies, which are beyond the on-site personnel capabilities, site personnel will be evacuated to a safe place of refuge and the appropriate emergency response agencies will be notified. It has been determined that a majority of potential emergency situations would be better supported by outside emergency responders. Based on this determination, Tetra Tech and subcontractor personnel will only provide emergency response support to the level of their capabilities. Workers who are ill or who have suffered a non-serious injury may be transported by site personnel to nearby medical facilities, provided that such transport does not aggravate or further endanger the welfare of the injured/ill person. The emergency response agencies listed in this plan are capable of providing the most effective response, and as such, will be designated as the primary responders. These agencies are located within a reasonable distance from the area of site operations, which ensures adequate emergency response time.

Tetra Tech will, through necessary services, include response measures for incidents such as:

- Incipient stage fire fighting support and prevention
- Incipient spill control and containment measures and prevention
- Removal of personnel from emergency situations
- Provide initial medical support for injuries or illnesses requiring only first-aid level support
- Provide site control and security measures as necessary

For MEC areas, emergency activities personnel will also comply with the requirements outlined in the APP, which is included as Attachment I to this HASP.

2.2 EMERGENCY PLANNING

Through the initial hazard/risk assessment effort, it has been determined that the most probable emergencies that could be encountered during site activities are injuries or illnesses from MEC, physical, natural, and fire hazards. To minimize and eliminate these potential emergency situations, emergency planning activities associated with this project include the following. The FOL, SSO and UXO Specialist are responsible for:

- Establishing and maintaining information at the project staging area (support zone) for easy access in the event of an emergency. This information will include the following:
  - Chemical Inventory (used on-site) with Material Safety Data Sheets (MSDS).
  - On-site personnel medical records (medical data sheets).
  - A logbook identifying personnel on site each day.

It will be the responsibility of the Tetra Tech FOL to ensure this information is available and present at the site.

- In the event of an emergency the FOL will serve as the Incident Commander until Emergency Services arrive. The UXO Specialist will be consulted on any MEC-related matters.

- Educating site workers to the hazards and control measures associated with planned activities at the site and providing early recognition and prevention where possible. This will include:
  - Site-specific Training
  - Tailgate/Safety Meetings
  - Activity Hazard Analysis (AHA) Review

2.3 EMERGENCY RECOGNITION AND PREVENTION

2.3.1 Recognition

Foreseeable emergency situations that may be encountered during site activities will generally be recognizable by visual observation. This will be done by the UXO Specialist who will visually scan the surface as well as use magnetometers to detect the potential presence of subsurface MEC-related materials. In addition, the UXO Specialist will provide training and instruction on MEC types that may be encountered, avoidance measures, etc. The Tetra Tech UXO SOP is provided as Attachment II of this HASP.

Visual observation is primarily relevant for physical hazards that may be associated with the proposed scope of work. Potential site hazards, the activities unto which they have been associated with, and the recommended control methods are discussed in detail in Sections 5.0 and 6.0 of this HASP. Additionally, early recognition of emergency situations will be supported by periodic site surveys to eliminate any situation predisposed to an emergency. The FOL and the SSO will make up the site evaluation committee responsible for these periodic surveys.

The above actions will provide early recognition for potential emergency situations. If an incident should occur, Tetra Tech will take defensive and offensive measures to control these situations. However, if the

FOL and the SSO determine that an incident has progressed to a serious emergency situation, site personnel will withdraw, and notify the appropriate response agencies.

2.3.2 Prevention

Tetra Tech and subcontractor personnel will minimize the potential for emergencies by ensuring compliance with the Tetra Tech APP, HASP, Health and Safety Guidance Manual, and UXO SOP.

2.4 SAFE DISTANCES AND PLACES OF REFUGE

In the event that the site must be evacuated, personnel will immediately stop activities and report to the selected assembly point for that area within that support zone. Safe places of refuge will be identified prior to the commencement of site activities and will be conveyed to personnel as part of the daily safety meeting conducted each morning. During an evacuation, personnel reporting to the refuge location will remain there until directed otherwise by the Tetra Tech FOL. The FOL or the SSO will take a head count at this location to account for and to confirm the location of the site personnel. The site logbook will be used to take the head count. Emergency response personnel will be immediately notified of any unaccounted personnel.

2.5 EVACUATION ROUTES AND PROCEDURES

An evacuation will be initiated whenever severe weather is encountered; a fire or explosion occurs; or if personnel show signs or symptoms of overexposure to potential site contaminants. When conditions require evacuation, personnel will cease activities and travel to the assembly areas via cleared pathways established by the UXO Specialist. In the event of an evacuation, personnel will proceed immediately to the designated place of refuge in the support zone, unless doing so would further jeopardize the welfare of workers. In such an event, personnel will proceed to a designated alternate location and remain until further notification from the Tetra Tech FOL.

Evacuation procedures will be discussed prior to the initiation of any work at the site. Evacuation routes from the site and safe places of refuge are dependent upon the location at which work is being performed and the circumstances under which an evacuation is required. Additionally, site location and meteorological conditions (i.e., wind speed and direction) may dictate evacuation routes. As a result, assembly points will be selected and communicated to the workers relative to the site location where work is being performed.

2.6 EMERGENCY CONTACTS

Prior to initiating field activities, personnel will be thoroughly briefed on the emergency procedures to be followed in the event of an accident. Table 2-1 provides a list of emergency contacts and their associated telephone numbers. This table must be posted where it is readily available to site personnel. Facility maps should also be posted showing potential evacuation routes and designated meeting areas.

Any pertinent information regarding allergies to medications or other special conditions will be provided to medical services personnel. This information is listed on Medical Data Sheets filed onsite. If an exposure to hazardous materials has occurred, provide information on the chemical, physical, and toxicological properties of the subject chemical(s) to medical service personnel. This information is listed on Medical Data Sheets filed onsite (See Attachment III).

TABLE 2-1

EMERGENCY REFERENCE
FORMER KILGORE MANUFACTURING SITE
WESTERVILLE, OHIO

CONTACT	PHONE NUMBER
EMERGENCY (Police, Fire, Ambulance Service)	**9-1-1**
Hospital Emergency Room	(787) 655-0505 Ext. 2206
Ohio Poison Control Center	(800) 222-1222
Ohio Utility Locating Service	811
Otterbein University	(614) 890-3000
Facility Contact Rebecca Vazquez-Skillings	(787) 685-3450
Tetra Tech Project Manager Al Quagliotti	(412) 921-8146
Tetra Tech UXO Specialist TBD	
Tetra Tech Field Operations Leader/ Site Safety Officer TBD	
Tetra Tech PHSO James K. Laffey	(614) 823-1150
Tetra Tech, Health and Safety Manager Matthew M. Soltis, CIH, CSP	(412) 921-8912

2.7 EMERGENCY ROUTE TO HOSPITAL

Mount Carmel St. Ann's Hospital
500 South Cleveland Avenue
Westerville, Ohio 43081
(614) 898-4040

Distance: 4.5 miles

- Head south on N. Spring Road toward Grindstone Road — 0.5 miles
- Turn right onto County Line Road — 2.3 miles
- Turn left onto N. Cleveland Avenue — 1.5 miles

The Hospital is on the Left.

FIGURE 2-1

ROUTE MAP TO HOSPITAL

2.8 EMERGENCY ALERTING AND ACTION/RESPONSE PROCEDURES

Site personnel will be working in close proximity. As a result, hand signals, voice commands, and line of site communication will be established to alert site personnel of an emergency.

If an emergency occurs, the following procedures are to be initiated:

- Initiate the evacuation via hand signals, voice commands, or line of site communication
- Report to the designated refuge point
- Once non-essential personnel are evacuated, appropriate response procedures will be taken
- Describe to the Incident Coordinator the pertinent incident details.
- When UXO is discovered the UXO Technician will flag the location.
  - The area, if necessary, will be barricaded or otherwise protected.
  - The POC will be notified and local law enforcement will be contacted for treatment if necessary.
  - Site operations will stop, and the area will be under the control of the UXO Technician until relieved by the POC or local law enforcement.

In the event that site personnel cannot mitigate the hazardous situation site personnel will:

- Dial 911 and call other pertinent emergency contacts listed in Table 2-1 and report the incident
- Give the emergency operator the location of the emergency, the type of emergency, the number of injured, and a brief description of the incident
- Stay on the phone and follow the instructions given by the operator
- The operator will then notify and dispatch the proper emergency response agencies.

2.9 PPE AND EMERGENCY EQUIPMENT

A first-aid kit, eye wash units (or bottles of disposable eyewash solution) and fire extinguishers will be maintained onsite in the project work vehicle and shall be immediately available for use in the event of an emergency. At least one first aid kit supplied with equipment to protect against bloodborne pathogens will also be available on site.

2.10 DECONTAMINATION PROCEDURES

During any site evacuation, decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. Decontamination will be postponed if the incident warrants immediate evacuation. However, it is unlikely that an evacuation would occur which would require workers to evacuate the site without first performing the necessary decontamination procedures.

3.0 SITE BACKGROUND

3.1 SITE HISTORY

In 1941, in response to the needs of the Army Chemical Warfare Service, Kilgore Manufacturing purchased undeveloped land near the Franklin and Delaware County border. The former farm was converted to a pyrotechnics and ordnance manufacturing facility consisting of a network of magazines, concrete buildings, Quonset huts, a water tower, and other ancillary support facilities. On site activities included experimental work, the manufacture and assembly of incendiary items and detonation, burning and disposal of waste material.

From 1967 to 1986, portions of the property were farmed. This farm was known as the Kilgore Farm and was used for soy bean and corn crops. The approximate 111-acre parcel was conveyed to Otterbein College on January 1, 1990.

The intended use of the property is for construction of the Otterbein University Equine Facility, a permanent home for the Equine Science Department field operations. Plans include construction of classrooms, a residence for the caretaker, stables, event areas and bridle trails.

3.2 SITES DESCRIPTION

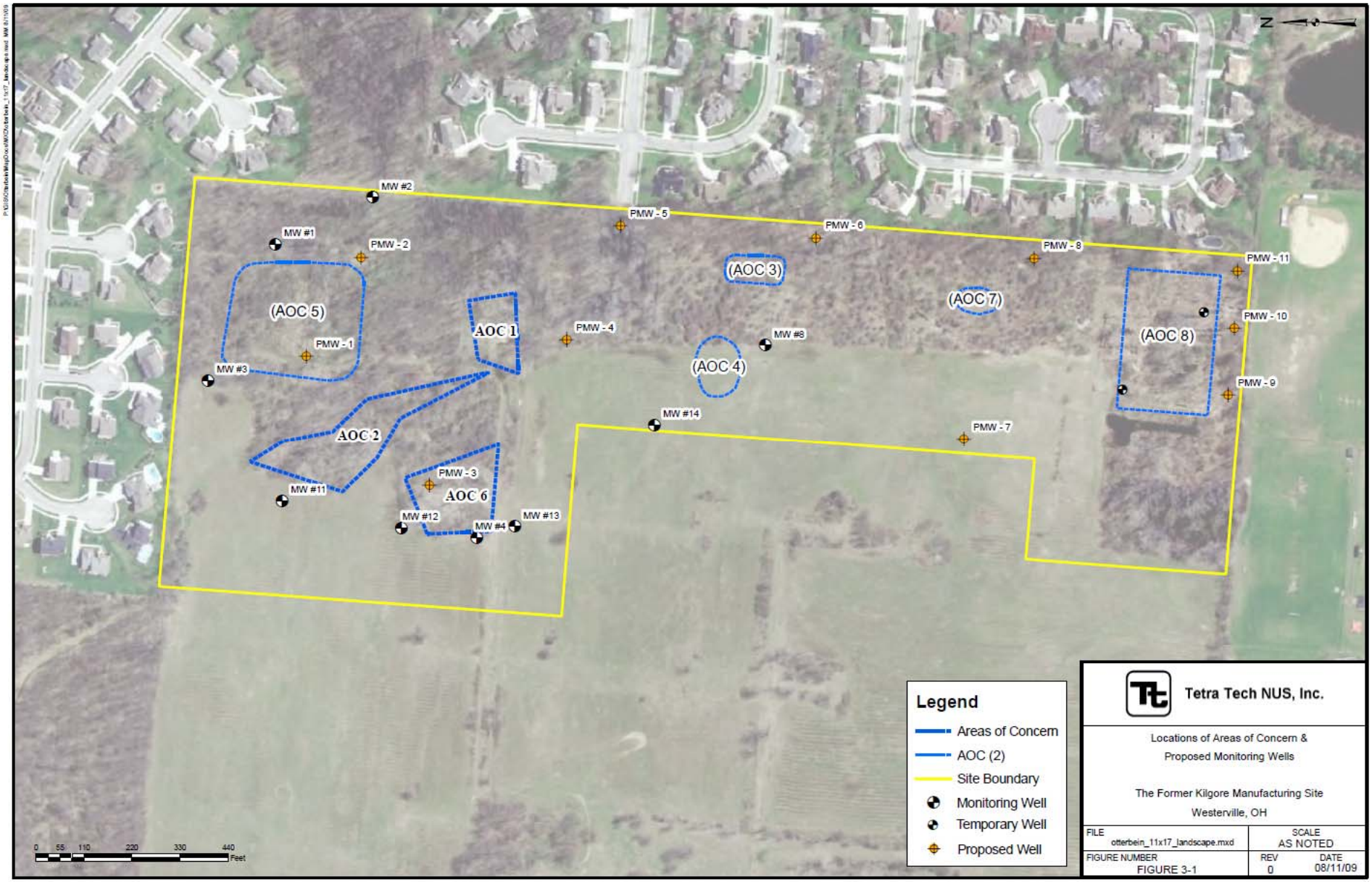
The site is located off of Spring Road approximately one-half mile north of County Line Road in Westerville, Ohio. The site is partially wooded and overgrown with dense grasses and brush. Gravel roads are still on site, however, the aboveground structures have been razed. There are eight areas of concern (AOCs) that will be investigated and evaluated.

Utilities including water supply, electricity and telephone service are available in the adjacent property owned by the Otterbein University in the Equine Center.

These areas are described in Table 3-1. An aerial photograph of the site is in Figure 3-1.

TABLE 3-1
SUMMARY OF SITES DESCRIPTIONS
FORMER KILGORE MANUFACTURING SITE

AOC Number	AOC Name	Description
1	Unidentified Rectangular Features	Surface and subsurface soils contaminated with metals.
2	Drainage Ditch Near Former Manufacturing Area	Intermittent drainage ditch where wastes were reportedly buried.
3	Burial Area East of Burn Pit	Former burial area for cinders and nonflammable materials.
4	Burn Pit	Used to burn flares, caps and other off-spec materials and waste.
5	UST in Former Manufacturing Areas East of Burn Pit	Area surrounding a former underground fuel oil storage tank that was removed in 1977.
6	Former Experimental Area	Area where product research and testing occurred.
7	Cinder Area SE of Burn Pit	Small area characterized by cinders, coal fragments, and slag at the ground surface.
9	Southeast Landfill Area	Former burial area in SE corner of the site.



Tetra Tech NUS, Inc.

Locations of Areas of Concern &
Proposed Monitoring Wells

The Former Kilgore Manufacturing Site
Westerville, OH

FILE	SCALE
otterbein_11x17_landscape.mxd	AS NOTED
FIGURE NUMBER	REV / DATE
FIGURE 3-1	0 / 08/11/09

4.0 SCOPE OF WORK

This section discusses the activities that are to be performed at the sites. The Activity Hazard Analysis (AHAs) found in Section 14.0 of the APP provides information related to each of the tasks that are to be performed as part of the scope of work. As new phases or tasks are to be performed at the sites, the AHAs will be modified accordingly.

The objective of this work is to conduct an RI/FS at each site in accordance with the Consent Order with the Ohio Environmental Protection Agency (OEPA). The primary reason to conduct an investigation of a site is to discover information not previously known. This site may present unexpected conditions. The most serious is for the discovery of additional MEC.

Primary tasks include:

- Mobilization/Demobilization
- UXO avoidance
- Brush clearing
- Monitoring well installation using direct push technology (DPT) or hollow stem auger (HSA)
- Multi-media sampling including:
  - Surface water
  - Sediment
  - Soil
- Decontamination
- Global Positioning System (GPS) survey
- Investigational-Derived Wastes (IDW) management

If tasks other than those presented in this HASP are performed at the sites, this section of the HASP and the APP will be modified accordingly.

5.0 GENERAL SAFE WORK PRACTICES

The purpose of this section is to identify general safe work practices to be used in conjunction with information provided in Section 2.0 as well as the information provided in the AHAs.

5.1 GENERAL SAFE WORK PRACTICES

The following general safe work practices are to be followed when conducting work on-site:

- Eating, drinking, chewing gum or tobacco, taking medication, or smoking in contaminated or potentially contaminated areas or where the possibility for the transfer of contamination exists is prohibited.
- Wash hands and face thoroughly upon leaving a contaminated or suspected contaminated area.
- If a source of potable water is not available at the work site that can be used for hands-washing, the use of waterless hand cleaning products will be used, followed by actual hand-washing as soon as practicable upon exiting the site.
- When soap and water are unavailable, it is recommended that sanitary hand wipes be used before hand to mouth activities.
- Avoid contact with potentially contaminated substances including puddles, pools, mud, or other such areas.
- Avoid kneeling on the ground or leaning or sitting on equipment.
- Keep monitoring equipment away from potentially contaminated surfaces.
- Maintain visual contact with your buddy and with other on-site team members by remaining in close proximity to assist each other in case of emergency.
- Establish appropriate safety zones including support, contamination reduction, and exclusion zones.
- Minimize the number of personnel and equipment in contaminated areas (such as the exclusion zone). Non-essential vehicles and equipment should remain within the support zone.
- Establish appropriate decontamination procedures for leaving the site.

- Immediately report injuries, illnesses, and unsafe conditions, practices, and equipment to the SSO.

- Observe co-workers for signs of heat or cold stress.

- Inform co-workers of potential symptoms of illness, such as headaches, dizziness, nausea, or blurred vision.

5.2 DPT/HSA SAFE WORK PRACTICES

The following Safe Work Practices are to be followed when working in or around the DPT/HSA Drill Rig Operations.

- Identify underground utilities and buried structures before commencing any DPT/HSA operations.

- Follow the TtNUS Utility Locating and Excavation Clearance Standard Operating Procedure.
  - Contact the Ohio Utilities Protection Service by calling 811 at least 48 hours but no more than 10 days (excluding weekends and legal holidays) before beginning any intrusive activity.

- DPT/HSA drill rigs will be inspected by the SSO or designee, prior to the acceptance of the equipment at the site and prior to the use of the equipment.

- Repairs or deficiencies identified will be corrected prior to use.

- The inspection will be accomplished using the Equipment Inspection Checklist for drill rigs provided in Attachment IV.

- After the initial inspection and release for use on site, additional inspections will be performed at least at the beginning of every 5 or 10-day shift, or following any repairs or significant maintenance activities.

- Ensure that all machine guarding is in place and properly adjusted.

- Block the drill rig and use levelers to prevent inadvertent movement.

- The work area around the point of operation will be cleared to the extent possible to remove any trip hazards near or surrounding operating equipment.

- An equipment staging and lay-down plan will help keep the work area clear of clutter and slips, trips, and fall hazards.

- Mechanisms to secure heavy objects such as drill flights will be provided to avoid the collapse of stacked equipment.

- Minimize contact to the extent possible with contaminated tools and environmental media.

- Potentially contaminated tools will be placed on polyethylene sheeting for storage and wrapped for transport to the centrally located equipment decontamination area

- Support functions (sampling and screening stations) will be maintained a minimum distance from the drill rig of the height of the mast plus five feet, but not less than 25 feet around the rig.

- Only qualified operators and knowledgeable ground crew personnel will participate in the operation of the drill rig.

- During maintenance, use only manufacturer provided/approved equipment (i.e. auger flight connectors, etc.)

- In order to minimize contact with potentially contaminated tools and to minimize lifting hazards, multiple personnel should be used to move auger flights and other heavy tools.

- Only personnel absolutely essential to the work activity will be allowed in the exclusion zone.

- Equipment used within the exclusion zone will undergo a complete decontamination and evaluation by the FOL and/or the SSO to determine cleanliness prior to moving to the next location, exiting the site, or prior to down time for maintenance.

- Motorized equipment will be fueled prior to the commencement of the day's activities.

- When not in use drill rig will be shutdown, and emergency brakes set and wheels will be chocked to prevent movement.

- Investigative areas will be restored to equal or better condition than original to remove any contamination brought to the surface and to remove any physical hazards.

- In situations where these hazards cannot be immediately removed, the area will be barricaded to limit access.

6.0 HAZARD ASSESSMENT

The following section provides information regarding chemical, physical and hazards associated with the sites and the activities that are to be conducted as part of the scope of work.

6.1 CHEMICAL HAZARDS

The potential health hazards associated with these sites include inhalation and ingestion of, and direct contact with various contaminants that may be present. Previous investigations have determined that metals are the primary contaminants of concern (COC) in water, however, analytes associated with the potential Munitions Constituents (MC) may be encountered and are also included:

- Metals including antimony, arsenic, barium, chromium, lead, and thallium

- Propellant and explosive contaminants may include several different chemicals used in the manufacture of explosives and incendiary devices.
  - Examples of these chemicals are ammonium picrate, boron phosphide, lead azide, magnesium, mercury fulminate, phosphorous, potassium nitrate, potassium perchlorate, sodium hypophosphite, sodium nitrate, sodium perchlorate, 2,4,6-trinitrotoluene (TNT), and tetryl.

As direct contact will be minimal given the sampling method, it is unlikely that exposure will occur. Area wetting techniques will be employed if dust generation occurs. Exposure to these compounds is most likely to occur through hand-to-mouth contact during sampling activities. For this reason, PPE and basic hygiene practices (washing face and hands before leaving site) and direct reading instruments will be the principal methods for minimizing exposures. The signs and symptoms of exposure for these substances are summarized below:

Metals: There are 35 metals that are of concern because of occupational exposure; 23 of these are the heavy metals: antimony, arsenic, bismuth, cadmium, cerium, chromium, cobalt, copper, gallium, gold, iron, lead, manganese, mercury, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium, and zinc. Small amounts of these elements are common in our environment and diet and are actually necessary for good health, but large amounts of any of them may cause acute or chronic toxicity (poisoning).

Heavy metal toxicity can result in damaged or reduced mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver, and other vital organs. Allergies are not

uncommon and repeated long-term contact with some metals or their compounds may even cause cancer.

The association of symptoms indicative of acute toxicity is not difficult to recognize because the symptoms are usually severe, rapid in onset, and associated with a known exposure or ingestion: cramping, nausea, and vomiting; pain; sweating; headaches; difficulty breathing; impaired cognitive, motor, and language skills; mania; and convulsions.

Propellant and explosive contaminants: Routes of exposure are inhalation, ingestion, skin and eye contact. Signs and symptoms of overexposure may include headaches, dizziness, nausea, hyperactivity, convulsions, seizures, fatigue, and irritability rashes, dry skin and itchy eyes, respiratory problems, joint pain, sore throat, and depression. These effects may be experienced quickly or several hours later. Some can be topically irritating to skin and eyes.

6.1.1 Ingestion and Skin Contact:

Potential exposure concerns to the contaminants of concern (COCs) may also occur through ingesting or coming into direct skin contact with contaminated media. The likelihood of worker exposure concerns through these two routes are also considered very unlikely, provided that workers follow good personal hygiene and standard good sample collection/sample handling practices, and wear appropriate PPE as specified in this HASP. Examples of onsite practices that are to be observed that will protect workers from exposure via ingestion or skin contact include the following:

- No hand-to-mouth activities on site (eating, drinking, smoking, etc.)
- Washing hands upon leaving the work area and prior to performing any hand to mouth activities
- Wearing surgeon's-style inner gloves and nitrile outer gloves whenever handling potentially-contaminated media, including soils, hand tools, and sample containers.

6.2 PHYSICAL HAZARDS

The following is a list of physical hazards that may be encountered at the site or may be present during the performance of site activities associated with the scope of work.

- Slips, trips, and falls
- Lifting (strain/muscle pulls)
- Ambient temperature extremes (cold and heat stress)
- Vehicular and foot traffic
- Contact with MEC

- Flying projectiles
- Heavy equipment hazards (rotating equipment, hydraulic lines, etc.)

6.2.1 Slips, Trips, and Falls

Conditions, such as steep terrain and/or heavy vegetation, may create an increased potential for slip, trip, and fall hazards:

- The safest approach to sample points will be identified and cleared to permit field crew access to sample locations.

- Establish anchor points and rope handrails for traversing/ascending/descending angles and slopes greater than 45% grade.

- Footwear with an adequate traction.

- Prepare work areas by removing tripping hazards (ruts, roots, debris). This is especially critical around rotating equipment, where a fall into the rotating apparatus could be life threatening.

6.2.2 Strain/Muscle Pulls from Lifting

During execution of planned activities there is some potential for strains, sprains, and/or muscle pulls due to the physical demands and nature of this site work. To avoid injury during lifting tasks personnel are to lift with the force of the load carried by their legs and not their backs. When lifting or handling heavy material or equipment, use an appropriate number of personnel. Keep the work area free from ground clutter to avoid unnecessary twisting or sudden movements while handling loads.

6.2.3 Vehicular, and Equipment Traffic

Hazards associated with vehicular and equipment traffic may exist during site activities. To minimize the potential for injuries associated with potential vehicular hazards, site personnel will be instructed to maintain awareness of traffic and moving equipment when performing site activities. When working near roadways, site personnel will wear high visibility vests.

6.2.4 Contact with MEC

Because of the prior uses of the areas that are being investigated, there is a possibility that MEC may be encountered during site operations. The term MEC includes military munitions that pose an explosive

safety risk, such as UXO, discarded military munitions (DMM) and MC present in high enough concentrations to pose an explosive hazard. Activities at the site will be conducted consistent with the UXO SOP, standard MEC procedures and the APP.

- In general, field personnel will practice UXO avoidance techniques.
  - Do not pick-up or kick any unknown materials.
  - Notify the UXO Specialist if you encounter unknown materials.
  - Where the potential exists for MEC materials the UXO Specialist will survey the access routes and work areas for MEC hazards.

- To minimize the risk of an MEC encounter, the trained UXO Specialist will provide support during site activities. An exclusion zone will be established before activities begin.

MEC or Related Items Hazards: One of the potential hazards associated with this activity is the potential for encountering MEC. The unintended detonation of MEC or an MEC-related item could result in injury or possibly death. To minimize this potential, the following measures will be incorporated:

- UXO Specialists will perform a visual and magnetic survey of all investigation areas as well as routes to and from the sites.

- The Team will follow instructions and directions provided by the UXO Specialist.

- The Team will restrict themselves to the areas identified by the UXO Specialist.

- The Team will be directed not to pick up, kick, or otherwise disturb articles lying on the ground.

- Intrusive activities, such as digging or unearthing items, are strictly prohibited until UXO avoidance techniques (Attachment II) have been implemented at the specific sample location.

- Personnel will be assigned in such a manner as to permit the direct visual observation of one another as well as provide any emergency assistance should it be required.

- Personnel will notify the UXO Specialist should they encounter suspected MEC articles or unidentified items.

- Smoking, eating, drinking, chewing gum or tobacco or other hand-to-mouth activities are prohibited while on the site.

- Matches, lighters, or other fire, flame, or spark-producing devices shall be prohibited on site.
- Personnel shall only use cell phones or radios in areas that are cleared for their use.
- Personnel shall suspend outdoor activities in the event of inclement weather (thunderstorms, lightning, heavy rain).

Potential MEC that the field crew may encounter during the investigation are identified in the Work Plan (WP). Components from these items may also be present at the sites. See the APP for further information. Also, refer to the Tetra Tech UXO SOP provided in the APP (Attachment II).

6.3 NATURAL HAZARDS

Insect/animal bites and stings, poisonous plants, parasites, and inclement weather are natural hazards that may be present given the location of activities to be conducted. In general, avoidance of areas of known infestation or growth will be the preferred exposure control for insects/animals and poisonous plants. Specific discussion on principle hazards of concern follows:

6.3.1 Indigenous Snakes

Ohio has only three species of venomous snakes the Eastern Massauga, Timber Rattlesnake and Northern Copperhead. The only one to inhabit Delaware County is the Eastern Massauga.

Eastern Massasauga

The Eastern massasauga is a medium-sized, dark-colored, rattlesnake with 29 to 50 dark dorsal blotches on its gray or brownish gray body. There are three rows of smaller dark spots on each side of the body. The snake can be identified by its short (two to three feet), thick body. The head of this snake is thick and triangular, with black stripes. Its belly is black and irregularly marked with white or yellowish spots. The pupils of its eyes are elliptical. The triangular head and elliptical eyes are two features used to help identify a venomous snake. The most distinguishable feature of this snake is the stubby rattle on the end of its tail. They have been recorded in as many as 22 counties; however, they are a rare sight. These rattlesnakes are found in wet prairies, sedge meadows, and early successional fields. Preferred wetland habitats are marshes and fens. They avoid open water and seem to prefer the cover of broad-leafed

plants, emergents, and sedges. Natural succession of woody vegetation is a leading cause of recent habitat deterioration throughout its range.

6.3.2 Ticks/Spiders/Other Insects

Many of the planned site activities will occur outside in areas that are not improved or maintained. As a result, the potential for encountering natural hazards exists. The following information is provided as a precaution to help recognize and avoid these types of hazards. Insect bites and stings may be difficult to control. However, in an effort to minimize this hazard the following control measures will be implemented where possible.

- Commercially available bug sprays and repellents will be used whenever possible.
- For effective protection, insect repellants should contain at least 10% DEET.
- Always follow the manufacturer's label instructions for proper application, re-application and precautions for use.
- Where possible, loose-fitting and light-colored clothing with long sleeves should be worn.
- This will also aid in insect control by providing a barrier between the field person and the insects and will aid in visual recognition of crawling insects against the lighter background.
- Pant legs should be secured to the work-boots using duct tape to prevent access by ticks.
- Clothing/limited body checks for ticks and other crawling insects should be conducted upon exiting heavily vegetated areas.
- Site personnel should perform a more detailed check of themselves when showering in the evening.
- Ticks prefer moist areas of the body and will migrate to those locations on the body.

The UXO support specialist will preview access routes and work areas in an effort to identify physical hazards including nesting areas in and around the work sites. These areas will be flagged or otherwise communicated to the Field Team. The UXO support specialist should attempt to determine if site personnel are allergic to bee and other insect stings and bites (using completed Medical Data Sheets).

Field crew members who are allergic to bites should have access to an emergency kit containing antihistamine or whatever method of response is recommended by their Doctor/Health Care Provider.

Bees, Wasps and Hornets

- Bees, hornets, yellow jackets, wasps and even mosquitoes can sting or bite.
- Though irritating and uncomfortable, in most cases insect bites or stings are harmless. However insect bites can cause allergic reactions in some people.
- If stung, remove the stinger by scraping a card across the wound (do not squeeze).
- Wash the area with warm, soapy water.
- Apply a cold compress to control swelling.
- Take aspirin for pain and an antihistamine, as needed, for minor itching and swelling.
- If you experience a body-wide reaction, severe local swelling, especially around the face or neck, or have difficulty breathing, call 911 immediately.

It is important that if you have allergies (to bee stings, fire ants, etc.) that this information is noted on your medical data sheet provided in Attachment III. In situations where you employ Benadryl or Doctor/Health Care Provider recommended antidotes insure you have these pharmaceuticals with you.

Mosquitos

The mosquito, *Aedes aegypti*, is a mosquito that can spread the dengue fever, Chikungunya and yellow fever viruses, and other diseases. The mosquito can be recognized by white markings on legs and a marking of the form of a lyre on the thorax. The mosquito originated from Africa but is now found in the tropics worldwide.

Ticks

Tick bites are common and usually harmless, but occasionally may result in Rocky Mountain spotted fever or Lyme disease.

- It usually takes about 24 hours of tick attachment to a "host" for disease to be transmitted.
- The symptoms can begin as early as a few days after a bite or take as long as two weeks before appearing.

- Symptoms include headache, chills, fever and rash - much like the flu.
- If bitten, carefully remove the tick using blunt tweezers.
- Grasp the tick close to the skin and pull straight out with a steady pressure.
- Check to see that the entire tick has been removed.
- Clean with warm, soapy water, then apply an antiseptic.
- Be observant of and if any of the above symptoms develop, contact your doctor immediately.

Ticks have been identified in the transmission of diseases including Lyme's disease. Warm months (Spring through early fall) are the most predominant time for this hazard. Information concerning Lyme's Disease including recognition, evaluation, tick removal, and control is provided in Section 4.0 of the Tetra Tech Health and Safety Guidance Manual.

Black Widow Spider

The female black widow spider has a round, glossy black abdomen one-half inch in diameter with an orange-red hourglass marking her belly. Her painful bite results in redness and warmth at the site as well as muscle cramps, twitching, rigid abdomen, difficulty breathing, weakness, headache, nausea and vomiting. The male black widow spider is solid in color, and his bite is not venomous. If bitten, wash the area with warm, soapy water and call Poison Center immediately

Brown Recluse Spider

The brown recluse spider is small, about one-half inch long with an oval body and a dark violin-shaped marking on its back.

- Its bite causes pain, redness, tenderness and a bull's eye appearance, progressing to ulceration.
- Bites may go unnoticed until a lesion develops.
- If bitten wash the area with warm, soapy water and call Poison Center immediately.
- A tetanus booster shot may be needed after a bite from a brown recluse spider.

6.3.3 Inclement Weather

Project tasks under this Scope of Work will be performed outdoors. As a result, inclement weather may be encountered. In the event that adverse weather conditions arise (electrical storms, hurricanes, etc.), the FOL and/or the SSO will be responsible for temporarily suspending or terminating activities until hazardous conditions no longer exist.

A NOAA Weather Radio is the best means to receive watches and warnings from the National Weather Service. The National Weather Service continuously broadcasts updated hurricane advisories that can be received by widely available NOAA Weather Radios.

7.0 AIR MONITORING

The COCs on this site are semi-volatile or metals. There are no contaminants expected to have the potential to be present in concentrations that could present an inhalation hazard during planned site activities, therefore air monitoring is not necessary during the activities being conducted under this HASP.

8.0 SITE CONTROL

This section outlines the means by which Tetra Tech will delineate work zones and use these work zones in conjunction with decontamination procedures to prevent the spread of contaminants into previously unaffected areas of the sites. It is also anticipated that this approach will control access to site work areas, restricting access by the general public, minimizing the potential for the spread of contaminants, and protecting individuals who are not cleared to enter work areas.

8.1 EXCLUSION ZONE

The exclusion zone will be considered the areas of the sites that are associated with known or suspected contamination. It is anticipated that the areas surrounding the sample points are contaminated as a result of the contaminants being brought to the surface. These areas will be marked and personnel will maintain safe distances. Once intrusive activities have been completed and surface contamination has been removed, the potential for exposure is again diminished and the area can then be reclassified as part of the contamination reduction zone. Therefore, the exclusion zones for this project will be limited to those areas of the sites where active work is being performed plus 15 feet.

Exclusion zones will be delineated as deemed appropriate by the FOL. This can be achieved through the sampler asking visitors to not approach any closer while the sampling or support activity is in progress. This can also occur by erecting visibility fencing, barrier tape, cones, and/or postings to inform and direct personnel.

8.2 CONTAMINATION REDUCTION ZONE

The contamination reduction zone (CRZ) may serve as a buffer area between the exclusion zone and any area of the sites where contamination is not suspected. This area may be segregated from the exclusion zone in that equipment will be removed and possibly transported to a centralized area for decontamination or investigation-derived waste (IDW) storage.

8.3 SUPPORT ZONE

The support zone for this project will include a staging area where site vehicles will be parked, equipment will be unloaded, and where food and drink containers will be maintained. The support zones will be established at areas of the sites well away from potential exposure to site contaminants during normal working conditions or foreseeable emergencies.

8.4 ACTIVITY HAZARD ANALYSIS

Exclusion Zone work conducted in support of this project will be performed using AHAs to guide and direct field crews on a task by task basis. The AHAs are located in Section 14.0, Table 1 of the APP.

8.5 SITE VISITORS

Site visitors must be escorted and restricted from approaching any work areas where they could be exposed to hazards from Tetra Tech operations. If a visitor has authorization from the client and from the Tetra Tech PM to approach the work areas, the FOL must ensure that the visitor first provides documentation indicating that they have successfully completed the necessary OSHA introductory training, receive site-specific training from the SSO, and that they have been physically cleared to work on hazardous waste sites. The FOL will instruct site visitors as to the requirements set forth by this HASP. Site visitors for the purpose of this document are identified as representing the following groups of individuals:

- Personnel invited to observe or participate in operations by Tetra Tech
- Regulatory personnel (i.e., OEPA and OSHA)
- Authorized personnel
- Other authorized visitors

Site visitors wishing to observe operations in progress will be escorted by a Tetra Tech representative and shall be required to meet the minimum requirements discussed below:

- Site visitors will be directed to the FOL/SSO, who will sign them into the field logbook.

- Information to be recorded in the logbook will include the individual's name (proper identification required), the entity which they represent, and the purpose of the visit.

- Site visitors wishing to enter the exclusion zone will be required to produce the necessary information supporting clearance to the site.

- In addition, to enter the site operational zones during planned activities, visitors will be required to first go through site-specific training.

Once the site visitors have completed the above items, they will be permitted to enter the operational zone. Visitors are required to observe the protective equipment and site restrictions in effect at the site at the time of their visit. Visitors entering the exclusion zones during ongoing operations will be

accompanied by a Tetra Tech representative. Visitors not meeting the requirements, as stipulated in this plan, for site clearance will not be permitted to enter the site operational zones during planned activities. Any incidence of unauthorized site visitation will cause the termination of on site activities until the unauthorized visitor is removed from the premises. Removal of unauthorized visitors will be accomplished with support from local law enforcement personnel.

8.6 SITE SECURITY

Site security will be accomplished using Tetra Tech field personnel. Tetra Tech will retain complete control over active operational areas. The first line of security will take place at the work site using exclusive zone barriers, site work permits, and site personnel to control unauthorized personnel. Interested parties from the general public will be referred to the POC for site access.

8.7 BUDDY SYSTEM

Personnel engaged in on site activities will practice the "buddy system" to ensure the safety of personnel involved in this operation.

8.8 MATERIAL SAFETY DATA SHEET REQUIREMENTS

Tetra Tech and where applicable subcontractor personnel will provide MSDSs for chemicals brought on site. The contents of these documents will be reviewed by the SSO with the user(s) of the chemical substances prior to any actual use or application of the substances on site. A chemical inventory of the chemicals used on site will be developed using the Health and Safety Guidance Manual (See Section 5.0). The MSDSs will then be maintained in a central location (i.e., temporary office) and will be available for anyone to review upon request.

8.9 COMMUNICATION

As personnel will be working in proximity to one another during field activities, a supported means of communication between field crew members will not be necessary.

External communication will be accomplished by using cell phones. External communication will primarily be used for the purpose of resource and emergency resource communications. Prior to the commencement of activities, the FOL will determine if telephone communications will be permitted.

9.0 SPILL CONTAINMENT PROGRAM

9.1 SCOPE AND APPLICATION

It is not anticipated that bulk hazardous materials (over 55 gallons) will be generated or handled at any given time as part of this scope of work as work is conducted using hand tools. It is also not anticipated that such spillage would constitute a danger to human health or the environment. However, as the job progresses, some potential may exist for accumulating IDW, such as decontamination fluids, soil cuttings, disposable sampling equipment, and personal protective equipment (PPE).

9.2 POTENTIAL SPILL AREAS

Potential spill areas will be periodically monitored in an ongoing attempt to prevent and control further potential contamination of the environment. Currently, limited areas are vulnerable to this hazard including:

- Resource deployment
- Waste transfer
- Central staging

It is anticipated that the IDW generated as a result of this scope of work will be containerized, labeled, and staged to await further analyses. The results of these analyses will determine the method of disposal through off site services.

9.3 LEAK AND SPILL DETECTION

To establish an early detection of potential spills or leaks, a periodic walk-around by the personnel staging or disposing of drums area will be conducted during working hours to visually determine that storage vessels are not leaking. If a liquid leak is detected, the contents will be transferred, using a hand pump, into a new vessel. The leak will be collected and contained using absorbents such as Oil-Dry, vermiculite, or sand, which are stored at the vulnerable areas in a conspicuously marked drum. This used material, too, will be containerized for disposal pending analysis. Inspections will be documented in the project logbook.

9.4 PERSONNEL TRAINING AND SPILL PREVENTION

Personnel will be instructed in the procedures for incipient spill prevention, containment, and collection of hazardous materials in the site-specific training. The FOL and the SSO will serve as the Spill Response

Coordinators for this operation, should the need arise. It is not anticipated that a spill would occur that onsite personnel could not handle.

9.5 SPILL PREVENTION AND CONTAINMENT EQUIPMENT

The following represents the types of equipment that should be maintained at the staging areas for the purpose of supporting this Spill Prevention/Containment Program:

- Sand, clean fill, or other non combustible absorbent (Oil-Dry)
- Drums (55-gallon UN 1A1 or 1A2)
- Shovels, rakes, and brooms
- Container labels

9.6 SPILL CONTROL PLAN

This section describes the procedures the Tetra Tech field crew members will employ upon the detection of a spill or leak.

- Notify the SSO or FOL immediately upon detection of a leak or spill.

- Employ the PPE stored at the staging area. Take immediate actions to stop the leak or spill by plugging or patching the container or raising the leak to the highest point in the vessel. Spread the absorbent material in the area of the spill, covering it completely.

- Transfer the material to a new drum and or container; collect and containerize the absorbent material. Label the new container appropriately. Await analyses for treatment and disposal options.

- Re-containerize spills, including 2-inch of top cover (if over soils) impacted by the spill. Await test results for treatment or disposal options.

It is not anticipated that a spill will occur that the field crew cannot handle. Should this occur, notification of the appropriate emergency response agencies will be carried out by the FOL or SSO in accordance with the procedures discussed in Section 2.0 of this HASP.

10.0 CONFINED-SPACE ENTRY

It is not anticipated, under the proposed scope of work, that confined space and permit-required confined space activities will be conducted. **Therefore, personnel under the provisions of this HASP are not allowed, under any circumstances, to enter confined spaces**.

A confined space is defined as a space that

- Is large enough and so configured that an employee can bodily enter and perform assigned work.
- Has limited or restricted means for entry or exit (for example, tanks, manholes, sewers, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry).
- Is not designed for continuous employee occupancy.

Additionally, a Permit-Required Confined Space is a confined space an area which has one or more of the following characteristics:

- Contains or has a potential to contain a hazardous atmosphere.
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly caving walls or by a floor that slopes downward and tapers to a smaller cross-section.
- Contains any other recognized, serious, safety or health hazard.

For further information on confined space, consult the Health and Safety Guidance Manual or call the PHSO. If confined space operations are to be performed as part of the scope of work, detailed procedures and training requirements will have to be addressed.

ATTACHMENT I

ACCIDENT PREVENTION PLAN

ACCIDENT PREVENTION PLAN

FOR THE

REMEDIAL INVESTIGATION/FEASIBILITY STUDY

AT

FORMER KILGORE MANUFACTURING SITE
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APPENDIX

1 Employee Training/Qualifications

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1 Activity Hazard Analysis

ACRONYMS

AHA	Activity Hazard Analysis
ANSI	American National Standards Institute
APP	Accident Prevention Plan
BLS	Bureau of Labor Statistics
CFR	Code of Federal Regulations
CIH	Certified Industrial Hygienist
CPR	Cardiopulmonary resuscitation
CSP	Certified Safety Professional
dB	Decibels
DART	Days Away/Restricted Duty/Transfer Case
DDESB	Department of Defense Explosives Safety Board
DEET	N, N-diethyl-m-toluamide
DPT	Direct Push Technology
EOD	Explosive Ordnance Disposal
FOL	Field Operations Leader
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSA	Hollow Stem Auger
HTRW	Hazardous Toxic and Radioactive Waste
MEC	Munitions and explosives of concern
MPPEH	Material potentially presenting an explosive hazard
MSDS	Material Safety Data Sheet
NAICS	North American Industry Classification System
NRR	Noise Reduction Rating
OSHA	Occupational Safety and Health Administration
PHSO	Project Health and Safety Officer
PM	Project Manager
PPE	Personal protective equipment
RCIR	Recordable Case Incident Rate
SHM	Safety and Health Manager
SSO	Site Safety Officer
TP	Technical Paper
UXO	Unexploded Ordnance
UXOSO/QC	Unexploded Ordnance Safety Officer/Quality Control

1.0 SIGNATURE SHEET

ACCIDENT PREVENTION PLAN FOR OTTERBEIN UNIVERSITY WESTERVILLE, OHIO

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Concurred by:

Matthew M. Soltis, CIH, CSP Tetra Tech NUS Safety and Health Manager	Signature	(412) 921-8912 Phone

Approved by:

Al Quagliotti, PG Tetra Tech NUS Project Manager	Signature	(412) 921-8146 Phone

2.0 BACKGROUND INFORMATION

2.1 PROJECT DESCRIPTION

This Accident Prevention Plan (APP) is specifically written for the various activities that are to be conducted at sites located at the Former Kilgore Manufacturing Site, in Westerville, Ohio. The objective of this investigation is to perform a Remedial Investigation/Feasibility Study (RI/FS). The APP addresses only the activities for Tetra Tech NUS (Tetra Tech) and their sub-contractor personnel. Other contractors or subcontractors are excluded in this APP and are to be addressed in safety and health planning documents prepared by that employer.

This document addresses applicable items specified under the U.S. Army Corps of Engineers Safety and Health Requirements Manual, Engineering Manual (EM) 385-1-1, and United States Occupational Safety and Health Administration (OSHA) Title 29 of CFR, § 1910.120(b).

This APP and the associated Site-Specific Health and Safety Plan (HASP) are for use during the completion of sampling tasks using unexploded ordnance (UXO) avoidance support. This APP and the accompanying HASP are available to:

- On-site personnel who may be exposed to hazardous on-site conditions, including Tetra Tech and subcontractor personnel participating in field activities and UXO avoidance activities

- Site visitors, including regulatory agency representatives

2.2 SITE MAPS

A facility location map and a site location map showing the location where Tetra Tech employees will be performing work are included as part of the Work Plan (WP) for the work associated with this field effort.

2.3 TETRA TECH SAFETY STATISTICS

The following table presents safety statistics for Tetra Tech for the last 3 calendar years compared to the national averages for our industry. This comparison uses data collected by the United States Department of Labor, Bureau of Labor Statistics (BLS) for different types of employers, segregated by North American Industry Classification System (NAICS) codes.

Comparison of Tetra Tech and

NAICS Code 562910 RCIR and DART Case Rates

	Remediation and other Waste Management Services 2009	Tetra Tech 2007	Tetra Tech 2007	Tetra Tech 2008	Tetra Tech 2009
Total Recordable Case Incident Rate (RCIR)	4.7	0.55	0.91	0.3	0.48
Days Away/Restricted Duty/Transfer Case Rate (DART)	3.22	0.27	0.30	0.3	0.24

The data comparison illustrate that Tetra Tech's performance compares favorably with the most-recent national averages for the environmental engineering and hazardous waste services industries.

Tetra Tech, Inc. Experience Modification Rates and OSHA Logs:

Policy Year (November 1 - November 30) 2006-2007:	0.90
Policy Year 2007-2008:	0.92
Policy Year 2008-2009:	0.81
Policy Year 2009-2010:	0.74

2.4 WORK PHASES

Work on this project will occur in the following phases. Associated dates when Tetra Tech personnel will be on site performing work will be listed for each phase of the project.

Phase 1 - Mobilization
Phase 2 - UXO Support (avoidance) and field activities
Phase 3 – Demobilization

2.5 SPECIFIC SITE ACTIVITIES

The detailed Scope of Work for field activities performed during UXO support during the site investigation at the Former Kilgore Manufacturing Site will include the following tasks:

- Mobilization/demobilization
- UXO surface survey

- Brush clearing
- Monitoring well installation using direct push technology (DPT) or hollow stem auger (HSA)
- Multi-media sampling including:
  - Surface water
  - Sediment
  - Soil
- Decontamination
- Global Positioning System (GPS) survey
- Investigational-Derived Wastes (IDW) management
- MEC and material potentially presenting an explosive hazard (MPPEH).

For each of these tasks a detailed Activity Hazard Analyses (AHAs) are available in Section 14.0 of this APP.

3.0 STATEMENT OF SAFETY AND HEALTH POLICY

Tetra Tech is committed to providing our employees with a safe and healthful workplace. The principal elements of our program are founded on the requirements presented in the Health and Safety Policy presented on the following page.

TETRA TECH NUS, INC.
HEALTH AND SAFETY POLICY

Tetra Tech NUS, Inc., is committed to providing our employees with a safe and healthful workplace. We believe that occupational injuries and illness can be prevented; and we are convinced that a strong Health and Safety Program is essential to achieve this objective.

The principal elements of our program are founded on the requirements that our managers and employees:

- **Recognize a *personal responsibility* for their own health and safety and for actions that affect the health and safety of fellow employees.**
- **Integrate safety and health into *all aspects* of their work, with the well-being of employees as the primary concern in all activities.**
- **Comply with applicable *federal, state, and local regulations*, as well as with our internal Corporate and our clients' safety and health policies and procedures.**
- **Take *an active role* in the Health and Safety Program by providing input and constructive criticism for improvements to the program.**

Mark T. Perry

Mark T. Perry, P.E.
President

Matthew M. Soltis

Matthew M. Soltis, CIH, CSP
Health and Safety Manager

Tetra Tech NUS. Inc.
January 2010

4.0 RESPONSIBILITIES AND LINES OF AUTHORITY

This section defines responsibility for site safety and health for Tetra Tech and subcontractor employees engaged in on-site activities. Personnel assigned to these positions will exercise the primary responsibility for on-site health and safety. These persons will be the primary points of contact for any questions regarding the safety and health procedures and the selected control measures that are to be implemented for on-site activities.

- The Tetra Tech PM is responsible for the overall direction of health and safety for this project.

- The work under this contract, including this field effort, is subject to a comprehensive health and safety program developed, designed, and implemented by Matthew M. Soltis, CIH, CSP. Mr. Soltis serves as Director of Health and Safety for Tetra Tech and as the Safety and Health Manager (SHM) for the planned work addressed in this APP.

- The Project Health and Safety Officer (PHSO) is responsible for developing the HASP in accordance with applicable OSHA regulations. Specific responsibilities include:

  - Providing information regarding site contaminants and physical hazards at the site
  - Establishing air monitoring and decontamination procedures
  - Assigning personal protective equipment
  - Determining emergency response procedures and emergency contacts
  - Stipulating training requirements and reviewing training and medical surveillance certificates
  - Providing standard work practices to minimize potential injuries and exposures associated with hazardous waste work

- The Tetra Tech Field Operations Leader (FOL) is responsible for implementation of the HASP with the assistance of an appointed Site Safety Officer (SSO). The FOL manages field activities, executes the work plan and enforces safety procedures as applicable to the work plan.

- The SSO supports site activities by advising the FOL on the aspects of health and safety on-site. These duties may include:

  - Coordinating the health and safety activities with the FOL
  - Selecting, applying, inspecting, and maintaining personal protective equipment

- Establishing work zones and control points
- Implementation of the air monitoring program for on-site activities
- Verifying training and medical clearances of on-site personnel status in relation to site activities
- Implementing hazard communication, respiratory protection, and associated health and safety programs as they pertain to site activities
- Coordination with identified emergency services
- Providing site specific training for on-site personnel

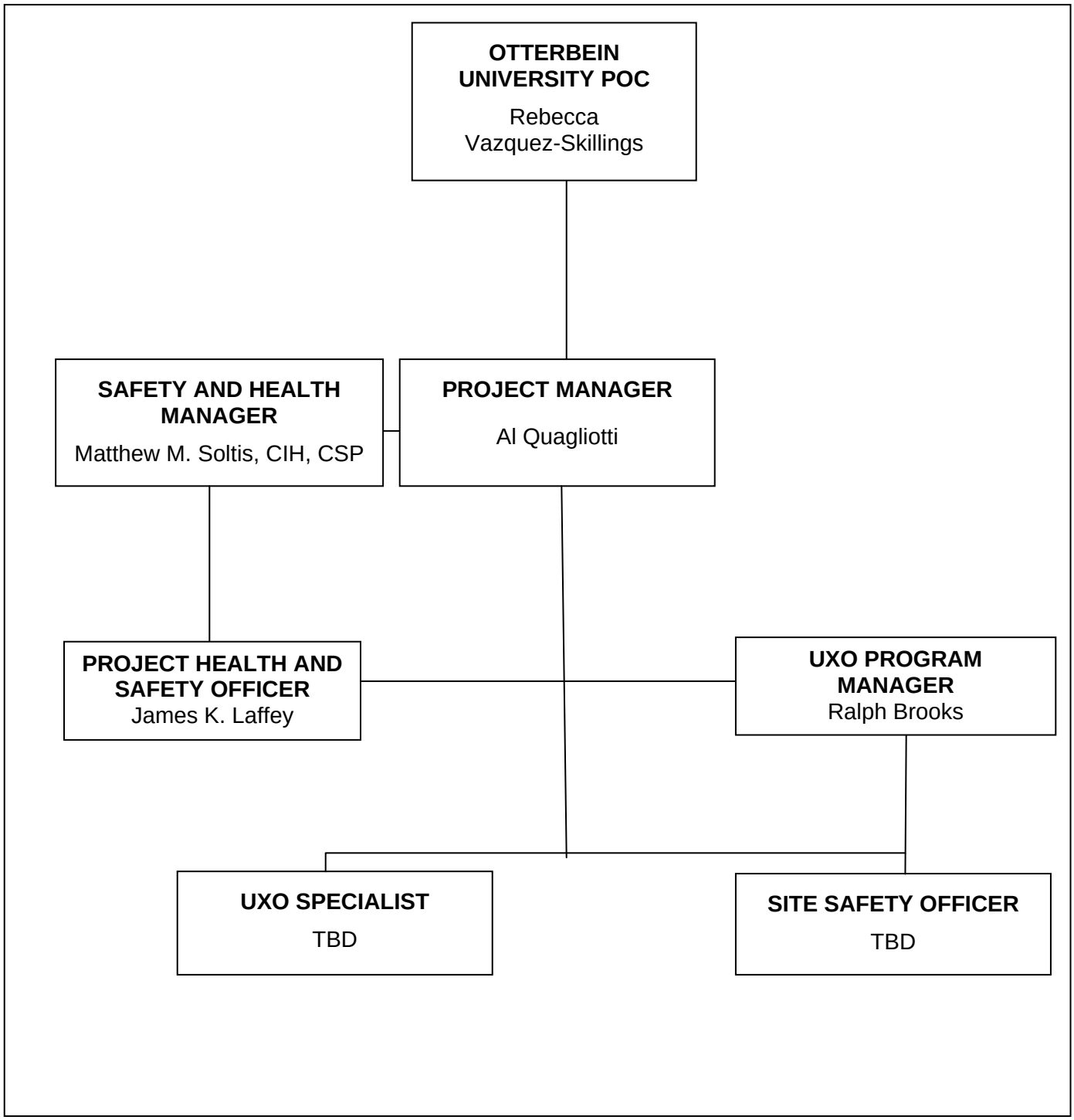
- The UXO Specialist directs daily implementation and enforcement of the contract requirements as they apply to MEC support and safety during site activities. The UXO Specialist has the overall responsibility for the day-to-day MEC operations at the site and directs site personnel resources at the site on MEC support issues to ensure their safety. The UXO Specialist will be responsible for the site MEC documentation. One UXO Specialist will be on site during all UXO-related activities including UXO avoidance in specified investigation areas. Other responsibilities of the UXO Specialist include:

  - Reviewing site-specific work plans and initiating field change requests as needed.
  - Scheduling and executing site MEC activities
  - Ensuring adequate communication between field personnel and emergency response personnel
  - Training site personnel about MEC in accordance with the HASP
  - Ensuring that the notifications are given prior to beginning work
  - Establishing and maintaining required exclusion zones
  - Conducting intrusive operations only in areas cleared by UXO avoidance techniques
  - Implementing the UXO safety program
  - Analyzing MEC and explosives operational risks, hazards, and safety requirements
  - Enforcing personnel limits and safety exclusion zones for MEC operations
  - Conducting safety inspections
  - Implementing quality control requirements including inspections of the MEC-related work

All employees are empowered, authorized, and responsible to STOP WORK at any time when there is, or there appears to be, an imminent and uncontrolled safety or health hazard. In a Stop Work event (immediately after the involved task has been shut down and the work area has been secured in a safe manner) the employee shall contact the Project Manager and the Corporate Health and Safety Manager. Through observations and communication, all parties involved shall then develop, communicate, and implement corrective actions necessary and appropriate to modify the task and to resume work.

ORGANIZATION CHART

ON-SITE SUPPORT OF SITE ACTIVITIES



5.0 SUBCONTRACTORS

Tetra Tech may employ a subcontractor in the performance of work covered by this APP. Any subcontractor is required to prepare and adhere to safety planning and program documents (e.g., APP, HASP, etc.) as appropriate for the activities that they will perform on this project site. In addition, subcontractor personnel will also be required to read and comply with the sections of this Tetra Tech APP and HASP. The subcontractor personnel entering the site must sign the Site-Specific Training Documentation form included in the HASP. Subcontractor personnel must comply with the applicable training and medical surveillance requirements. Subcontractors are responsible for providing personal protective equipment (PPE) needed to protect personnel as specified by their safety and health planning documents and by this APP and are directly responsible for assuring the health and safety of their employees. Subcontractors must meet OSHA training, medical surveillance, and PPE requirements to be permitted to enter areas where exposure to hazardous materials is possible.

This APP and associated HASP is rigorously enforced during this field effort. Violators of the HASP are verbally notified upon first violation. The Tetra Tech SSO then notes the violation in the field logbook. Upon second violation, the Tetra Tech PM, the violator and his/her supervisor are notified. A third violation results in a written notification and the violator's eviction from the site. The written notification is sent to the human resources department and the SHM.

Any violations deemed serious, intentional, or otherwise egregious will be subject to immediate corrective action, up to and including removal from the site, and will not require adherence to this progressive, three-step disciplinary process.

Personnel will be encouraged to report to the SSO any conditions or practices that they consider detrimental to their health or safety, or those they believe violate applicable health and safety standards. Such reports can be oral or written. Personnel who believe that an imminent danger threatens human health or the environment are encouraged to bring the matter to the immediate attention of the SSO for resolution. Job site activities presenting danger to life or limb shall be stopped immediately and reported to the SSO for resolution.

At least one copy of this APP and the HASP will be available to site personnel. Each vehicle taken to the job site will contain a copy of the APP and the HASP to ensure quick and easy access by employees. Minor changes in the HASP procedures are discussed at the beginning of each workday by the SSO at the daily tailgate safety meeting. Significant HASP revisions are discussed with the SHM and PM and approved via the HASP amendment form.

6.0 TRAINING AND MEDICAL SURVEILLANCE

Site personnel who may be exposed to hazardous conditions and who will participate in on site activities are required to meet the training requirements outlined in the OSHA HAZWOPER standard. Furthermore, site personnel must satisfy any specialized training requirements that are presented in the AHAs for tasks to be completed under this contract.

6.1 MANDATORY TRAINING AND CERTIFICATIONS

Tetra Tech personnel qualification and training certification documentation will be obtained by the PM/FOL and included in Appendix 1 of this APP, and a copy maintained on site. Mandatory training and certifications applicable to this project include the following:

- Initial HAZWOPER 40 hour Hazardous Waste Site Worker
- Current 8-hour HAZWOPER refresher
- The supervisory personnel will also have Supervisory Training
- Specialized operations (UXO) or responsibilities (blood-borne pathogen-first aid) will also require additional training for personnel filling those roles.
- UXO Technicians will carry certificates on their person.

6.2 SITE-SPECIFIC SAFETY AND HEALTH TRAINING

Prior to accessing active work areas of the sites or participating in any intrusive activities, site personnel and visitors will first be required to undergo a site-specific safety and health training session conducted by the SSO, which will include a review of the HASP and signing of the Site-Specific Training Documentation form. Site workers will be required to sign a Daily Tailgate Safety Meeting form (included in HASP).

In addition, UXO team members on site will meet or exceed the requirements stated in the Department of Defense Explosives Safety Board (DDESB) Technical Paper (TP) 18 for their respective assignments.

Before on-site activities begin, the Tetra Tech SSO will present a briefing for site personnel who will participate in on-site activities. The following topics will be addressed during the pre-work briefing:

- Names of the SSO and designated alternate
- Site history
- Work tasks

- Hazardous chemicals that may be encountered on site
- Physical hazards that may be encountered on site
- PPE, including types of respiratory protection to be used for work tasks
- Mandatory training and certification requirements (e.g., HAZWOPER; Refresher; MEC-specific)
- Environmental surveillance (air monitoring) equipment use and maintenance
- Action levels and situations requiring an upgrade or downgrade of level of protection
- Site control measures including site communications and control zones
- Decontamination procedures
- Emergency communication signals and codes, including incident reporting procedures
- Environmental accident emergency procedures (if contamination spreads outside exclusion zone)
- Personnel exposure and emergency procedures (falls, chemical exposure or hazardous situations)
- Fire and explosion emergency procedures
- Emergency telephone numbers
- Emergency routes

Any other health and safety-related issues that may arise before site activities begin is covered during the pre-work briefing by the SSO.

Issues that arise during implementation of on-site activities will be addressed during tailgate safety meetings to be held daily before the workday or shift begins and will be documented in the FOL or SSO Field Log Book). The tailgate safety meetings will be attended by site workers, subcontractors, and visitors and will be conducted by the PM and/or SSO. Any changes in procedures or site-specific health and safety-related matters will be addressed during these meetings.

6.3 MEDICAL SURVEILLANCE

Tetra Tech personnel participating in project field activities will have had a physical examination that meets the requirements of Tetra Tech's medical surveillance program. Documentation for medical clearances will be maintained in the Tetra Tech Pittsburgh office and made available, as necessary, and will be documented using Figure 6-1 for every employee participating in onsite work activities at the sites.

FIGURE 6-1

SITE-SPECIFIC TRAINING DOCUMENTATION

My signature below indicates that I am aware of the potential hazardous nature of performing field investigation activities at the and that I have received site-specific training which included the elements presented below:

- Names of designated personnel and alternates responsible for site safety and health
- Safety, health, and other hazards present on site
- Use of personal protective equipment
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- Emergency response procedures (evacuation and assembly points)
- Incipient response procedures
- Review of the contents of relevant Material Safety Data Sheets
- Review of the use of AHAs
- Stop work authorization and process

I have been given the opportunity to ask questions and all of my questions have been answered to my satisfaction. The dates of my training and my medical surveillance requirements indicated below are accurate.

Name (Printed and Signature)	Site-Specific Training Date	40-Hour Training (Date)	8-Hour Refresher Training (Date)	8-Hour Supervisory Training (Date)	Medical Exam

7.0 SAFETY AND HEALTH INSPECTIONS

Daily site safety inspections are conducted by the Tetra Tech SSO during this field effort to ensure safe work areas and compliance with the HASP. The items noted during field audits are reported to the Tetra Tech SHM who maintains a corrective/preventive action database. Responsibility for resolving each item noted during these audits is assigned and tracked through resolution. Results from field audits are also regularly communicated throughout Tetra Tech through training and electronic means as a method of continuous program improvement.

8.0 SAFETY HEALTH EXPECTATIONS AND COMPLIANCE

It is the goal of Tetra Tech to continue excellent safety performance all of our contracts. Specifically, Tetra Tech will perform work in a manner that is consistent with the Zero Incident Philosophy. It is our goal to plan and perform the work in a manner that integrates safety and health considerations so that work is accomplished without experiencing any worker injuries or illnesses, environmental releases/impacts, or property damage. In addition to the line and staff management functions described in this APP and the accompanying HASP, each individual performing work under this contract has the responsibility for their own personal health and safety, as well as assisting in assuring the health and safety of their co-workers. This element is also the first one listed in our corporate Health and Safety Policy Statement, which requires that "each employee recognize a *personal* responsibility for their own health and safety and for actions that affect the health and safety of fellow employees." This employee responsibility includes observing specified health and safety requirements and communicating with the designated SSO on matters such as the effectiveness of specified control measures, identification of new potential hazards, and other related issues.

An employee's failure to adhere to the requirements of this APP and HASP, to observe specified safety requirements, or to use protective equipment properly, may lead to injury or illness. As a result, deviation from safety and health procedures is not tolerated. Failure to comply with health and safety procedures and requirements will lead to reprimand up to and including dismissal.

Health and safety-related information is communicated to employees through meetings, postings, written communications, and reporting of hazards.

9.0 INCIDENT REPORTING

Accidents or incidents as well as near-miss events are reported using the Tetra Tech incident reporting process and forms. The SHM is responsible for assuring that incidents and serious near-miss events are adequately investigated and is responsible for collecting, tracking, and trending incident data (e.g., recordable cases, employee hours worked, etc.). Accidents involving near misses, injuries, or illnesses must be immediately reported to the PM and the SHM, and documented.

9.1 INJURY/ILLNESS REPORTING

If any Tetra Tech personnel are injured or develop an illness as a result of working on site, the Tetra Tech "Incident Report Form" (Attachment V) must be followed. Following this procedure is necessary for documenting of the information obtained at the time of the incident.

9.1.1 TOTAL Incident Reporting System

TOTAL is Tetra Tech's new online incident reporting system. Site employees can use TOTAL to directly report health and safety incidents, notify key personnel, and initiate the process for properly investigating and addressing the causes of incidents, including near-miss events. An incident is considered any unplanned event. It may include several types of near misses, events where no loss was incurred, or incidents that resulted in injuries or illness, property or equipment damage, chemical spills, fires, or damage to motor vehicles.

TOTAL looks like the incident reporting form in Attachment V. TOTAL is an intuitive system that will guide you through the necessary steps to report an incident within 24 hours of its occurrence. Behind the scenes, TOTAL is a powerful tool for H&S professionals, and will help Tetra Tech to better track incidents, analyze root causes, implement corrective action plans, and share lessons learned. The ultimate result is a more safe and healthy working environment.

TOTAL is maintained on the Tetra Tech Intranet site at https://my.tetratech.com/

Once on the "My Tetratech" site, TOTAL can be found under the Health and Safety tab, Incident Reporting section, select "Report an Incident (TOTAL)". This will connect you directly to TOTAL. TOTAL can also be accessed directly from the internet using the following web address: http://totalhs.tetratech.com/

Note: When using the system outside the Tetra Tech intranet system or when operating in a wireless mode, a VPN connection will be required. The speed of the application may be affected dependent upon outside factors such as connection, signal strength, etc. Enter the system using your network user name and password. The user name should be in the following format - TT\nickname.lastname.

10.0 MEDICAL SUPPORT

Tetra Tech will ensure that a minimum of two people have current certifications in CPR, First Aid, and Blood-borne Pathogens. They will perform emergency rescue or other duties up to the level of their training. Tetra Tech personnel will perform rescue operations from emergency situations and may provide initial medical support for injury/illnesses requiring only "Basic First-Aid" level support, and only within the limits of training obtained by site personnel. Basic First-Aid is considered treatment that can be rendered by a trained first aid provider at the injury location and not requiring follow-up treatment or examination by a physician (for example: minor cuts, bruises, stings, scrapes, and burns). Second or third degree burns, cuts, lacerations requiring stitches or butterfly bandaging, heat exhaustion, severe poisonous plant or insect bite reactions are beyond Basic First Aid. Personnel providing medical assistance are required to be trained in First-Aid. Medical attention above Basic First-Aid level support will require assistance from the designated emergency response agencies.

Attachment III of the HASP is the Medical Data Sheet is to be completed by site personnel and made available in the case of an incident. The closest hospital to the site and directions to it are included in the HASP, as well as contact numbers for both the hospital and ambulance services. Tetra Tech personnel will perform a drive-by of the hospital to ensure that it is accessible and available by the most efficient route.

11.0 PERSONAL PROTECTION REQUIREMENTS

The levels of personal protection used for work tasks at the site is selected based on the nature of the planned work activities and on the known or anticipated hazards; types and concentrations of contaminants that may be encountered on site; and contaminant properties, toxicity, exposure routes, and matrixes. Specific PPE selected for this project is listed, by task, in the AHAs located in Section 14.0 of this APP.

The Project Health and Safety Officer (PHSO) determines the PPE when preparing the APP and HASP. The Tetra Tech SHM confirms the selection through a rigorous review process. To assure the proper PPE both the physical and chemical hazards present at the job site are considered in the development and review of the safety-related documents. The signatures of the SHM and the PHSO on the Signature Page of this APP constitute approval of the hazard assessment contained in the HASP.

The anticipated levels of protection selected for use by field personnel during site activities is Level D. If site conditions warrant a higher level of protection, field personnel will withdraw from the site, immediately notify the Tetra Tech SSO, and obtain further instructions.

PPE levels can be upgraded or downgraded based on a change in site conditions or investigation findings. When a significant change in site conditions occurs, hazards will be reassessed. Some indicators of the need for reassessment are discussed in HASP.

PPE has been selected based on the results of task-specific hazard assessments. Through the completion of employee training, Tetra Tech employees have been informed of the proper selection, use, and care of PPE items provided to them. After PPE is provided to an employee, the responsibility for using and caring for it appropriately is the responsibility of that employee. The SSO is responsible for assuring that these responsibilities are fulfilled through daily observations and work area inspections at the sites. The SSO is also responsible for assuring that appropriate and adequate supplies of PPE are maintained such that they are readily available for issuance/replacement and in a clean and sanitary manner and location. Site personnel will use the procedures presented in the HASP to obtain optimum performance from PPE.

12.0 APPLICABLE SITE SPECIFIC PLANS, PROGRAMS AND PROCEDURES

Listed below are potential site-specific plans and procedures that may be applicable to this field effort. The required plans and safety procedures are included in the HASP and this APP.

- ☒ Emergency Response Plan
- ☒ Spill Plan
- ☒ Posting of Emergency Telephone Numbers
- ☒ Hazard Communication Program
- ☒ Health Hazard Control Program
- ☒ Contingency Plan for Severe Weather
- ☒ Health and Safety Plan

13.0 CONTRACTOR (TETRA TECH) INFORMATION

Tetra Tech's HASP must accompany this APP on job sites. The HASP contains information specific to the Former Kilgore Manufacturing Site effort and provides requirements that employees must follow to ensure that their activities are carried out in accordance with OSHA requirements. Compliance with the HASP by Tetra Tech will be the means used to meet the requirements outlined in this APP.

Additionally, site-specific AHAs (Section 14.0) and the Tetra Tech's UXO SOP (Attachment II of the HASP) comply with OSHA requirements. By adhering to requirements specified in the AHAs, work is performed on site in a safe manner. Minor changes to AHAs based on actual site conditions are permitted as necessary and applicable by the SSO in the field. Major changes to AHAs, such as Scope of Work changes, are documented on a revised AHA form and are subject to additional review by the Tetra Tech SHM.

14.0 SITE-SPECIFIC HAZARDS AND CONTROLS

Detailed task-specific hazards and controls are provided in the AHAs attached to this APP. Table 1 details the AHAs for the UXO and sampling activities provided in support of the field activities.

TABLE 1

ACTIVITY HAZARD ANALYSIS

ACTIVITY: Mobilization/Demobilization **ANALYZED BY/DATE: J Laffey 10/10**

ACTIVITY / PHASE	POTENTIAL HAZARDS	RECOMMENDED ACTIONS / CONTROLS
Mobilization/Demobilization: Assembling, packing, unpacking equipment and supplies	1. Minor cuts, abrasions, or contusions handling equipment and tools	1. Wear cut-resistant gloves when handling items with sharp or rough edges.
Performing a Jobsite Hazard Evaluation and initial/exit inspections of the intended work areas.	2. Heavy lifting (muscle strains and pulls)	2. Practice safe lifting techniques (use mechanical lifting devices such as a dolly whenever possible, ensure a clear path of travel and good grasp on object. Lift with legs not back, obtain help when needed to lift large, bulky, or heavy items).
Performing initial clearance of travel pathways (foot/vehicular).	3. Vehicular traffic at the work site including rail road traffic	3. Locate vehicle and equipment staging areas. Inform site personnel of equipment areas and of their responsibility to stay clear of moving vehicles. Observe designated and marked travel pathways. Wear safety vests when activities involve encroaching on active traffic ways. When working near the railroad stay at least 25 feet away from the right of way. Tracks, trestles, rail yards and equipment are private property. If you drive or walk on or next to the tracks without permission, you are trespassing on private property. Besides being fined, you could lose your life. The only safe place to cross railroad tracks is at a public crossing — designated by the crossbuck. Anywhere other than a public crossing, stay off and away from the tracks.
	4. Intermittent high noise levels	4. Although not considered a highly probable event, based on the anticipated activities, the use of hearing protection may occasionally be required (at the onsite SSO's/UXO Technician's discretion). The SSO or the UXO Technician will observe the following: • Available data or monitoring results collected from similar operations and/or collected during this activity. • Use of hearing protection within an established distance from an operation potentially generating excessive noise levels until these levels can be quantified. For instance, during the operation of heavy equipment (excavator) typical site control boundary will be the length of the boom/bucket plus 10 feet. This is a sufficient distance to remove personnel from excessive noise levels. Inside this boundary, personnel will wear hearing protection. • Lastly, the employees may utilize the following general rule of thumb to help make these determinations: • If noise levels are such that a worker must raise their voice to communicate with someone who is within arm's reach (approximately 2 feet) of them, excessive noise levels are being approached and hearing protection is required. • Hearing protection will consist of either ear muffs or ear plugs that have a Noise Reduction Rate (NRR) of at least 25 decibels (dB).
	5. Slip/trip/fall hazards	5. Implement and maintain good housekeeping practices throughout work areas. Preview walking/working areas and maintain them to identify and avoid when possible slipping/tripping hazards. Preview work locations for unstable/uneven terrain.

TABLE 1

ACTIVITY HAZARD ANALYSIS

ACTIVITY: Mobilization/Demobilization **ANALYZED BY/DATE: J Laffey 10/10**

EQUIPMENT TO BE USED	INSPECTION REQUIREMENTS	TRAINING REQUIREMENTS
Hand tools (dollies, hand carts, hand knives, shovels, etc.)	Visual inspection of hand tools prior to use by user. The SSO or UXO Technician is to perform regular inspections for housekeeping issues and surveys of operational areas to insure compliance with the HASP.	None required.

TABLE 1

ACTIVITY HAZARD ANALYSIS

ACTIVITY: Brush Clearing **ANALYZED BY/DATE: J Laffey 10/10**

ACTIVITY / PHASE	POTENTIAL HAZARDS	RECOMMENDED ACTIONS / CONTROLS
Site Preparation/ Vegetation Clearance	1. Brush clearing equipment	1. Power equipment will be inspected prior to use in accordance with operating instructions. Equipment must be operated by knowledgeable field personnel. The UXO Technician is responsible to identify the area to be cleared and the means to clear it. Prior to the start of clearing and grubbing the equipment to be used will be: • Using the Hand and Power Tool Inspection Checklist provided in Attachment IV prior to beginning work. • Only manufacturer approved parts may be used in repair of site equipment. • Only personnel directly supporting the clearance activity will remain in the area, others will stay at least 50-100 feet away from the point of operation. • Site personnel will be instructed in the location and operation of the emergency shut off devices. • Secure all loose clothing articles to avoid possible entanglement. If hand tools (brush hooks, machetes, etc.) are used to clear brush and small trees the following precautions should be followed: • Inspect handles are they in good condition (no cracks, splinters, loose heads/cutting apparatus. • Check cutting tools edges all blades should be sharp without nicks or gouges in the blade. • All hand tools (brush hooks, machetes, etc.) should be kept in a sheath when not in use. • A 10-foot perimeter will be established around areas where brush clearing is being conducted.
	2. Natural hazards • Insect/animal bites • Inclement weather	2. Tape up joint between the bottom of pants legs and top of work boot with duct tape. Apply insect repellants containing at least 10% DEET. Follow manufacturer's label instructions for proper application and re-application. Perform close body inspections at the end of each day to detect/remove any insects. If walking through high grass or brush areas avoid approaching or disturbing potential nesting areas. If electrical storms or inclement weather are in the area, as determined through local forecasting or weather alerts issued, the SSO will suspend outside activities. The 30-30 rule shall be applied, which is “if a time interval of 30 seconds or less is between lightning and its thunder, go inside (building/vehicle) and stay inside for at least 30 minutes.” If no additional lightning and/or thunder is noted within this 30 minutes, work may resume at the SSO's direction. Personnel will be directed to seek suitable shelter that will provide adequate protection from the elements.
	3. MEC/MPPEH Hazards	3. MEC/MPPEH operations will be conducted by trained UXO Technicians. Non-UXO personnel will be clear of the area during initial surveys activity. Exclusion zone distances will be defined based on those specified in the Work Plan. Magnetometers will be tested using inert MEC/surrogates similar in size to suspected target anomalies. No suspect MEC/MPPEH items may be moved or disturbed during UXO Avoidance activities. UXO Technicians will clear vehicle and foot travel paths within the area. Support personnel and equipment will wait until the clearance is complete. • If MEC is observed, the UXO Technician making the observation will signal to stop

TABLE 1

ACTIVITY HAZARD ANALYSIS

ACTIVITY: Brush Clearing **ANALYZED BY/DATE: J Laffey 10/10**

ACTIVITY / PHASE	POTENTIAL HAZARDS	RECOMMENDED ACTIONS / CONTROLS
		operations and take the following precautions: • The UXO Technician will visually inspect the MEC/MPPEH to determine the type and condition if possible. This identification and the exact location will be recorded in the logbook. MEC/MPPEH will not be moved or disturbed during this inspection. • Suspect MEC/MPPEH items discovered will be reported to the Otterbein University POC by the UXO PM. The Otterbein University POC will report all suspect MEC/MPPEH to local law enforcement for treatment. • An inventory will be maintained by the UXO Technician with locations and descriptions for suspect MEC/MPPEH discovered during this operation.
	4. Strains/sprains from heavy or improper lifting	4. Practice safe lifting techniques (use mechanical lifting devices such as a dolly whenever possible, ensure a clear path of travel and good grasp on objects, lift with legs not back, obtain help when needed to lift large, bulky, or heavy items).
	5. Slip/trip/fall hazards	5. Implement and maintain good housekeeping practices throughout work areas. Preview walking/working areas and maintain them to identify and avoid possible slipping/tripping hazards. Preview work locations for unstable/uneven terrain.
	6. Chemical exposure:	6. As direct contact will be minimal given the nature of the work, it is unlikely that exposure will occur. Area wetting techniques will be employed if significant dust generation occurs. Exposure to contaminants is most likely to occur through incidental ingestion of contaminated water, or hand-to-mouth contact during field activities. For this reason, PPE and basic hygiene practices (washing face and hands before leaving site) will be the principal methods for minimizing exposures. The signs and symptoms of exposure for these substances are summarized in HASP Section 6.0. Potential exposure concerns to the COCs may also occur through ingesting or coming into direct skin contact with contaminated media. The likelihood of worker exposure concerns through these two routes are also considered very unlikely, provided that workers follow good personal hygiene and standard good sample collection/sample handling practices, and wear appropriate PPE as specified in this HASP. • Examples of onsite practices that are to be observed that will protect workers from exposure via ingestion or skin contact include the following: • No hand-to-mouth activities on site (eating, drinking, smoking, etc.) • Washing hands upon leaving the work area and prior to performing any hand to mouth activities • Wearing surgeon's-style gloves whenever handling potentially-contaminated media, including soils, and hand tools.

TABLE 1

ACTIVITY HAZARD ANALYSIS

ACTIVITY: Brush Clearing **ANALYZED BY/DATE: J Laffey 10/10**

EQUIPMENT TO BE USED	INSPECTION REQUIREMENTS	TRAINING REQUIREMENTS
Personal Protective Equipment: **Minimum**: Steel toe boots, hard hats, and safety impact eye protection, work gloves, work clothes. **Optional items**: Hearing protection at SSO discretion, Chainsaw Chaps and Loggers helmet with full faceshield (when operating chainsaws and handheld brushcutters) High-visibility vests when near active traffic areas. For UXO Technician - Steel toe/shank boots are required when working in areas where there is a danger of foot injuries due to falling or rolling objects or of objects piercing the sole. If steel toe footwear cannot be worn because of interferences with UXO detection devices, safety impact footwear with non-metallic toe protection (provided that the footwear satisfies ANSI Z-41 requirements for protective footwear) shall be used. **HTRW**: none	PPE inspection performed by the UXO. Ongoing (prior to each use) inspections are the responsibility of PPE users. The UXO Technician is responsible as the safety observer to watch for any potential MEC/MPPEH. This individual will not operate equipment or otherwise be involved in vegetation clearance operations.	PPE training in proper use, care, storage, and limitations. It is anticipated that this has been covered in employees' 40-hour HAZWOPER training, which is to be verified by the SSO through initial training documentation and reviewed prior to permitting personnel to participate in site activities, and will be confirmed by visual observations of worker activities. No explosive handling or transportation is planned during this operation.

TABLE 1

ACTIVITY HAZARD ANALYSIS

ACTIVITY: UXO Avoidance During Multi-Media Sampling Activities **ANALYZED BY/DATE: J Laffey 10/10**

ACTIVITY / PHASE	POTENTIAL HAZARDS	RECOMMENDED ACTIONS / CONTROLS
Land sampling activities, including UXO avoidance during sampling activities. Direct Push Technology (DPT) or Hollow Stem Auger (HSA)	1. MEC/MPPEH Hazards	1. MEC/MPPEH avoidance operations will be conducted by trained UXO Technicians. Non-UXO personnel will be escorted while in the area of concern. The site investigation team will be accompanied by a UXO Technician II or higher during the fieldwork and intrusive operations. Exclusion zone distances will be defined based on those specified in the Work Plan. Operations will immediately stop if MEC/MPPEH is discovered and UXO Technicians will secure the area. The non-UXO personnel will leave the area. If MEC/MPPEH is observed, the UXO Technician making the observation will signal to stop operations and take the following precautions: • The UXO Technician will inspect the MEC/MPPEH to determine its condition, if possible. No suspect MEC/MPPEH will be moved or disturbed during this phase of the investigation. This identification and the exact location will be recorded in the logbook. • Any MEC/MPPEH item discovered will be flagged for UXO avoidance as stated in the Work Plan. • The SSO/UXO Technician will notify the Otterbein University POC, who will in turn notify local law enforcement. • An inventory will be maintained by the SSO/UXO Technician with locations and descriptions for the MEC/MPPEH discovered during this operation, and the Otterbein University POC will be provided an update about the inventory on a daily basis. • If at any time during the sampling activities, MEC, suspect MEC, MPPEH, or munitions debris are discovered in the excavation area, the operations will stop and the item will be reported.
	2. Insect/animal bites	2. Tape up joint between bottoms of pant legs and top of work boot with duct tape. Apply insect repellants containing at least 10 percent N,N-diethyl-m-touluamide (DEET). Follow manufacturer's label instructions for proper application and re-application. Perform close body inspections at the end of each day to detect/remove any insects. If walking through high grass or brush areas, wear snake chaps and avoid approaching or disturbing potential nesting areas.
	3. Inclement weather	3. If electrical storms or inclement weather are in the area, as determined through local forecasting or weather alerts issued, the SSO/UXO Technician will suspend outside activities. The 30-30 rule shall be applied, which is “if a time interval of 30 seconds or less is between lightning and its thunder, go inside (building/vehicle) and stay inside for at least 30 minutes.” If no additional lightning and/or thunder is noted within this 30 minutes, work may resume at the SSO's/UXO Technician’ direction. Personnel will be directed to seek suitable shelter that will provide adequate protection from the elements.

TABLE 1

ACTIVITY HAZARD ANALYSIS

ACTIVITY: UXO Avoidance During Multi-Media Sampling Activities **ANALYZED BY/DATE: J Laffey 10/10**

ACTIVITY / PHASE	POTENTIAL HAZARDS	RECOMMENDED ACTIONS / CONTROLS
	4. Slips/Trips/Fall Hazards	4. Practice good housekeeping to the extent possible and conduct the following: • Maintain clear walking and working areas. • Eliminate, when possible, any debris and rutted areas that may create a tripping hazard. • Remaining hazards should be pointed out to the UXO Technicians. • Personnel will return the site to a neat and orderly condition prior to leaving the site. • Exit and access pathways will be maintained free of obstructions.
	5. Chemical contaminants, MC contaminants, and/or decontamination fluids	5. Exposure to potential site contaminants during this activity is unlikely given the nature of the work and the limited contact with potentially contaminated media. The following precautionary procedures will be implemented: • Generation of dusts should be minimized. If airborne dusts are observed, area wetting methods will be used. If area wetting methods are not feasible, termination of activities may be used to minimize exposure to observed airborne dusts. • Use proper protective equipment and good hygiene practices to minimize contact with site contaminants and hazardous decontamination fluids. Obtain manufacturer's Material Safety Data Sheets (MSDS) for any decontamination fluids used on-site. These must be used in well-ventilated areas, such as outdoors. Use appropriate PPE as identified on MSDS. The chemicals used must be listed on the Chemical Inventory for the site, and site activities must be consistent with the Hazard Communication section of the Health and Safety Guidance Manual (Section 5). Decontaminate the equipment and supplies between sampling and prior to leaving the site.

TABLE 1

ACTIVITY HAZARD ANALYSIS

ACTIVITY: UXO Avoidance During Multi-Media Sampling Activities **ANALYZED BY/DATE: J Laffey 10/10**

EQUIPMENT TO BE USED	INSPECTION REQUIREMENTS	TRAINING REQUIREMENTS
Personal Protective Equipment: **Minimum**: • Safety toe boots, hard hats, and safety impact eye protection (when handling heavy boxes and/or containers) • Work gloves for MEC operations • Surgeon-style inner gloves, and when required, nitrile outer gloves for sampling events. • Work clothes **Optional items**: High-visibility vests when near active traffic areas. **Other equipment:** • For UXO Technicians - Safety toe shoes/boots are required when working in areas where there is a danger of foot injuries due to falling or rolling objects or objects piercing the sole. If safety toe footwear cannot be worn because of interferences with UXO detection devices, safety impact footwear with non-metallic toe protection (provided that the footwear satisfies ANSI Z-41 requirements for protective footwear) shall be used. • Sampling equipment **Hazardous Toxic and Radioactive Waste (HTRW)**: None	Initial PPE inspection performed by the SSO/UXO Technician. Ongoing (prior to each use) inspections are the responsibility of PPE users.	PPE training in proper use, care, storage, and limitations. It is anticipated that this has been covered in employees' 40-hour HAZWOPER training, which is to be verified by the SSO/UXO Technician through initial training documentation and reviewed prior to permitting personnel to participate in site activities, and will be confirmed by visual observations of worker activities. Explosive handling and transportation is not anticipated. If required this task will be conducted by qualified UXO Technicians. Therefore, this training and background is considered sufficient for this task. Site personnel must carefully read the manufactures instructions for the proper calibration and operation of the air monitoring instruments. Knowledgeable operators with OHSA 29 CFR 1910.120 Hazardous Waste Site Worker 40 hour training.

15.0 HEALTH AND SAFETY PLAN

This APP and the site-specific HASP must be used together and be available for site personnel during the duration of this work.

16.0 MATERIALS AND DOCUMENTATION

The Tetra Tech FOL shall ensure the following materials/documents are taken to the project site and used when required:

- A complete copy of the HASP & APP
- Health and Safety Guidance Manual (available on line at http://intranet.Tetra Tech.com)
- Incident Reports
- Medical Data Sheets
- MSDS for chemicals brought on site
- An OSHA Job Safety and Health Poster
- Training/Medical Surveillance Documentation Form (blank)
- Emergency Telephone List
- Directions to the hospital

16.1 MATERIALS TO BE POSTED AT THE SITE

The following documentation is to be posted or maintained at the site for quick reference purposes. If posting these documents is not feasible (such as no office trailer), these documents should be separated from this plan and made readily accessible.

- **Chemical Inventory Listing (posted)** - This list represents the chemicals brought on-site, including decontamination solutions, sample preservations, fuel, etc. This list should be posted in a central area.

- **MSDSs (maintained)** - The MSDSs should also be in a central area accessible to the site personnel. These documents should match the listings on the chemical inventory list for the substances brought on-site including decontamination solutions, fuels, sample preservatives, calibration gases, etc. It is acceptable to have these documents within a central folder and the chemical inventory as the table of contents.

- **The OSHA Job Safety & Health Protection Poster (posted)** - This poster should be conspicuously posted in places where notices to employees are normally posted. Each FOL shall ensure that this poster is not defaced, altered, or covered by other material. See Attachment VI in the HASP.

- **Site Personnel Clearance (maintained)** - This list is found within the Medical Surveillance section of the APP (Figure 6-1). This list identifies the site personnel, dates of training (including site-specific training), and medical surveillance. The list indicates not only clearance, but also status. If personnel do not meet these requirements, they do not enter the site while site personnel are engaged in activities.

- **Emergency Phone Numbers and Directions to the Hospital(s) (posted)** - This list of numbers and directions will be maintained in each site vehicle.

- **Medical Data Sheets/Cards (maintained)** - Medical Data Sheets will be filled out by on-site personnel and filed in a central location. The Medical Data Sheet will accompany any injury or illness requiring medical attention to the medical facility. A copy of this sheet or a wallet card will be given to site personnel to be carried on their person.

- **Personnel Monitoring (maintained)** - The results generated through personnel sampling (levels of airborne toxins, noise levels, etc.) will be posted to inform individuals of the results of that effort.

- **Placards and Labels (maintained)** - Where chemical inventories have been separated because of quantities and incompatibilities, these areas will be conspicuously marked using Department of Transportation (DOT) placards and acceptable labels.

The purpose of maintaining or posting this information, as stated above, is to allow site personnel quick access. Variations concerning location and methods of presentation are acceptable providing the objective is accomplished.

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November 2010

APPENDIX TO ACCIDENT PREVENTION PLAN

Appendix 1

Employee training/qualifications are to be collected and attached by PM/FOL prior to the start of site activities.

(40-Hour HAZWOPER Certificates; 8-Hour HAZWOPER Refresher Certificates; First Aid/CPR Certificates; Employee Resumes as required)

ATTACHMENT II

UXO STANDARD OPERATING PROCEDURE

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1.0 GENERAL

This Standard Operating Procedure (SOP) was prepared in accordance with applicable U.S. Army Corps of Engineers procedures and policies governing field activities requiring Unexploded Ordnance (UXO) and Chemical Warfare Material (CWM) operations. All personnel conducting operations under this SOP must read and understand applicable parts of references listed in paragraph 9.1 below prior to commencing any work described within this SOP. Other documents supporting this SOP include project-specific Work Plans and Health and Safety Plans which are prepared for the purpose of accomplishing work that contain a UXO or CWM component.

2.0 PURPOSE

This SOP applies to all operations involving UXO and/or CWM support during field operations at various sites where Tetra Tech NUS (TtNUS) personnel are present. It provides procedural requirements for any activity involving UXO and CWM, as well as detailed procedures for the location, identification, documentation, and emergency response actions pertaining to UXO/CWM activities.

3.0 APPLICABILITY

This SOP applies to persons who may visit any site where TtNUS is performing work that involve some UXO or CWM component. Compliance the content of this SOP is mandatory for all TtNUS personnel, subcontractors, and visitors to any site where UXO/CWM activities are in progress.

4.0 RESPONSIBILITIES

Project Manager

Effective implementation of this SOP at the project level will be the ultimate responsibility of the assigned TtNUS Project Manager. The Project Manager is responsible for ensuring that all applicable rules and regulations are complied with, and that all necessary safety precautions are taken to conduct operations in accordance with this SOP. To fulfill this responsibility, the assigned Project Manager is required to ensure that appropriately-qualified technical staff are involved in all stages of project planning and field work, as well as for ensuring that appropriate resources are marshaled and used on his/her assigned projects. For projects involving UXO and/or CWM, this will involve ensuring that a suitably qualified and experienced UXO technician and a site Health and Safety Officers are part of the project team. In some cases, the assigned UXO Technician may also serve as the project site Health and Safety Officer.

It is also the responsibility of the Project Manager to ensure that all personnel conducting field activities in accordance with this SOP have proper training (including hazard control briefings) and, if required, the proper certifications for the job being performed.

UXO Technician

A suitably qualified and experienced UXO Technician will be included as part of the project team where these types of concern are known or suspected to exist. The UXO Technician will be primarily responsible for advising the Project Manager on all UXO/CWM matters, including on the measures that will be necessary to effectively implement and adhere to this SOP. Other specific duties will include:

- Providing technical expertise and input into project planning activities and documents such as the project-specific Work Plan and Health and Safety Plan
- Clearing worksite areas of UXO/CWM concerns prior to the initiation of any other onsite activities

- Participating in the development and conductance of site specific training sessions and daily tailgate meetings to communicate UXO/CWM matters to the field personnel
- Maintaining a sound familiarity with the contents of this SOP, the contents of the references listed in section 9.1, and keeping current with new information and technology pertinent to UXO/CWM matters

Site Health and Safety Officer
A suitably qualified and experienced health and safety pr ofessional will be assigned to all projects that involve fieldwork. Project-specific responsibilities will include:

- Effectively implementing the requirements and restrictions specified in the project-specific Health and Safety Plan
- Ensuring that all personnel participating in onsite activities have satisfied all appropriate medical and training qualifications prior to participating in any onsite intrusive activities.
- Conduct initial site-specific health and safety traini ng for all personnel participating in onsite activities prior to their participation in any onsite intrusive activities.
- Conduct tail-gate safety briefings prior to the initiation of all tasks, but not less than daily.
- On certain projects, these duties may be assigned to the UXO Technician. This would be considered acceptable on field projects where the predominant concern is contact with UXO and/or CWM, and minimal health concerns or requirements (e.g., chemical exposures or monitoring) exist.

Corporate Health and Safety Manager
Perform periodic project audits and evaluations to determine the ongoing effectiveness of this SOP to address UXO/CWM concerns, and review and evaluate th is SOP to determine any revisions that are appropriate.

5.0 LOCATION OF OPERATIONS

Activities where UXO and/or CWM concerns may exist may be encounter ed in support of various TtNUS contracts, with potential project sites located throughout the continental United States and abroad. Wherever the installation/site is located, it will be necessary to ensure that project planning activities include collecting available historical information that may be pertinent to these issues, as well as identifying and addressing contract/client-specific r equirements and any location-specific requirements (e.g., State, local-level, or host-nation requirements). A detailed site description, discussion of known and/or suspected contamination sources, and result s of previous studies will be provided to field personnel as part of their field mobilization and initial site-specific training activities.

The initial project evaluation must involve the performance of a preliminary risk assessment, including the investigation of probable contami nants, potential transport pathways, the identification of potential receptors, and a preliminary evaluation of human health and environmental concerns. Preliminary identification of applicable or relevant and appropriate requirements (ARARs) will also be made available to field personnel conducting activities at the installation.

6.0 PERSONNEL QUALIFICATIONS AND REQUIREMENTS

6.1 Personnel Qualifications: Qualifications of those pers onnel actively involved in UXO/CWM operations shall be as follows:

a. UXO personnel shall be graduates an accr edited Explosive Ordnance Disposal (EOD) School such as Indian Head or Eglin Air Force Base.

b. The Senior UXO Superviso r (SUXOS) for the operation w ill have been awarded the Master EOD Badge and have served at least 15 years in military EOD assignments, of which more than 10 years were in a supervisory position.

c. UXO personnel are responsible for maintaining current status with training and medical surveillance requirements, as specified in the project-specifc Health and Safety Plans and OSHA 29 CFR 1010.120, paragraphs (e) and (f).

6.2 Personnel Requirements: During any activity where the possibility that UXO and or CWM may be encountered (no matter how remote), the following requirements will be met:

a. One UXO-qualified technician will be required to support each field team engaged in operations in areas that might contain UXO/CWM.

b. One UXO-qualified technician will be present at the site during all activities to provide UXO/CWM support in the event their services are required.

7.0 PERSONNEL LIMITS

The activities to be conducted under most contracts will not normally be conducted in areas requiring maximum personnel limitations except for intrusive UXO activities. Work will not be permitted unless at least two persons are present in the work area. The provisions of 29 CFR 1910.120 concerning personnel qualifications and requirements will be followed while working on-site. Any additional personnel limitation requirements specified by the client or the project work location (e.g., state, local ordnance, host nation, etc.) will also be identified and adhered to at all times.

7.1 Personnel Limits for UXO Operations:

a. UXO Avoidance Operations – Two UXO Technicians (one UXO Technician III and one UXO Technician II)

b. UXO Intrusive Operations - Three UXO Technicians (one UXO Technician III and two UXO Technician II)

8.0 MATERIAL LIMITS

The properties and configurations of specific explosive materials are not addressed in this SOP. That level of detail is required to be addressed in project-specific Work Plans and Health and Safety Plans. This SOP must be maintained onsite along with these project-specific documents to aid in appropriate communication and implementation activities. Bulk liquids to be used for decontamination of equipment will be maintained in 2-gallon containers or less. Material Safety Data Sheets (MSDSs) will be kept on file in the TtNUS Command Post for any chemical substances brought to the project site by TtNUS and TtNUS subcontractor personnel. This is addressed in greater detail in section 5. of the TtNUS Health and Safety Guidance Manual.

9.0 SAFETY REQUIREMENTS

9.1 Referenced Safety Requirements: The safety requirements that apply to the UXO/CWM operations covered under this SOP are:

a. OSHA 29 CFR 1910.120 and 1926.65 – Hazardous Waste Operations and Emergency Response (HAZWOPER). Available online at: http://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=STANDARDS&p_toc_level=0&p_keyvalue=OSHA_Std_toc.html

b. US Army Corps of Engineers Engineering Regulation 385-1-92, *Safety and Occupational Health Document Requirements for Hazardous, Toxic and Radioactive Waste (HTRW) and Ordnance and Explosive Waste (OE) Activities.*

c. US Army Corps of Engineers Engineering Regulation (ER) 385-1-96, *Safety and Health Requirements.* Available on line at: http://www.usace.army.mil/publications/eng-manuals/em385-1-1/toc.htm.

d. US Army Corps of Engineers Engineering Pamphlet (EP) 1110-1-18, *Ordnance and Explosive (OE) Response.*

e. US Army Corps of Engineers Engineering Pamphlet (EP) 75-1-2, *Unexploded Ordnance Support for Hazardous, Toxic and Radioactive Waste and Construction Activities.*

f. US Army Corps of Engineers Engineering Pamphlet (EP) 75-1-3, *Chemical Warfare Material Response.*

g. US Army Technical Manual 9-1300-206 (TM 9-1300-206), *Ammunition and Explosive Hazards.*

h. Technical Manual 60A-1-1-31, *Explosive Ordnance Disposal Procedures, General Information on EOD Disposal Procedures.*

9.2 Specific Safety Requirements:

a. All site operations will be suspended if any site worker encounters an item of suspected UXO/CWM. Site work will remain suspended until the item is inspected and cleared by the UXO Technician.

b. All site operations will be suspended if so ordered by an authorized client representative (i.e., Installation Range Control and/or Safety Office).

c. A minimum of two UXO-qualified technicians will be present during all UXO-related activities.

d. Standard work practices as outlined in project-specific Health and Safety Plans and/or Work Plans will be observed.

9.3 Inherent UXO/CWM Hazards: UXO/CWM operations have inherent safety and health risks associated with the various field activities conducted. All planned activities will be conducted in accordance with the requirements of the references listed in Section 9.1 above, as safety is the primary consideration in all UXO/CWM activities. Every effort should be made to determine all hazards associated with the site through a thorough research of archives, past site/range uses, and any other available information. Some of the hazards to consider are:

a. Propellant, Explosives, and Pyrotechnics (PEP)
b. Depleted Uranium (DU)
c. White Phosphorus (WP)
d. Corrosive chemicals (acids and bases) and decontamination agents
e. Toxic gases, liquids and solids
f. Corroded and damaged containers, munitions bodies, drums, etc.
g. Fuze conditions
h. Etiological agents

10.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

Task-specific PPE will be identified in project-specific Health and Safety Plans. Typical PPE for project sites where the principle concern is for UXO/CWM will include the items listed below. Items marked with an asterisk (*) will be available and will be used as specified in the Health and Safety Plan and/or as determined by the TtNUS Site Health and Safety Officer.

a. Safety glasses

b. Safety shoes (and protective over boots or steel-toed rubber boots). NOTE: During geophysical survey operations, the UXO technicians will not wear steel-toed boots as they interfere with the magnetometer survey; however, around heavy equipment and activities where foot and overhead hazards may exist, steel-toed boots and hard hats will be worn.

c. Cotton clothing (with protective coveralls*)

d. Gloves (type to be specified for each project task in the Health and Safety Plan and/or by the site Health and Safety Officer)

e. Respiratory protection equipment* (29CFR1910.134)

f. Hearing protection*

g. Hard hats*

11.0 EMERGENCY RESPONSE AND CONTINGENCY PLANS

11. Emergency Contacts: The identification of (and means to communicate with) appropriate local emergency response agencies must be identified as part of project planning/mobilization activities, and these agencies must be contacted prior to the initiation of any onsite work. These initial communications must determine the capabilitities of these agencies to respond to foreseeable emergency situations, their willingness to respond, and their locations/driving directions/phone numbers. These details must be specified in the project-specific Health and Safety Plan and posted in the site Command Center/Field office.

At a minimum, the names and means of communication (phone number, radio frequency, etc.) of the following parties must be included in the project-specific Emergency Contacts procedure:

a. Local Emergency Fire Response that will respond (i.e., local Fire Department)

b. Emergency Medical Assistance (Hospital, Emergency Room, and ambulance service that will respond)

c. Installation Safety Office or other client safety/emergency response contact

d. Installation EOD Office/Detachment

e. Installation Environmental Office

The senior TtNUS managing employee onsite (Project Manager, Site Manager, Site Supervisor, Field Operations Leader) is responsible for initiating these calls in the event of an emergency where such support is needed. If the Project Manager is not onsite at the time of an emergency event, he/she must be added to the above list of contacts.

In the event of an emergency, all site personnel will be evacuated to a predetermined location away from the work place. Emergency Response Planning will be addressed in the project-specific Health and Safety Plan and will be in accordance with either 29 CFR 1910.38(a) or 1910.120(l). TtNUS will utilize the Installations Base Fire Protection and Emergency Services in emergencies or potential emergencies.

11.2 Contingency Plans: The following contingency plans will be implemented:

a. Pre-Planning – Upon arrival at the site/installation, the TtNUS Field Operations Leader (FOL) and/or the Site Safety Officer will meet with the Base or local Fire Protection Department, Base Security Personnel or local Police Department, and onsite and/or offsite Emergency services to notify them of the activities that are to be undertaken, when, and where. All site personnel will be required to follow established base/local emergency procedures and will rely on base/local services to handle emergency calls when needed.

b. Emergency Escape Procedures and Assignments – Upon notification of a site emergency that requires evacuation, all site personnel will proceed to predetermined locations based on emergency location and wind direction. An alternate assembly point will be designated in case personnel cannot reach these locations without danger to their lives and health. These primary and alternate escape routes and meeting places will be designated during the daily hazard control briefing. Personnel will be trained to remain at the assembly points until directed to either resume work or to leave the site.

c. Procedures to Account for Site Personnel – The site work force is typically small enough that accounting for personnel will not be a problem via visual head counting. On projects with larger field team sizes, roll calls will be taken using the daily sign in logs, logbook entries, or the tail-gate briefing sheets. Accounting for personnel will be the Field Operations Leader's responsibility.

d. Rescue and Medical Duties – TtNUS personnel will not be authorized to participate in emergency rescue operations. Typical first aid response equipment that is to be on hand at a project site includes suitable first aid kit, an emergency eye wash station, and Class ABC fire extinguishers.

e. Activation of Emergency Response Procedures - Should an emergency occur which requires the support of outside services, the appropriate contacts will be made by the senior TtNUS managing employee onsite (Project Manager, Site Manager, Site Supervisor, Field Operations Leader). A list of appropriate contacts will be posted at the Command Post. Cellular phones, land-line phones, or hand-held radios will be the primary means of communication.

f. Airborne Chemical Release Contingency Plan –

(1) Chemical Release Monitoring – every member of the site team will be responsible for observing and reporting any gross chemical releases or conditions that could lead to releases. Air monitoring will be performed as described in the project-specific Work Plans and Health and Safety Plans.

(2) Responses to Measured Airborne Chemical Releases – the readings on monitoring instrumentation will be compared to the action levels specified in the project-specific Work Plans and Health and Safety Plans. The primary purpose of appropriate real-time monitoring instruments will be monitor worker breathing zone areas for the protection of employee health. The project-specific Health and Safety Plan will specify actions that are to be taken in the event that monitoring instrument readings indicate that detected

concentrations may represent a health threat to onsite workers. Area and perimeter monitoring as well as sample screening activities may also be called for in the Work Plan or Health and Safety Plan, but these are *secondary* purposes for the use of these instruments.

Unless otherwise specified in a project-specific Health and Safety Plan, the following monitoring instrument action levels and response measures will be observed on UXO/CWA sites:

Parameter	Action Level
Total Organic Vapors	Any sustained level above background
Airborne particulates	Readings >2.5 mg/m^3
Flammable Vapors	10% of the Lower Explosive Limit (LEL)

If such levels are noted at site perimeters or adjacent to neighboring residential or commercial property, the TtNUS Field Operations Leader and/or the Site Safety Officer will notify the appropriate client or base contacts.

g. Liquid Release Monitoring – All field team members will be responsible for observing and reporting any liquid chemical releases or conditions that could lead to a release. If field operations on site result in a release of liquid chemicals in the absence of vapors, field personnel will attempt to contain the liquid by means of berms constructed with available equipment. If the work team cannot control the spill, they will leave the area for the assembly point quickly, without panic. The TtNUS Field Operations Leader and/or the Site Safety Officer will notify the appropriate client/base contact. This is not considered to be a significant probability during operations. However, in the unlikely instance that it should occur, field personnel may effect these types of defensive efforts, providing that such a response does not appear to present a chemical overexposure or other personal health or safety threat.

12.0 TYPICAL CLIENT/FACILITY SAFETY POINTS OF CONTACT

The following positions are typically encountered on UXO/CWA projects. Communication and coordination with these positions should be implemented and maintained throughout all project activities (from pre-field operations planning through to project close-out).

a. Installation Safety Management Office

b. Installation Ordnance Officer and/or EOD Officer

c. Installation Radiation Officer

d. Installation Environmental Office

13.0 TOOLS AND EQUIPMENT

Tools and equipment necessary to safely and effectively accomplish the objectives of a project will be detailed in the project-specific Work Plans and Health and Safety Plans. Items commonly required for UXO/CWM operations are presented below:

13.1 Personal Protective Equipment

a. Respiratory Protective Equipment (i.e., air purifying or air supplied devices)

b. Dermal (chemical resistant) protective equipment (e.g., coveralls, gloves, eye and face protection)

c. Physical safety PPE (hard hats, hearing protection, safety glasses, safety shoes, etc.)

13.2 Air Monitoring Equipment

a. Explosive/O_2 Meter (Combustible Gas Indicator)

b. Direct reading Organic Vapor Analyzer (PID or FID)

c. Direct reading particulate meter

d. Radiation Survey Meters and TLD Badges

13.3 Geophysical/Hydrology Survey Instrumentation

a. Magnetometers (Cesium Vapor, Schonstedt)

b. Electromagnetic Terrain Conductivity Meter (EM-31)

c. Time-Domain Electromagnetic All-Metals Detector (EM-61)

d. Water Level Indicator/Recorder

e. pH/Temperature/Conductivity Meter for water samples (Horiba, etc.

f. Survey Equipment (transit, tripod, level, etc.) as required

13.4 UXO Support Equipment

a. Schonstedt Magnetic Locators (GA-52Cx or equivalent passive instrument) will be used for UXO surface survey during UXO activities. The GA-52Cx detects the magnetic field of any ferromagnetic object.

b. Schonstedt MG-220 Magnetic Gradiometer (Down-Hole Magnetometer or equivalent will be used to conduct down hole UXO checks. The MG-220 detects the magnetic field of any ferromagnetic object as it is lowered into a borehole.

c. Marking tape, pin flags, stakes, utility spray paints, etc.

13.5 CWM Support Equipment

a. Chemical Agent Identification Kits (M18A2 Kit)

b. ICAMs (Individual Chemical Agent Monitor)

13.6 Decontamination Equipment

As required by the level of protection for each site. See Site Health and Safety Plan for specifics.

13.7 Hand Tools/ Miscellaneous Equipment

As may be required.

14.0 ENVIRONMENTAL CONCERNS

The field operations covered by this SOP will be performed in such a manner as to minimize the effects of pollution of air, water, or land and to control noise and dust emissions within reasonable limits.

Every effort will be made to:

a. Protect the land areas and to preserve them in their existing condition.

b. Protect water resources, including measures for run-off or run-off controls if applicable.

c. Implement sediment control measures, where warranted. These measures will also be implemented to control erosion.

Usually, field operations will generate solid and liquid waste (Investigative Derived Waste – IDW) requiring onsite handling and possible offsite disposal. The major types of waste to be generated, their environmental concerns, and their handling and disposition are summarized below:

a. Personal and equipment decontamination containers disposed offsite following a thorough decontamination. Liquid waste will be included with well purging and development fluids.

b. Personal Protective Equipment (PPE) will be double-bagged and will be the responsibility of TtNUS to dispose of according to applicable regulations. Disposal will normally be offsite.

It is not anticipated that any chemical releases will occur during the field activities.

The MSDSs for chemicals being brought onto the installation for use in field operations will be listed on a site-specific Chemical Inventory and maintained at the TtNUS Field Command Post. Copies of these documents are to be made available to client and offsite representatives who may be called upon to respond to an emergency event.

15.0 UXO/CWM PROCEDURES FOR FIELD OPERATIONS

15.1 General – field procedures for work on any installation can include any or all of the following tasks:

a. Initial entry into suspect areas

b. CWM operations

c. Surface and subsurface sampling

d. Monitoring well installation

e. Exploratory trenching

f. Geophysical surveys

g. Other miscellaneous operations

15.2 Initial Entry – initial entry into suspect areas require an UXO-qualified technician with a magnetometer (GA-52Cx) to screen a path into the area. The screened area is marked with lanes using either pin flags with plastic pins or marking tape. Suspect items on the surface and subsurface magnetic anomalies will be marked, usually with a different color tape or flag, and will be avoided by team members. The site where the work is to be conducted will be thoroughly screened for UXO/CWM contamination prior to any work commencing. All personnel will stay within the cleared areas and not venture out into areas not screened. If an area that has magnetic anomalies cannot be avoided, the UXO-qualified technician will hand excavate down to the anomaly to check to see if a hazard exists. Before excavation begins, the immediate area will be cleared of non-essential personnel outside of what could be a fragmentation zone (as determined by the UXO Technician). If the excavation reveals a hazard, the emergency notification procedures in paragraph 11.0 will apply.

15.3 CWM Operations - prior to conducting CWM operations, an Emergency Response Plan as required by 29CFR1910.120 and DA Pam 50-6 will be developed and implemented. Most of the information required to develop this plan should be obtained from the installation safety office; however, as a minimum, the following elements will be addressed:

a. Pre-emergency planning and procedures for reporting incidents to appropriate government agencies for potential chemical exposure, person injuries, fire/explosions, environmental spills and releases, and discovery of radioactive materials.
b. Personnel roles, lines of authority, communications.
c. Posted instructions and list of emergency contacts: physicians, nearby notified medical facility, fire and police departments, ambulance service, state/local/federal environmental agencies, Certified Industrial Hygienist (CIH), and installation commander.
d. Emergency recognition and prevention.
e. Site topography, layout and prevailing weather conditions.
f. Criteria and procedures for site evacuation (emergency alerting procedures/employee alarm system, emergency PPE and equipment, safe distance, place of refuge (assembly area), evacuation routes, site security and control).
g. Specific procedures for decontamination and medical treatment of injured personnel.
h. Route maps to nearest pre-notified medical facility.
i. Criteria for initiating community alert program, contacts and responsibilities.
j. Critique of emergency responses and follow-up.
k. Material Safety Data Sheets (MSDS) for each hazardous substance anticipated to be encountered on site would be made accessible to site personnel at all times.

15.4 Sampling – sampling will be conducted in accordance with established protocols and methodologies. Site-specific sampling requirements will be presented in the project-specific Work Plans and/or in other project-specific documents such as Field Sampling and Analysis Plans and Quality Assurance Plans.

Prior to initiating any sampling activities, an UXO-qualified technician will screen sites potentially contaminated with UXO/CWM. A magnetometer will be used to screen entry into a suspect area as in paragraph 15.2 above. Lanes will be marked and suspect items and subsurface anomalies will be identified and avoided. The immediate sampling area will be surface-screened prior to the introduction of the sampling team into the area.

Prior to any subsurface intrusive sampling, another check with a magnetometer needs to be accomplished. The GA-52Cx Magnetic Locator (magnetometer) can be used for collecting

subsurface samples not greater than 0.5 feet. If excavation of a borehole or hand auguring hole is to exceed this depth, a MG-220 Magnetic Gradiometer (down hole magnetometer) shall be utilized with readings taken at two feet depth intervals.

If an anomaly is detected, the location will be marked and avoided. If appropriate and acceptable, an alternate sampling location (in a cleared area) will be designated. If the sampling location cannot be relocated them the UXO-qualified technician will hand excavate down to the anomaly to determine if it is hazardous. If it is not hazardous, the object will be set aside and the sampling event will continue. If the object has been determined to be hazardous or suspect, the sampling team will move out of the area and the emergency procedures listed in paragraph 11.0 will be implemented.

15.5 Monitoring Well Installation – the area within a 50-foot radius of the borehole and the off- road access path will be screened with the GA-52Cx magnetometer and be cleared of all metal objects. Once this is accomplished, the areas around borehole sites will be marked using colored marking tape and/or pin flags. Heavy equipment such as front-end loaders, backhoes, and bulldozers will not be used to develop or establish drill sites. The following action will be followed:

a. The GA-52Cx magnetometer will be used directly over the borehole site to check for buried items down to 0.5 feet. After a surface check, the UXO-qualified technician will hand auger down to a depth of two feet and check down the hole using the MG-220 magnetometer.

b. Once the hand-auguring hole has been cleared, the drill rig will be positioned over the proposed borehole. Drilling will commence to a depth of four feet, the drill auger will be removed from the borehole, the drill crew chief and UXO personnel will make observations of the soil from the core barrel and the soil removed from the hole by hand auger (if needed). The drilling log and lithologic log will be maintained in accordance with standard practices, noting any metal objects that may be found.

c. The drilling derrick will be secured and drill rig moved to a position at least 20 feet from the borehole.

d. The borehole will be checked again with the MG-220 magnetometer.

e. If UXO or magnetic anomaly is present, the borehole will be abandoned and another location selected. The new borehole should be at least six feet from the original borehole. If a UXO or anomaly is not detected and the clearance is given, the drill rig shall be positioned back over the borehole, and drilling will proceed to the next depth (6 feet).

f. Repeat above steps at intervals of 2 feet, until a depth of ten feet is reached. At the ten-foot interval, a magnetometer reading shall be taken with the MG-220 set on the maximum sensitivity. The instrument will detect larger objects (approaching 100 lbs.) that could be expected to penetrate to depths of 10 feet or more.

g. After reaching the depth of ten feet, the above steps will be repeated at intervals of 4 feet, until the desired depth is reached.

15.6 Exploratory Trenching and Excavation – at times, exploratory trenching may be required to determine the lateral extent of a landfill, burial pit, or subsurface geophysical anomaly. Trenching and excavation to uncover a subsurface area will be conducted using a backhoe, an excavator, or sometimes a front-end loader. **Any trenching or excavation activities (regardless of depth) must be done in accordance with OSHA 29 Subpart P requirements, which must be considered and addressed in the project-specific Health and Safety Plan.**

On project sites where excavation activities are within the scope of work *and* a UXO/CWM concern exists, the following additional procedures will be utilized to conduct these operations:

a. The surface of the area to be trenched or excavated will first be swept with the GA-52Cx magnetometer. Anomalies will be hand excavated to determine if hazardous.

b. No more than 0.5 feet of surface soil will then be gingerly removed (scraped) from the area of concern.

c. The heavy equipment will be removed at least 20 feet away from the area, and the area will be checked with the MG-220 magnetometer. If the area is a trench, the entire length of the trench will be checked with the MG-220 and the excavation can continue two feet at a time. If the area is a wide-open area, it can once again be checked with the GA-52Cx, but only 0.5 feet of soil removal can be excavated at a time.

d. Anomalies will continue to be uncovered by hand excavation until the desired results are obtained and the trench/area is abandoned and refilled.

e. Excavation will continue another 2 feet if using the MG220 or 0.5 feet if using the GA-52Cx magnetometer. Once again after the proper depth of soil is excavated, the heavy equipment is removed from the area (>20 feet) and the area is rechecked with the magnetometer. If excavation depths reach 4 feet, suitable means of access/egress must be provided (e.g., ladders) and atmospheric monitoring must be performed prior to any entries.

f. The above procedures are followed until the desired depth is reached and/or the desired results are obtained.

Once the area or trench has been cleared, excavation can continue to the proper depth before the equipment is again moved away (at least 20 feet) and the area/trench.

15.7 Geophysical Surveys – there are several instruments that can be used to conduct geophysical surveys. The GA-52Cx (Schonstedt) and the MG-220 are magnetometers and are passive instruments. The Geonics Terrain Conductivity Meter (EM-31) is an active instrument and is commonly used to measure subsurface terrain conductivity. This information can be used geophysical surveys, as well as for locating voids, discontinuities in soil structures such as boundaries of disposal pits and buried conducting objects. An Ordnance Safety Analysis of the Geonics Model EM-61 Non-Contacting Terrain Conductivity Meter was conducted by the Naval Surface Warfare Center at the request of TtNUS in April 1993. The analysis concluded, in summary, that the "Geonics EM-61 poses no ordnance safety hazard when operated in the normal survey mode, where the device is held at hip height." However, the Geonics EM-61 should not be used with the boom on the ground if ordnance is present or suspected.

When using the magnetometer or the EM-61, a UXO-qualified technician will conduct a surface sweep of the area to be surveyed to ensure that no surface ordnance or other hazards exist. The magnetometer is a passive instrument; therefore, no special ordnance safety precautions are required.

Manufacture recommended procedures for the EM-61 must be followed to ensure safe operation during the geophysical survey. Standard survey protocols and quality assurance methods will also be required during survey operations.

15.8 Miscellaneous Operations – due to the potential of UXO/CWM materials being encountered during field activities, UXO support will be provided at all site locations. UXO support will be

provided for any and all field activities that are in areas suspected to contain UXO and/or CWM. These areas also include those areas covered with water and creeks, canals, etc.

Operations that involve the inspection, hazard classification, segregation, and final disposal of UXO and UXO-related scrap will not be covered in this SOP. The demilitarization of UXO and UXO-related scrap is not authorized unless specific work plans, SOPs, health and safety plans and other established procedures are written and approved addressing these operations.

16.0 HAZARD CONTROL BRIEF

A Health and Safety Hazard Control Briefing (i.e., tailgate meetings) will be conducted daily prior to the start of onsite activities. The briefing will be detailed and will cover the information in the Safe Work Permits for the anticipated tasks for the day, as well as applicable portions of this SOP. Additional briefings will be conducted as necessary for tasks that become necessary during the course of a workday, if they were not covered in the morning briefing. These briefings are in addition to (not in place of) the site-specific health and safety training that is required for all onsite personnel prior to their participation in any onsite, intrusive activities.

The following information will be given during the daily briefings:

a. Overview of task(s) to be performed and review of appropriate Safe Work Permits with task participants.

b. Overview of the day's objectives, as well as general site hazards

   - Unexploded Ordnance Hazards
   - Chemical Warfare Agents and Materials
   - Physical Hazards

c. Overview of Standard Work Practices pertinent to the day's planned activities

d. Review of any worker incidents or near-miss events, including a review of corrective/preventive measures to prevent recurrence

e. Overview of Emergency Response Actions, evacuation routes and assembly points

17.0 SECURITY

Field activities under various TtNUS contracts are typically unclassified and normal security measures apply in accordance with above references (paragraph 9.1 above). TtNUS personnel and their subcontractors will check in with the appropriate client/installation's security office and may be issued security badges for entry into certain work areas. This SOP will not cover special security requirements for projects involving UXO/CWM as most installations have established policies and procedures on reporting and securing recovered items that are UXO and/or CWM. The TtNUS Project Manager will incorporate all security procedures required by the installation into the site work plan.

ATTACHMENT III

MEDICAL DATA SHEET

MEDICAL DATA SHEET

This Medical Data Sheet must be completed by on-site personnel and kept in the command post during the conduct of site operations. This data sheet will accompany any personnel when medical assistance is needed or if transport to hospital facilities is required.

Project _____

Name _____ Home Telephone _____

Address _____

Age _____ Height _____ Weight _____

Person to notify in the event of an emergency: Name: _____

Phone: _____

Drug or other Allergies: _____

Particular Sensitivities: _____

Do You Wear Contacts?_____

What medications are you presently using? _____

_____

Name, Address, and Phone Number of personal physician: _____

_____

_____

Note: Health Insurance Portability and Accountability Act (HIPAA) Requirements

HIPAA took effect April 14, 2003. Loosely interpreted, HIPAA regulates the disclosure of Protected Health Information (PHI) by the entity collecting that information. PHI is any information about health status (such as that you may report on this Medical Data Sheet), provision of health care, or other information. HIPAA also requires Tetra Tech to ensure the confidentiality of PHI. This Act can affect the ability of the Medical Data Sheet to contain and convey information you would want a Doctor to know if you were incapacitated. So before you complete the Medical Data Sheet understand that this form will not be maintained in a secure location. It will be maintained in a file box or binder accessible to other members of the field crew so that they can accompany an injured party to the hospital.

DO NOT include information that you do not wish others to know, only information that may be pertinent in an emergency situation or treatment.

_____ _____ _____

Name (Print clearly) Signature Date

ATTACHMENT IV

EQUIPMENT INSPECTION CHECKLISTS

EQUIPMENT INSPECTION CHECKLIST
DRILL RIGS

Company:_____ **Unit/Serial No#:**_____

Inspection Date: _____/_____/_____ **Time:**_____:_____ **Equipment Type:**_____
(e.g., Drill Rigs Hollow Stem, Mud Rotary, Direct Push, HDD)

Project Name:_____ **Project No#:**_____

Yes	No	NA	Requirement	Comments
			Emergency Stop Devices	
☐	☐	☐	• Emergency Stop Devices (At points of operation)	
☐	☐	☐	• Have all emergency shut offs identified been communicated to the field crew?	
☐	☐	☐	• Has a person been designated as the Emergency Stop Device Operator?	
			Highway Use	
☐	☐	☐	• Cab, mirrors, safety glass?	
☐	☐	☐	• Turn signals, lights, brake lights, etc. (front/rear) for equipment approved for highway use?	
☐	☐	☐	• Seat Belts?	
☐	☐	☐	• Is the equipment equipped with audible back-up alarms and back-up lights?	
☐	☐	☐	• Horn and gauges	
☐	☐	☐	• Brake condition (dynamic, park, etc.)	
☐	☐	☐	• Tires (Tread) or tracks	
☐	☐	☐	• Windshield wipers	
☐	☐	☐	• Exhaust system	
☐	☐	☐	• Steering (standard and emergency)	
☐	☐	☐	• Wheel Chocks?	
☐	☐	☐	• Are tools and material secured to prevent movement during transport? Especially those within the cab?	
☐	☐	☐	• Are there flammables or solvents or other prohibited substances stored within the cab?	
☐	☐	☐	• Are tools or debris in the cab that may adversely influence operation of the vehicle (in and around brakes, clutch, gas pedals)	

EQUIPMENT INSPECTION CHECKLIST
DRILL RIGS

Yes	No	NA	Requirement	Comments
☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐	Fluid Levels: • Engine oil • Transmission fluid • Brake fluid • Cooling system fluid • Hoses and belts • Hydraulic oil	
☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	High Pressure Hydraulic Lines • Obvious damage • Operator protected from accidental release • Coupling devices, connectors, retention cables/pins are in good condition and in place	
☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐	Mast Condition • Structural components/tubing • Connection points • Pins • Welds • Outriggers • Operational • Plumb (when raised)	
☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐	Hooks • Are the hooks equipped with Safety Latches? • Does it appear that the hook is showing signs of wear in excess of 10% original dimension? • Is there a bend or twist exceeding 10% from the plane of an unbent hook? • Increase in throat opening exceeding 15% from new condition • Excessive nicks and/or gouges • Clips • Number of U-Type (Crosby) Clips (cable size 5/16 – 5/8 = 3 clips minimum) (cable size 3/4 – 1 inch = 4 clips minimum) (cable size 1 1/8 – 1 3/8 inch = 5 clips minimum)	

EQUIPMENT INSPECTION CHECKLIST
DRILL RIGS

Yes	No	NA	Requirement	Comments
			Power cable and/or hoist cable	
☐	☐	☐	• Reduction in Rope diameter π (5/16 wire rope>1/64 reduction nominal size -replace) (3/8 to 1/2 wire rope>1/32 reduction nominal size-replace) (9/16 to 3/4 wire rope>3/64 reduction nominal size-replace)	
☐	☐	☐	• Number of broken wires (6 randomly broken wires in one rope lay) (3 broken wires in one strand)	
☐	☐	☐	• Number of wire rope wraps left on the Running Drum at nominal use (≥3 required)	
☐	☐	☐	- Lead (primary) sheave is centered on the running drum	
☐	☐	☐	• Lubrication of wire rope (adequate?)	
☐	☐	☐	• Kinks, bends – Flattened to > 50% diameter	
			Hemp/Fiber rope (Cathead/Split Spoon Hammer)	
☐	☐	☐	• Minimum ¾; maximum 1 inch rope diameter (Inspect for physical damage)	
☐	☐	☐	• Rope to hammer is securely fastened	
			Safety Guards –	
☐	☐	☐	• Around rotating apparatus (belts, pulleys, sprockets, spindles, drums, flywheels, chains) all points of operations protected from accidental contact?	
☐	☐	☐	• Hot pipes and surfaces exposed to accidental contact?	
☐	☐	☐	• High pressure lines	
☐	☐	☐	• Nip/pinch points	
			Operator Qualifications	
☐	☐	☐	• Does the operator have proper licensing where applicable, (e.g., CDL)?	
☐	☐	☐	• Does the operator, understand the equipment's operating instructions?	
☐	☐	☐	• Is the operator experienced with this equipment?	
☐	☐	☐	• Is the operator 21 years of age or more?	

EQUIPMENT INSPECTION CHECKLIST
DRILL RIGS

Yes	No	NA	Requirement	Comments
			PPE Required for Drill Rig Exclusion Zone	
☐	☐	☐	• Hardhat	
☐	☐	☐	• Safety glasses	
☐	☐	☐	• Work gloves	
☐	☐	☐	• Chemical resistant gloves_____	
☐	☐	☐	• Steel toed Work Boots	
☐	☐	☐	• Chemical resistant Boot Covers	
☐	☐	☐	• Apron	
☐	☐	☐	• Coveralls Tyvek, Saranex, cotton)_____	
			Other Hazards	
☐	☐	☐	• Excessive Noise Levels? _____dBA	
☐	☐	☐	• Chemical hazards (Drilling supplies - Sand, bentonite, grout, fuel, etc.)	
☐	☐	☐	- MSDSs available?	
☐	☐	☐	• Will On-site fueling occur	
☐	☐	☐	- Safety cans available?	
☐	☐	☐	- Fire extinguisher (Type/Rating -_____ _)	

Approved for Use ☐ Yes ☐ No ☐ See Comments

_____ Site Health and Safety Officer

_____ Operator

EQUIPMENT INSPECTION CHECKLIST
HAND AND POWER TOOLS

Yes	No	NA	Requirement	Comments
☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	Are all tools and equipment (both company and employee owned) used by employees at their workplace in good condition? Any loose parts? Missing pins and/or bolts?	
☐	☐	☐	Are broken or fractured handles on hammers, axes and similar equipment replaced promptly?	
☐	☐	☐	Are hand tools such as chisels and punches, which develop mushroomed heads during use, reconditioned or replaced as necessary?	
☐	☐	☐	Are worn or bent wrenches replaced regularly?	
☐	☐	☐	Are appropriate handles used on files and similar tools?	
☐	☐	☐	Are employees made aware of the hazards caused by faulty or improperly used hand tools?	
☐	☐	☐	Are jacks checked periodically to ensure they are in good operating condition?	
☐	☐	☐	Are tool handles wedged tightly in the head of all tools?	
☐	☐	☐	Are tool cutting edges kept sharp so the tool will move smoothly without binding or skipping?	
☐	☐	☐	Are tools stored in dry, secure locations where they won't be tampered with?	
☐	☐	☐	Are appropriate safety glasses, face shields, etc. used while using hand tools or equipment which might produce flying materials or be subject to breakage?	

Power Tool Inspection Checklist

Yes	No	NA	Requirement	Comments
☐	☐	☐	Are grinders, saws and similar equipment provided with appropriate safety guards?	
☐	☐	☐	Are power tools used with the correct shield, guard, or attachment, recommended by the manufacturer?	
☐	☐	☐	Are portable circular saws equipped with guards above and below the base shoe? Are circular saw guards checked to assure they are not wedged up, thus leaving the lower portion of the blade unguarded?	
☐	☐	☐	Are rotating or moving parts of equipment guarded to prevent physical contact?	
☐	☐	☐	Are all cord-connected, electrically operated tools and equipment effectively grounded or of the approved double insulated type?	

EQUIPMENT INSPECTION CHECKLIST
HAND AND POWER TOOLS

Yes	No	NA	Requirement	Comments
☐	☐	☐	Are effective guards in place over belts, pulleys, chains, sprockets, on equipment such as concrete mixers, and air compressors?	
☐	☐	☐	Are portable fans provided with full guards or screens having openings ½ inch or less?	
☐	☐	☐	Is hoisting equipment available and used for lifting heavy objects, and are hoist ratings and characteristics appropriate for the task?	
☐	☐	☐	Are ground-fault circuit interrupters provided on all temporary electrical 15 and 20 ampere circuits, used during periods of construction?	
☐	☐	☐	Are pneumatic and hydraulic hoses on power operated tools checked regularly for deterioration or damage?	
☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	Air compressor: • Is the air compressor equipped with a Surge Check Valve? • Pressure regulator gauge and valve? • Pressure relief valve? • Water trap and filter?	
Chainsaws				
Yes	**No**	**NA**	**Requirement**	**Comments**
☐	☐	☐	Is the chain sharp, well oiled, and properly adjusted (Chain tension)?	
☐	☐	☐	Is the Bar straight? • Are there indications of excessive wear?	
☐ ☐	☐ ☐	☐ ☐	Does the chain brake lever move freely? Does chain brake stop the chain when applied?	
☐	☐	☐	Does the chain move when idling?	
☐	☐	☐	Are the cans used to fuel the chainsaw safety cans?	
☐	☐	☐	Does the on/off switch function properly?	
☐ ☐	☐ ☐	☐ ☐	Does the throttle lock function properly? Is the chainsaw equipped with continuous pressure throttle control?	

EQUIPMENT INSPECTION CHECKLIST
HAND AND POWER TOOLS

Yes	No	NA	Requirement	Comments
☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	PPE: Is the following PPE in serviceable condition? Hardhat with mesh visor and ear muffs? Safety glasses? Chainsaw chaps? Gloves with protection also on the hack of the hands?	
☐ ☐	☐ ☐	☐ ☐	Emergency Equipment: Is a Fire extinguisher (3A:B:C) available for immediate use? Is a First-Aid Kit immediately available for use? Does it contain the minimum content as required in the HASP?	
☐	☐	☐	Communication – Is an acceptable means of communication available (Hand signals, radios, air horns, etc.) that will support communication over the engine noise? Type?	
☐	☐	☐	Are MSDSs available for the fuels, fuel additives, and lubricating oils?	
☐ ☐	☐ ☐	☐ ☐	Is the operator trained in proper operation of the chainsaw? Does the operator demonstrate knowledgeable operation?	

ATTACHMENT V
TETRA TECH INCIDENT REPORTING FORMS

TETRA TECH, INC.
Safety Excellence

INCIDENT REPORT

Report Date	Report Prepared By	Incident Report Number

INSTRUCTIONS:

All incidents (including those involving subcontractors under direct supervision of Tetra Tech personnel) must be documented on the IR Form.

Complete any additional parts to this form as indicated below for the type of incident selected.

TYPE OF INCIDENT (Check all that apply)	Additional Form(s) Required for this type of incident	
Near Miss (No losses, but could have resulted in injury, illness, or damage)	☐	Complete IR Form Only
Injury or Illness	☐	Complete Form IR-A; Injury or Illness
Property or Equipment Damage, Fire, Spill or Release	☐	Complete F orm IR -B; Dam age, F ire, S pill or Release
Motor Vehicle	☐	Complete Form IR-C; Motor Vehicle

INFORMATION ABOUT THE INCIDENT

Description of Incident

_____

_____

_____

_____

Date of Incident	Time of Incident
	_____ AM ☐ PM ☐ *OR* Cannot be determined ☐
Weather conditions at the time of the incident	**Was there adequate lighting?**
	_____ Yes ☐ No ☐

Location of Incident

_____ Was location of incident within the employer's work environment? Yes ☐ No ☐

Street Address	City, State, Zip Code and Country
Project Name	**Client:**
Tt Supervisor or Project Manager	**Was supervisor on the scene?**
	Yes ☐ No ☐

WITNESS INFORMATION (attach additional sheets if necessary)

Name	Company
Street Address	**City, State and Zip Code**

Telephone Number(s)

CORRECTIVE ACTIONS

Corrective action(s) immediately taken by unit reporting the incident:

_____

_____

_____

Corrective action(s) still to be taken (by whom and when):

_____

_____

_____

ROOT CAUSE ANALYSIS LEVEL REQUIRED

Root Cause Analysis Level Required: Level - 1 ☐ Level - 2 ☐ None ☐

Root Cause Analysis Level Definitions

Level – 1	**Definition:** A Level 1 RCA is conducted by an individual(s) with experience or training in root cause analysis techniques and will conduct or direct documentation reviews, site investigation, witness and affected employee interviews, and identify corrective actions. Activating a Level 1 RCA and identifying RCA team members will be at the discretion of the Corporate Administration office. The following events may trigger a Level 1 RCA: ▪ Work related fatality ▪ Hospitalization of one or more employee where injuries result in total or partial permanent disability ▪ Property damage in excess of $75,000 ▪ When requested by senior management
Level – 2	**Definition:** A Level 2 RCA is self performed within the operating unit by supervisory personnel with assistance of the operating unit HSR. Level 2 RCA will utilize the 5 Why RCA methodology and document the findings on the tools provided. The following events will require a Level 2 RCA: ▪ OSHA recordable lost time incident ▪ Near miss incident that could have triggered a Level 1 RCA ▪ When requested by senior management

Complete the Root Cause Analysis Worksheet and Corrective Action form. Identify a corrective action(s) for each root cause identified within each area of inquiry.

NOTIFICATIONS

Title	Printed Name	Signature	Telephone Number	Date
Project Manager or Supervisor				
Site Safety Coordinator or Office H&S Representative				
Operating Unit H&S Representative				
Other: _____				

The signatures provided above indicate that appropriate personnel have been notified of the incident.

INSTRUCTIONS:

Complete all sections below for incidents involving injury or illness.
Do NOT leave any blanks.
Attach this form to the IR FORM completed for this incident.

Incident Report Number: (From the IR Form)	

EMPLOYEE INFORMATION

Company Affiliation

Tetra Tech Employee? ☐ TetraTech subcontractor employee (directly supervised by Tt personnel)? ☐

Full Name	**Company (if not Tt employee)**

Street Address, City, State and Zip Code	**Address Type**
_____	Home address (for Tt employees) ☐
_____	Business address (for subcontractors) ☐

Telephone Numbers

Work: _____	Home: _____	Cell: _____

Occupation (regular job title)	**Department**

Was the individual performing regular job duties?	**Time individual began work**
Yes ☐ No ☐	_____ AM ☐ PM ☐ *OR* Cannot be determined ☐

Safety equipment

Provided? Yes ☐ No ☐

Used? Yes ☐ No ☐ If no, explain why

_____

_____

_____

Type(s) provided:
- ☐ Hard hat
- ☐ Gloves
- ☐ Eye protection
- ☐ Safety shoes
- ☐ Respirator
- ☐ Protective clothing
- ☐ High visibility vest
- ☐ Fall protection
- ☐ Machine guarding
- ☐ Other (list)

_____

NOTIFICATIONS

Name of Tt employee to whom the injury or illness was first reported	**Was H&S notified within one hour of injury or illness?**
	Yes ☐ No ☐
Date of report	**H&S Personnel Notified**
Time of report	**Time of Report**

If subcontractor injury, did subcontractor's firm perform their own incident investigation?

Yes ☐ No ☐ If yes, request a copy of their completed investigation form/report and attach it to this report.

INJURY / ILLNESS DETAILS

What was the individual doing just before the incident occurred? Descr be the activity as well as the tools, equipment, or material the individual was using. Be specific. Examples: "Climbing a ladder while carrying roofing materials"; "Spraying chlorine from a hand sprayer"; "Daily computer key-entry"

_____

_____

_____

What Happened? Descr be how the injury occurred. Examples: "When ladder slipped on wet floor and worker fell 20 feet"; "Worker was sprayed with chlorine when gasket broke during replacement"; Worker developed soreness in wrist over time"

_____

_____

_____

_____

Describe the object or substance that directly harmed the individual: Examples: "Concrete floor"; "Chlorine"; "Radial Arm Saw". If this question does not apply to the incident, write "Not Applicable".

_____

_____

MEDICAL CARE PROVIDED

Was first aid provided at the site: Yes ☐ No ☐ If yes, describe the type of first aid administered and by whom?

_____

Was treatment provided away from the site: Yes ☐ No ☐ If yes, provide the information below.

Name of physician or health care professional	**Facility Name**
Street Address, City State and Zip Code	**Type of Care?**
_____ _____	Was individual treated in emergency room? Yes ☐ No ☐ Was individual hospitalized overnight as an in-patient? Yes ☐ No ☐ Did the individual die? Yes ☐ No ☐ If yes, date: _____ Will a worker's compensation claim be filed? Yes ☐ No ☐
Telephone Number	

NOTE: Attach any police reports or related diagrams to this report.

SIGNATURES

I have reviewed this report and agree that all the supplied information is accurate

Affected individual (print)	**Affected individual (signature)**	**Telephone Number**	**Date**

This form contains information relating to employee health and must be used in a manner that protects the confidentiality of the employee to the extent possible while the information is being used for occupational safety and health purposes.

INSTRUCTIONS:

Complete all sections below for incidents involving property/equipment damage, fire, spill or release.
Do NOT leave any blanks.
Attach this form to the IR FORM completed for this incident.

Incident Report Number: (From the IR Form)	

TYPE OF INCIDENT (Check all that apply)

Property Damage ☐	Equipment Damage ☐	Fire or Explosion ☐	Spill or Release ☐

INCIDENT DETAILS

Results of Incident: Fully describe damages, losses, etc.

_____

_____

_____

Response Actions Taken:

_____

_____

_____

Responding Agency(s) (i.e. police, fire department, etc.)	**Agency(s) Contact Name(s)**

DAMAGED ITEMS (List all damaged items, extent of damage and estimated repair cost)

Item:	**Extent of damage:**	**Estimated repair cost**

SPILLS / RELEASES (Provide information for spilled/released materials)

Substance	**Estimated quantity and duration**	**Specify Reportable Quantity (RQ)**
		_____ Exceeded? Yes ☐ No ☐ NA ☐

FIRES / EXPLOSIONS (Provide information related to fires/explosions)

Fire fighting equipment used? Yes ☐ No ☐ If yes, type of equipment: _____

NOTIFICATIONS

Required notifications	**Name of person notified**	**By whom**	**Date / Time**
Client: _____ Yes ☐ No ☐			
Agency: _____ Yes ☐ No ☐			
Other: _____ Yes ☐ No ☐			

Who is responsible for reporting incident to outside agency(s)? Tt ☐ Client ☐ Other ☐ Name: _____

Was an additional written report on this incident generated? Yes ☐ No ☐ If yes, place in project file.

INSTRUCTIONS:

Complete all sections below for incidents involving motor vehicle accidents. Do NOT leave any blanks. Attach this form to the IR FORM completed for this incident.

Incident Report Number: (From the IR Form)	

INCIDENT DETAILS

Name of road, street, highway or location where accident occurred	**Name of intersecting road, street or highway if applicable**

County	**City**	**State**

Did police respond to the accident?	**Did ambulance respond to the accident?**
Yes ☐ No ☐	Yes ☐ No ☐
Name and location of responding police department	**Ambulance company name and location**
Officer's name/badge #	

Did police complete an incident report? Yes ☐ No ☐ If yes, police report number: _____
Request a copy of completed investigation report and attach to this form.

VEHICLE INFORMATION

How many vehicles were involved in the accident? _____ (Attach additional sheets as applicable for accidents involving more than 2 vehicles.)

Vehicle Number 1 – Tetra Tech Vehicle		**Vehicle Number 2 – Other Vehicle**	
Vehicle Owner / Contact Information		**Vehicle Owner / Contact Information**	
Color		**Color**	
Make		**Make**	
Model		**Model**	
Year		**Year**	
License Plate #		**License Plate #**	
Identification #		**Identification #**	
Describe damage to vehicle number 1		**Describe damage to vehicle number 2**	
Insurance Company Name and Address		**Insurance Company Name and Address**	
Agent Name		**Agent Name**	
Agent Phone No.		**Agent Phone No.**	
Policy Number		**Policy Number**	

DRIVER INFORMATION

Vehicle Number 1 – Tetra Tech Vehicle		Vehicle Number 2 – Other Vehicle	
Driver's Name		**Driver's Name**	
Driver's Address		**Driver's Address**	
Phone Number		**Phone Number**	
Date of Birth		**Date of Birth**	
Driver's License #		**Driver's License #**	
Licensing State		**Licensing State**	
Gender	Male ☐ Female ☐	**Gender**	Male ☐ Female ☐
Was traffic citation issued to Tetra Tech driver? Yes ☐ No ☐		Was traffic citation issued to driver of other vehicle? Yes ☐ No ☐	
Citation #		**Citation #**	
Citation Description		**Citation Description**	

PASSENGERS IN VEHICLES (NON-INJURED)

List all non-injured passengers (excluding driver) in each vehicle.
Driver information is captured in the preceding section.
Information related to persons injured in the accident (non-Tt employees) is captured in the section below on this form.
Injured Tt employee information is captured on FORM IR-A

Vehicle Number 1 – Tetra Tech Vehicle		Vehicle Number 2 – Other Vehicle	
How many passengers (excluding driver) in the vehicle? ____		How many passengers (excluding driver) in the vehicle? ____	
Non-Injured Passenger Name and Address		**Non-Injured Passenger Name and Address**	
Non-Injured Passenger Name and Address		**Non-Injured Passenger Name and Address**	
Non-Injured Passenger Name and Address		**Non-Injured Passenger Name and Address**	

INJURIES TO NON-TETRATECH EMPLOYEES

Name of injured person 1				Address of injured person 1		
Age	**Gender**	**Car No.**	**Location in Car**	**Seat Belt Used?**	**Ejected from car?**	**Injury or Fatality?**
	Male ☐ Female ☐			Yes ☐ No ☐	Yes ☐ No ☐	Injured ☐ Died ☐
Name of injured person 2				**Address of injured person 2**		
Age	**Gender**	**Car No.**	**Location in Car**	**Seat Belt Used?**	**Ejected from car?**	**Injury or Fatality?**
	Male ☐ Female ☐			Yes ☐ No ☐	Yes ☐ No ☐	Injured ☐ Died ☐

OTHER PROPERTY DAMAGE

Describe damage to property other than motor vehicles	
Property Owner's Name	**Property Owner's Address**

COMPLETE AND SUBMIT DIAGRAM DEPICTING WHAT HAPPENED

ATTACHMENT VI

OSHA POSTER

Job Safety and Health

It's the law!

OSHA

Occupational Safety and Health Administration
U.S. Department of Labor

EMPLOYEES:

- You have the right to notify your employer or OSHA about workplace hazards. You may ask OSHA to keep your name confidential.
- You have the right to request an OSHA inspection if you believe that there are unsafe and unhealthful conditions in your workplace. You or your representative may participate in that inspection.
- You can file a complaint with OSHA within 30 days of retaliation or discrimination by your employer for making safety and health complaints or for exercising your rights under the *OSH Act*.
- You have the right to see OSHA citations issued to your employer. Your employer must post the citations at or near the place of the alleged violations.
- Your employer must correct workplace hazards by the date indicated on the citation and must certify that these hazards have been reduced or eliminated.
- You have the right to copies of your medical records and records of your exposures to toxic and harmful substances or conditions.
- Your employer must post this notice in your workplace.
- You must comply with all occupational safety and health standards issued under the *OSH Act* that apply to your own actions and conduct on the job.

EMPLOYERS:

- You must furnish your employees a place of employment free from recognized hazards.
- You must comply with the occupational safety and health standards issued under the *OSH Act*.

This free poster available from OSHA –
The Best Resource for Safety and Health

Free assistance in identifying and correcting hazards or complying with standards is available to employers, without citation or penalty, through OSHA-supported consultation programs in each state.

1-800-321-OSHA

www.osha.gov

OSHA 3165-12-06R

State of Ohio Environmental Protection Agency

STREET ADDRESS:

Central District Office

MAILING ADDRESS:

Lazarus Government Center
50 W. Town St., Suite 700
Columbus, Ohio 43215

TELE: (614) 728-3778 FAX: (614) 728-3898
www.epa.state.oh.us

P.O. Box 1049
Columbus, OH 43216-1049

October 29, 2010

Al Quagliotti, P.G.
Tetra Tech, NUS, Inc.
Foster Plaza 7
661 Andersen Drive
Pittsburgh, PA 15220-2745

Re: Review of Draft Health and Safety Plan
Former Kilgore Manufacturing Company Property
Westerville, Delaware County, Ohio
Project ID #121001187012

Dear Mr. Quagliotti:

On October 22, 2010, the Ohio Environmental Protection Agency (Ohio EPA) received the *Draft Health and Safety Plan for the Remedial Investigation/Feasibility Study at Former Operations Area of Kilgore Manufacturing, Otterbein University, Westerville, Ohio* (HASP). The HASP was prepared by Tetra Tech, NUS Inc. on behalf of Otterbein University following Section VIII. *Remedial Investigation and Feasibility Study* (RI/FS) of the draft consent decree (the most current version is October 15, 2010) for preparation of the RI/FS work plan. (Although the consent decree remains in draft form, a revised version should not affect our comments on the HASP.)

Ohio EPA has completed its review of the draft HASP and provides the following comments.

Comments:

A. Chapter 3.2, Site Description, should address the availability of utilities including water supply, electricity and telephone service, as specified in Appendix D, Health and Safety Plan (HASP) and Section 2.3 of the RI/FS Statement of Work.

B. The delineation of the work areas should include a map showing the eight Areas of Concern. Note that a detailed map of the proposed wetland delineation excavations should also be included in the field sampling plan.

C. Section 5.2, DPT/HAS Work Practices, must include contacting the Ohio Utilities Protection Service, 1-800-362-2764 or 8-1-1, at least 48 hours but no more than 10 working days (excluding weekends and legal holidays) before beginning any excavation project. See Ohio Revised Code Chapters 3781.25 to 3791.32.

D. Section 6.1.1 of the HASP and Table 1, Activity Hazard Analysis, in Attachment II, UXO Standard Operating Procedures, suggests "W(w)earing surgeon's-style gloves whenever handling potentially-contaminated media" however, these "surgeon's-style gloves" might not provide adequate chemical protection. See Table 1 for the use of "Nitrile gloves for sampling events" or "U(u)se of proper protective equipment..."

E. The description of requirements for an environmental monitoring program in Chapter 7.0, Air Monitoring, should include a description of the frequency and type of air and personnel monitoring, environmental sampling techniques, and a description of the calibration and maintenance of the instrumentation used. See Section 11.2. f., Airborne Chemical Release Contingency Plan and Section 13.2, Air Monitoring Equipment, in Appendix II for chemical release monitoring requirements. Due to the potential for petroleum chemicals of concern at the site, air monitoring of volatile organic chemicals should be included.

F. Confirm whether two UXO-qualified technicians will be present during all UXO-related activities including UXO avoidance in specified investigation areas, and whether the wetland delineation excavations will follow protocols listed in Section 15.6, Exploratory Trenching and Excavation, in Appendix II.

G. Provide copies of the *Tetra Tech Health and Safety Guidance Manual* and *TtNUS Utility Locating and Excavation Clearance Standard Operating Procedure* to Ohio EPA.

Wetland Investigation

Given the ongoing negotiation of the consent decree for performance of the RI/FS and Otterbein University's request to conduct wetland delineation sampling in advance of submittal of an approvable RI/FS work plan, Ohio EPA is agreeable that such activities be performed under a health and safety plan.

Response Required

A comprehensive RI/FS work plan is to be submitted to Ohio EPA by November 1, 2010, in accordance with the schedule in the draft consent order.

Ohio EPA's review of the draft HASP does not constitute an approval of the document. Additionally, the absence of comments on the draft HASP does not eliminate the discussion of any item in the subsequent RI/FS process. If you have any questions concerning this letter, please contact Robin Roth at (614) 466-2476.

Sincerely,

Robin Roth
Site Coordinator
Division of Emergency and Remedial Response
Central District Office

c: Rebecca Vasquez-Skillings, Otterbein University
Ron Kuis, Ronald L. Kuis & Associates
CDO File #121001187012

ec: Deborah Strayton, Manager, DERR-CDO
Ken Schultz, Assistant Manager, DERR-CDO
Tom Harcarik, DSW
Mark Rickrich, DERR-ACRE
Mark Navarre, Legal Office
Tim Kern, AGO, EES

RR/ Kilgore Mfg Review of HASP

TETRA TECH

PITT-12-10-019

December 9, 2010

Mr. Robin Roth
Ohio EPA, Division of Emergency and Remedial Response
50 W. Town Street, Suite 700
Columbus, OH 43215

RE: Response to Kilgore Health and Safety Plan

Dear Mr. Roth:

Tetra Tech Inc. appreciates the review of the Kilgore Site Health and Safety Plan conducted by the Ohio EPA, which was provided in your letter of October 29, 2010. Most of the comments have been incorporated in the final version of the HASP, which was resubmitted in November, 2010. Your comments are discussed in the following paragraphs:

Comment A: This comment (utility availability) was incorporated into Section 2.2.
Comment B: This comment (work area map) was incorporated as Figure 3.1.
Comment C: This comment (Utility One call) was incorporated in Section 5.2.
Comment D: This comment (double gloving) was incorporated into Section 6.1.6 and Table 1 – Activity Hazard Analysis.
Comment E: This comment (air monitoring) was determined to be unnecessary at the Kilgore site. Prior analytical data indicates that the only chemicals of concern to human health are munitions constituents and metals. A heating oil UST was taken out of service in 1962 and subsequently removed in 1997. A total of 104 yd3 was removed and follow up confirmation sampling determined that the petroleum constituents remaining were below VAP cleanup standards. A report was filed with OEPA and no further action was required. In 2000, a boring located near the former UST had a hydrocarbon odor in soil from a depth of 19 to 24 feet bgs. (No sample collected.) In 2005, three monitor wells in the area failed to detect any BTEX.
Comment F: This comment (utility location) is addressed by the inclusion of Tetra Tech Utility Locating and Excavation Clearance Standard Operating Procedure. The Health and Safety Guidance manual is an internal document and classified as company confidential.

I trust these responses satisfy your concerns with the HASP. If you have any questions, please do not hesitate to call me at 412-921-8146 or my cell (412-860-0264).

Very truly yours,

Al Quagliotti, P.G.
Site Coordinator
JAQ/smr

Tetra Tech, Inc.
661 Andersen Drive, Pittsburgh, PA 15220-2745
Tel 412.921.7090 Fax 412.921.4040 www.tetratech.com

Tetra Tech, NUS Inc.
Response To Comments
Former Kilgore Manufacturing Company Property
Westerville, Delaware County, Ohio
Project ID #121001187012

Comment	Action	Explanation
A	Incorporated	Utility availability - See Section 3.2
B	Incorporated	Work area map - See Figure 3.1
C	Incorporated	Utility One Call - See Section 5.2
D	Incorporated	Double gloving - See Section 6.1.1 and Table 1 Activity Hazard Analysis
E	No change	Prior analytical data indicates that the only chemicals of concern to human health are munitions constituents and metals. A heating oil UST was taken out of service in 1962 and subsequently removed in 1997. A total of 104 yd^3 was removed and follow up confirmation sampling determined that the petroleum constituents remaining were below VAP cleanup standards. A report was filed with OEPA and no further action was required. In 2000 a boring located near the former UST had a hydrocarbon odor in soil from a depth of 19 to 24 feet bgs. (No sample collected.) In 2005 three monitor wells in the area failed to detect any BTEX.
F	Incorporated	One UXO-qualified technician will present during all UXO-related activities. This language has been added to the APP in Section 4. The wetland delineation excavation is beyond the Tetra Tech task order and will be conducted by another contractor.
G	No change	The TtNUS Utility Locating and Excavation Clearance Standard Operating Procedure is provided as requested. The Health and Safety Guidance manual is an internal document and classified as company confidential.

James K. Laffey
Project Health and Safety Officer
November 23, 2010