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Quality Assurance Project Plan Addendum No. 1 for Ammunition Burning Grounds, Little Sulphur Creek, and Old Jeep Trail

Resource Conservation and Recovery Act Phase III RCRA Facility Investigation

Naval Surface Warfare Center Crane

Crane, Indiana

Southern Division Naval Facilities Engineering Command

Contract Number N62467-94-D-0888

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QUALITY ASSURANCE PROJECT PLAN
ADDENDUM NO. 1
FOR
AMMUNITION BURNING GROUNDS, LITTLE SULPHUR CREEK, AND OLD JEEP TRAIL

RESOURCE CONSERVATION AND RECOVERY ACT PHASE III RCRA FACILITY INVESTIGATION

NAVAL SURFACE WARFARE CENTER, CRANE CRANE, INDIANA

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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2-1 Project Organization Chart

ACRONYMS

%R	Percent recovery
°C	Degrees Celsius
ABG	Ammunition Burning Grounds
amsl	Above mean sea level
BC-BC	Big Clifty Sandstone-Beech Creek Limestone
bgs	below ground surface
CAS	Chemical abstract service
CEC	Cation exchange capacity
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
CMS	Corrective Measures Study
COC	Chemical of concern
COPC	Chemical of potential concern
CSM	Conceptual Site Model
CTO	Contract Task Order
DBG	Dye Burial Grounds
DO	Dissolved oxygen
DOD	Department of Defense
DPT	Direct Push Technology
FOL	Field Operations Leader
ft^3/s	Cubic feet per second
G-H	Golconda-Haney
gpm	Gallon per minute
HASP	Health and Safety Plan
IDEM	Indiana Department of Environmental Regulation
IDW	Investigation-derived waste
LSC	Little Sulphur Creek
mL/min	milliliters per minute
MS	Matrix spike
MSD	Matrix spike duplicate
MTA	Main Treatment Area
NA	Natural attenuation
NAD	North American Datum

NAVD	North American Vertical Datum
NAVFAC	Naval facilities
NFESC	Naval Facilities Engineering Service Center
NGVD29	National Geodetic Vertical Datum of 1929
NSWC	Naval Surface Warfare Center
NTU	Nephelometric turbidity unit
OJT	Old Jeep Trail
ORP	Oxidation-reduction potential
OSHA	Occupational Safety and Administration
PCB	Polychlorinated biphenyl
PID	Photoionization detector
PPE	Personal protective equipment
PVC	Polyvinyl chloride
QA	Quality assurance
QAM	Quality Assurance Manager
QAPP	Quality Assurance Project Plan
QC	Quality control
RBTL	Risk-based target level
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RL	Reporting limit
RPD	Relative percent difference
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SSO	Site Safety Officer
SVOC	Semivolatile organic compound
SWMU	Solid waste management unit
TOC	Total organic carbon
TOM	Task Order Manager
TOX	Total organic halide
TtNUS	Tetra Tech NUS, Inc.
TV	Threshold value
µg/kg	Micrograms per Kilogram
µg/L	Micrograms per Liter
U.S. EPA	United States Environmental Protection Agency
USACE	United States Army Corps of Engineers

USCS	Unified Soil Classification System
UST	Underground storage tank
UXO	Unexploded ordnance
VOC	Volatile organic compound
WES	Waterways Experiment Station

1.0 INTRODUCTION

The Naval Surface Warfare Center (NSWC) Crane Ammunition Burning Grounds (ABG) solid waste management unit (SWMU) 03 consists of the Main Treatment Area (MTA), Old Jeep Trail (OJT), and Little Sulphur Creek (LSC). Figure 1-1 depicts the MTA, and Figure 1-2 depicts the OJT and LSC. The Navy prepared a Quality Assurance Project Plan (QAPP) for a Phase III Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at the OJT and LSC (TtNUS, 2001).

This QAPP was approved by the United States Environmental Protection Agency (U.S. EPA) Region 5. The field program was conducted and the RFI Report was prepared. The RFI Report recommended that a Corrective Measures Study (CMS) be conducted to address explosives, chlorinated solvents, and metals contamination in ground water and soils at the OJT. RFI studies had been conducted by the United States Army Corps of Engineers (USACE) for ground water, soils, and surface waters at the MTA. These studies had recommended that corrective measures be considered to address explosives, chlorinated solvents, and metals contamination from the MTA in soils, ground water, and surface waters. The MTA, which is permitted by U.S. EPA Region 5 as a treatment facility for hazardous waste munitions, explosives, and pyrotechnics, is subject to the ground water monitoring and corrective action requirements of 40 Code of Federal Regulations (CFR) 264 Subpart F. These regulations require corrective actions for any ground water contamination resulting from the treatment operations.

The Navy is in the process of preparing the CMS to address ground water and soils contamination at SWMU 03. The initial phase of the CMS consists of development of the conceptual site model (CSM), which describes the geology, hydrology, ground water contamination sources, transport of contamination, and fate. The CSM is the basis for developing, evaluating, and choosing corrective measures. During the development of the CMS, the Navy determined that ground water contamination sources were not adequately delineated at the MTA and that it was not possible to fully develop the CSM until this data gap was filled.

This document, QAPP Addendum No. 1, describes the field investigation designed to fill these data gaps. Generally, background information already described in the approved QAPP (TtNUS, 2001) or RFI Report (TtNUS, 2003), is referenced rather than repeated. New or updated information necessary to understand the CSM data gaps and the investigations designed to address these gaps are presented.

This section of the QAPP Addendum No. 1 presents historical information and the basis for the sampling strategy and field work described later. Section 2.0 is a description of the project organization. Section

3.0 is a detailed description of the field activities. Section 4.0 presents the requirements for laboratory and field quality control (QC) operations not included in the first three sections. Standard Operating Procedures (SOPs) for field work are provided in Appendix A. All pertinent boring logs for the ABG/OJT/LSC are included as Appendix B. All laboratory SOPs that have changed since the approved QAPP (TtNUS, 2001) or that were added to this QAPP Addendum No. 1 are contained in Appendix C.

1.1 PROJECT BACKGROUND AND STATUS

Since 1981, several investigations of the geology, hydrogeology, and the nature and extent of contamination at the ABG, OJT, and LSC have been completed (Table 1-1). The RFI reports generated by these investigations include the following:

- RCRA Facility Investigation, Phase III Ground Water Release Characterization, SWMU 03/10, Ammunition Burning Ground prepared by the USACE Waterways Experiment Station (WES) (Murphy, 1994).

- RCRA Facility Investigation, Part 2, Phase III Soils Study, Ammunition Burning Ground, SWMU 03/10 prepared by the USACE WES (Albertson et al., 1998).

- RCRA Facility Investigation, Phase II Release Assessment for Surface Water, SWMU 03/10, Ammunition Burning Ground prepared by the USACE WES (Murphy and Wade, 1998).

- Current Contamination Conditions Risk Assessment, SWMU # 03/10, Ammunition Burning Ground prepared by TtNUS, 1999.

- RCRA Facility Investigation for SWMU 03 – Old Jeep Trail/Little Sulphur Creek prepared by TtNUS, 2003.

These past environmental investigations showed overburden soils and ground water to be contaminated with several operationally related chemicals including chlorinated volatile organic compounds (VOCs), explosive compounds, and metals. Contaminated ground water reaches LSC primarily through karst conduits that discharge to the Creek via several springs located toward the southern end of LSC (TtNUS, 2003).

Based on early investigations, the ABG was scheduled for a RCRA CMS to address the identified contaminants. The 2001/2002 RFI confirmed the need for a CMS to include the OJT/LSC area. While planning for the CMS, the following data gaps were identified:

- Lack of chemical concentration data, except for a few locations, in deep soil [i.e., greater than 60 inches below ground surface (bgs)] at the ABG MTA. This results in the inability to correlate observed soil concentrations of explosives, volatile organic compounds, and metals, with observed ground water concentrations of the same chemicals.

- Sparsely distributed sampling locations in a lateral direction in multiple areas. It is believed that refining the spatial contaminant distributions will support the correlations of chemical concentrations in soils and ground water.

- Additional information is needed to more closely estimate the location(s) of the VOC source(s) in soils to support the evaluation of remedial alternatives and costs in the CMS and provide additional information on explosives concentration.

- A need to obtain additional temporal and spatial information on ground water chemical concentrations. This information will support the evaluation of remedial alternatives such as natural attenuation (NA). Many of the ground water monitoring wells have not been sampled for more than 10 years.

1.2 PROJECT OBJECTIVES

The overall CMS objective is to identify, evaluate, and recommend one or more cost-effective corrective measures for safely reducing contamination in soils, ground water, and surface water at the ABG, OJT, and LSC, which will result in a reduction of potential human health risks to acceptable levels within a reasonable time frame. The field investigation governed by this QAPP Addendum No. 1 will fill data gaps for soils and ground water at the ABG and OJT/LSC areas. The specific objectives of this field effort are as follows:

- To better define the horizontal and vertical nature and extent of explosive (RDX) and trichloroethene (TCE) contamination in ABG soils, especially around historical operational units believed to be primary contaminant sources.

- To update knowledge of extent and levels of contamination in ground water across SWMU 03.

- To collect additional concentration data on RDX degradation products and supplement existing data on perchlorate to determine whether perchlorate may be present in soils and ground water at the MTA.

- If present, to sample ground water at the base of the overburden soils at ABG (i.e., perched on the bedrock surface). This water represents contamination that leaches through overburden soils and integrates contaminants from a relatively large soil volume. It could indicate the locations of contaminant source areas and the extent of their influence on surrounding soils and ground water.

- To more definitively establish links between contaminated soils and ground water contaminants.

1.3 SITE PHYSICAL DESCRIPTION

1.3.1 Physiography, Topography, and Ground Cover

The LSC watershed encompassing ABG and OJT is characterized by rugged relief. Ground surface elevations range from about 600 to 800 feet above mean sea level (amsl) in the headwaters of LSC. The surface elevation is approximately 500 feet amsl where LSC exits the southern border of the installation.

The ABG MTA is relatively flat and is within the northern headwater area of LSC. The MTA is maintained to be devoid of vegetation to minimize the risk of fires during open burning treatments. However, areas along LSC within the ABG have been seeded with grass to minimize erosion of soil into LSC. The OJT area is located in the valley of LSC, approximately one-half mile south-southeast of the ABG on Jeep Trail 25 (Figure 1-4). The ABG and OJT area are surrounded on all sides by wooded hills and ridges, with miscellaneous natural ground vegetation under the tree canopy and along the creek banks. See Section 1.2.4 of the OJT/LSC QAPP (TtNUS, 2001) and Section 1.3.1 of the OJT/LSC RFI (TtNUS, 2003) for additional details.

1.3.2 Geology and Stratigraphy

The unconsolidated overburden deposits at NWSC Crane generally consist of two types, Quaternary and Pleistocene age alluvial and colluvial deposits near the floodplains of primary streams and unconsolidated residual soils and loess on sides and tops of ridges. The residual soils developed on the ridge tops and upper side slopes of the ridges were derived from the weathering of Pennsylvanian strata. The residual soils in the lower elevations of the LSC valley were derived from the weathering of Mississippian

sandstones, limestones, and collapse fill materials. These soils consist of clay, silt, sand, and fragmented and/or partially weathered bedrock.

The uppermost bedrock formations found in the LSC watershed include sedimentary rocks from the Lower Pennsylvanian Mansfield Formation (Raccoon Creek Group) and the Upper Mississippian Stephensport and West Baden Groups. The USACE, the Indiana Geological Survey, and Indiana University have been investigating the geology and hydrogeology of this watershed since the early 1980s. Based on logs from borings drilled to various depths throughout the LSC watershed, the USACE has developed a detailed understanding of the geologic units in the watershed. Several existing USACE geologic cross-sections are reproduced in the 2003 RFI report (TtNUS, 2003). One representative geologic cross section runs east-west through the ABG (see 2003 RFI Report Figure 1-1 for the trace of this cross section) and is presented in this QAPP Addendum No. 1 (Figure 1-3).

The uppermost (youngest) bedrock units in the LSC watershed belong to the Lower Pennsylvanian Mansfield Formation of the Raccoon Creek Group. This formation consists of alternating beds of shales (e.g., black shale and carbonaceous shale), sandstone, mudstone, siltstone, and thin discontinuous coal units and is typically about 110 feet thick or more (Murphy and Wade, 1998). The Pennsylvanian age sedimentary rocks are absent in the valley of LSC and its tributaries where it has been removed by erosion. As a result, the Mansfield Formation is only present in the uppermost portions of the ridges around the perimeter of the watershed (Figure 1-3).

The Hardinsburg Formation is found immediately below the Mississippian-Pennsylvanian unconformity in the northeastern, central, and southern portions of the watershed. This unit is up to 50 feet thick and contains primarily shale. This shale unit typically acts as an aquitard between the Mansfield units above and the underlying Haney Limestone.

The Haney Limestone (also called Golconda Limestone) is characterized by shaly limestone and limey shales. The thickness ranges from several feet to almost 20 feet. The Golconda-Haney (G-H) Limestone is found around the perimeter of the ABG at elevations from about 600 to 610 feet amsl (Figure 1-3).

The Big Clifty Formation underlies the Haney Limestone and includes two distinctly different lithologic members. The upper member is the Indian Springs Shale and is approximately 10 to 20 feet thick (Figure 1-3). The lower member of the Big Clifty Formation is the Big Clifty Sandstone and consists of 35 to 45 feet of tan to green-gray, massive to thick-bedded, fine-grained, friable sandstone. Barnhill and Ambers (1994) discuss the lithologic characteristics and sedimentary facies of this sandstone in detail. Erosion has removed the Indian Springs Shale from above the Big Clifty Sandstone in the southeastern

portion of the ABG area and from the floodplain south of the ABG. As a result, the Big Clifty Sandstone is the uppermost bedrock unit in the southeastern portions of the ABG (Figure 1-3) and along the floodplain of LSC southward to the NSWC Crane property line.

The Beech Creek Limestone Formation underlies the Big Clifty Formation and consists of fossiliferous, hard, and dense limestone, when unweathered. The thickness of this unit ranges from 20 to 25 feet (Figure 1-3). The lithologic characteristics and sedimentary facies of this limestone are discussed in detail by Barnhill and Ambers (1994). Joints and bedding-plane fractures in the limestone are sparse to numerous in cores recovered from this formation and in surface outcrops (Barnhill and Ambers, 1994). Dissolution of the limestone has enlarged the fractures and joints (Figure 1-3). Fracture widths in creek bed exposures range from 2 to 25 cm (1 to 10 inches) and these fractures are filled with cobbles, gravel, and sand (Barnhill and Ambers, 1994). Drilling logs for wells along the LSC valley show a mass of weathered sandstone and limestone blocks, gravel, silt, and clay that is 10 to 30 feet thick. This zone along LSC downstream of the ABG MTA has been interpreted as an area where the Beech Creek Limestone was intensely fractured and karstified (Hunt, 1988; Murphy and Ciocco, 1990; Murphy, 1994; and Murphy, 1996). Solution channel development in this area was so intense that the Beech Creek and overlying Big Clifty Sandstone collapsed in the geologic past, and all that remains of these units in the valley is weathered rubble and alluvium.

The Elwren Formation (uppermost unit of the West Baden Group) lies below the Beech Creek Limestone and below the collapse zone material in the LSC valley. It consists of massive to thinly bedded, dark gray to green shale with interbedded red-brown claystone. The formation averages approximately 20 feet in thickness. The Reelsville Formation lies just below the Elwren Shale and is approximately 10 feet thick. It consists of dark gray to gray-green shale, with thin (less than 3 feet thick) beds of fine-grained sandstone. The Sample Formation is just below the Reelsville, and consists of 40 to 45 feet of dark gray to black, thinly bedded, platy to fissile shale with some interbeds of fine-grained sandstone. Together, the Elwren, Reelsville, and Sample Shales form an aquiclude that is approximately 75 feet thick (Figure 1-3). These shales form an aquitard, limiting the vertical seepage of shallow ground water downward into the underlying Beaver Bend Limestone.

The Beaver Bend Limestone is the deepest geologic unit in the ABG/OJT/LSC area that is considered a significant aquifer and that has been investigated or monitored in the past. The Beaver Bend ranges from 10 to 12 feet thick and consists of medium gray-brown, medium to coarsely crystalline, very hard and dense limestone. This limestone has numerous intersecting joints.

1.3.3 Hydrology and Hydrogeology

Based on 20 years of drilling and hydrogeological investigations in the LSC watershed (most notably in the ABG area), the hydrostratigraphic units and hydrogeologic conditions in the watershed are well characterized and documented. However, because of the fractured rock units and karstic nature of the limestone formations present in the watershed, the ground water flow system is very complex and uncertainties exist concerning the details of the flow system at a local scale.

Four primary aquifers in the LSC watershed have been identified in the Pennsylvanian and Upper Mississippian strata:

- Pennsylvanian sandstones
- G-H Limestone aquifer
- Big Clifty Sandstone/Beech Creek Limestone (BC-BC) aquifer
- Beaver Bend Limestone

The Pennsylvanian sandstone aquifer is the uppermost aquifer and is present only along the tops of ridges at elevations above 615 feet amsl. The Pennsylvanian sandstone aquifer is not present in the ABG, OJT area, or the LSC valley floor.

The Hardinsburg Shale is up to 50 feet thick and contains mostly shale with some low-permeability sandstone in the middle. This formation is a nearly continuous, low permeability barrier to ground water flow between the Pennsylvanian sandstones above and the G-H Limestone below. The G-H Limestone aquifer crops out on the sides of LSC and Johnson Hollow. This limestone aquifer is up to 20 feet thick.

The Indian Springs Shale aquitard (the 20-foot-thick upper member of the Big Clifty Formation) underlies the G-H Limestone and minimizes vertical movement of ground water downward into the Big Clifty Sandstone. In places where the Indian Springs Shale and higher strata have been removed by post-Pennsylvanian erosion, surface recharge into the Big Clifty Sandstone is relatively rapid.

The Big Clifty Sandstone and the underlying Beech Creek Limestone are both permeable rock units and are in direct hydraulic communication with one another. Together, they form the most important aquifer unit in the watershed for reasons described below. The porosity and permeability of the Big Clifty Sandstone are due to intergranular pore spaces and to fractures (i.e., it has both primary and secondary permeability). The Beech Creek Limestone is very dense and well cemented; all of its permeability and porosity is due to vertical fractures, bedding-plane fractures, and solution openings along the fractures.

The lithology, fracture patterns, and permeability characteristics of the BC-BC are detailed in reports by the USACE (Hunt, 1988; Murphy and Ciocco, 1990; Murphy, 1994) and the Indiana Geological Survey (Barnhill and Ambers, 1994). The BC-BC aquifer is exposed near the ground surface in the eastern half of the ABG, along the LSC valley, and in the lower elevations of Johnson Hollow. Beneath the ridges, the aquifer is approximately 60 feet thick, and fracture flow is dominant in the limestone (Figure 1-3, zone 3). Solution openings and cavities become larger and hydraulically more significant close to the stream valleys where conduit systems in the limestone have developed (Figure 1-3, zones 4 and 5). Starting in the eastern half of the ABG and continuing down the LSC valley to the facility property line, the dissolution of the Beech Creek Limestone was so extensive that the overlying limestone collapsed in the geologic past, and the Big Clifty Sandstone collapsed with it. The collapsed zones are located along the centers of the LSC valley and Johnson Hollow, are permeable, and form a hydraulic continuum with the BC-BC aquifer on both sides of the valleys.

The Elwren, Sample, and Reelsville Formations lie beneath the BC-BC aquifer and have a combined thickness of about 75 feet. The permeability of the shales in these formations is so low that a significant hydraulic head difference (about 46 feet) exists between the BC-BC aquifer above and the Beaver Bend Limestone aquifer below (Baedke, 1998). The chemistries of the ground water in the BC-BC and Beaver Bend aquifers are also significantly different (Baedke, 1998). Based on the geological, hydrogeological, and geochemical evidence mentioned above and on previous reports, the hydrological separation of the BC-BC aquifer from lower strata in the LSC watershed appears to be significant. Ground water flows laterally through the BC-BC aquifer on top of the Elwren Shale and discharges as springs along the valley bottoms where this aquifer is exposed.

The Beaver Bend Limestone forms an important aquifer below the Elwren-Sample-Reelsville aquiclude. The Beaver Bend aquifer is about 12 feet thick. Five monitoring wells and one ground water production well have been drilled and screened in the Beaver Bend aquifer, all within the ABG area. Because of its depth, hydraulic isolation, and lack of contamination, this aquifer unit is not discussed further.

Ground Water Flow Directions

In general, the shallow ground water flow patterns mimic topography; highest ground water elevations are typically found along ridge crests, and ground water flow is toward the major stream or tributary valleys. Recharge to the shallow ground water system generally occurs over most of the uplands and side slopes. Ground water moves downward and then laterally, where it discharges to the deeper stream valleys as springs, seeps, and base flow.

Ground water in the G-H aquifer is prevented from seeping downward into the BC-BC aquifer by the intervening Indian Springs Shale. Instead, perched ground water in the G-H aquifer flows on top of the shale toward nearby outcrops. In the ABG area, ground water in the G-H aquifer generally flows toward the ABG from the northern, western, and southern upland areas (Hunt, 1988; Murphy, 1994; Duwelius, et al., 1995). When the ground water reaches the cropline of this aquifer, the ground water apparently seeps near the ground surface through residual soils and weathered shale until it reaches the cropline of the Big Clifty Sandstone. There, it infiltrates into the Big Clifty Sandstone.

The next lower aquifer, the BC-BC aquifer, has the most monitoring wells screened in it, and more effort has gone into characterizing the hydrogeology of this aquifer than any of the other three aquifers. The BC-BC aquifer has been studied the most because:

- It lies directly under the ABG and OJT treatment areas
- It is the only aquifer which is contaminated
- It contains the conduits that feed the majority of springs and base flow in LSC

Potentiometric surface maps for the BC-BC aquifer in the LSC watershed have been presented in previous reports (Murphy and Ciocco, 1990; Murphy, 1994; TtNUS, 2003). In general, the highest ground water elevations (560 to 565 feet amsl) in this aquifer were found at the northern end of the LSC watershed (north of the ABG and in the vicinity of the Dye Burial Grounds). Ground water generally flows from north to south in the watershed, and the flow direction is also inward toward LSC (i.e., from the perimeter of the watershed toward the creek and Johnson Hollow). The elevation at which ground water discharges from Spring C is about 530 feet amsl. The lowest ground water elevations (about 510 to 515 feet amsl) were recorded at the southern end of the watershed at Spring A and well 03B10. A comprehensive set of water levels measured on June 12 and 13, 2002 included 120 monitoring wells and four stream gage locations. The resulting potentiometric surface contours indicate that LSC is a losing stream (i.e., recharging the ground water system) in the northern part of the watershed and is a gaining stream (i.e., receives ground water discharge) near and south of Spring C.

In the smaller area surrounding the OJT study site, a localized flow system in the BC-BC/breccia zone aquifer is contrary to the overall flow system for the watershed described above. Measurements of ground water elevations at the OJT area (Murphy and Ciocco, 1990; Murphy, 1996; TtNUS, 2003) show a ground water high runs from the northwest to the southeast beneath LSC (Figure 1-2). Potentiometric contours indicate that ground water is flowing away from this high under the streambed toward the northeast and the south-southwest. As stated in previous investigations, LSC is a losing stream between the ABG and OJT and probably southward toward Spring C. In this section of the watershed, the

streambed is usually dry, and ground water flows either through the breccia zone materials parallel to the stream (i.e., underflow) or flows back toward the bedrock valley margins, as suggested by local potentiometric contours (TtNUS, 2003). These localized flow directions (i.e., away from the creek toward the northeast and southwest) are opposite to the overall watershed flow directions, which are toward the stream valley. The apparent contradiction in flow directions can be explained however, by the presence of the karst conduits that run in a north-south direction along both sides of the stream valley. The majority of ground water in the OJT area is likely flowing toward the karst conduits. In June 2001, there were relatively large horizontal hydraulic gradients toward the northeast (0.0219 foot/foot between wells 03-07 and 03-24) and southwest (0.0414 foot/foot between wells 03-07 and 03-17).

Ground water in the BC-BC aquifer and the conduits eventually discharge into the stream at Springs A, A', B, C, smaller springs, and diffuse seepage through the streambed. All this ground water discharge occurs at Spring C and south of Spring C, where the top of the Elwren Shale intersects the streambed and LSC becomes a gaining stream (i.e., flow of water is from the ground into the stream). LSC becomes a perennial stream at Spring C, where the discharge of ground water is sufficient to maintain flow in the stream continuously.

The Beaver Bend limestone is 10 to 12 feet thick and comprises the lowest aquifer that has been investigated in this watershed. Five monitoring wells in the ABG area are screened in the Beaver Bend Limestone. Based on data from these five wells, the Beaver Bend is fully saturated and flowing southward at a very gentle gradient (Murphy, 1994). The Beaver Bend is considered to be isolated hydraulically from the BC-BC aquifer above.

Ground Water Discharge and Springs of the Big Clifty-Beech Creek Aquifer

As stated above, the BC-BC aquifer discharges from both sides of the valley via numerous springs and base flow in LSC downstream of Spring C, where the stream has incised down to the underlying Elwren Shale. Springs A, A', B, and C are the largest in this watershed area and are located on the western side of the valley, approximately 6,000 to 6,800 feet south of the ABG. Spring C is located on the eastern side of the creek, about 2,000 feet south of the OJT area. Presumably, Springs A, A', and B are draining the portion of the BC-BC aquifer west of the creek, and Spring C is draining the portion of the aquifer on the eastern side of the creek. These springs flow year round; however, flow rates fluctuate rapidly due to rainstorms or large snowmelt events. Flow rates of Springs A and C were measured continuously in March and April 1996. The flow rates of the two springs rose rapidly in response to rain events and declined fairly rapidly within a few days. The peak flows in these two springs during the 2-month time period were approximately 10,000 gallons per minute (gpm), or 22.3 cubic feet per second (ft^3/s). It has

been noted in previous reports (e.g., Hunt, 1988; Murphy and Ciocco, 1990) that the springs become turbid during high flow events and then clear up and return to normal flow within a day or two after a storm event. The flashiness of the spring flows and the fact that the discharge becomes turbid during a storm indicate that the springs are linked to conduit systems that take surface recharge and transfer it through the conduit systems quickly. The suspended solids contained in the discharge waters likely come from the areas of recharge and move through the conduit system, primarily during storm events.

1.3.5 Surface Hydrology and Drainage System

LSC is a tributary of Sulphur Creek and is approximately 4.6 miles long from its northernmost headwaters to its intersection with Sulphur Creek south of the installation. The creek consists of a northern and a southern fork from the headwaters to approximately the center of the ABG Treatment Area (Figure 1-1). From the ABG, a single channel meanders south-southeastward approximately 0.5 mile to the OJT area and then continues another 0.6 mile until it reaches the installation boundary. Several intermittent tributaries discharge into LSC from both sides of the stream, including the Johnson Hollow tributary, which intersects with LSC near the NSWC Crane boundary.

The LSC channel is usually dry north (upstream) of Spring C. During dry periods of summer and fall, the flow rate in the creek between Springs C and A is typically less than about 50 gpm. Downstream of where the discharge from Spring A enters the creek, the dry weather flow in the creek is typically greater than 100 gpm. Flow rates in the creek were visually estimated on June 19, 2001. The flow estimate for 03SG05 was about 20 gpm. Downstream of Spring A at 03SG06, the flow rate in the creek can increase by two to three orders of magnitude, due in large part to the rapid increases in the discharge rates of the springs along the creek.

From the installation boundary, LSC flows southward about 2 miles before it enters Sulphur Creek. Sulphur Creek then flows southward and empties into Indian Creek, which drains into the East Fork of the White River and then southwestward into the Wabash River.

1.4 SITE HISTORY

1.4.1 Historical Operations

Operational History of the ABG

As noted in Section 1.0 of this QAPP Addendum No. 1, the ABG is used extensively to destroy unwanted materials contaminated with explosives and related materials. Several separate burning areas are

located within the site. The largest quantities of materials were treated at the MTA from 1956 to 1960, when 15,000 pounds per day of smokeless powder were flashed. In the same period, about 46,000 pounds per day of high explosives were burned. The area is also used to flash the residue from bombs and projectiles after they have been subjected to melt-out or drill-out operations to remove the bulk of the explosive (Murphy, 1994).

Prior to the construction and use of steel pans (lined and unlined) for open burning operations, explosives and propellants and materials contaminated with explosives and propellants were spread and ignited on pads or in pits at the MTA of the ABG. These burn pads and pits were reportedly located in the area now occupied by the clay-lined steel burn pans (Figure 1-1).

Three unlined surface impoundments, approximately 40 feet in diameter each, (no longer present) were used to remove liquids from otherwise combustible sludges resulting from the blending and loading of munitions (Figure 1-1). In 1982, each impoundment was modified to include a liner and leachate collection system. Two impoundments held TNT, RDX, and breakdown compounds in water from a facility munitions plant (Rockeye) and other locations within NSWC Crane. A third impoundment held phosphorus compounds. The three impoundments have been removed and replaced by dewatering units (Figure 1-1).

Two underground storage tanks (USTs) were used to store runoff and leachate from the three former impoundments. One tank was located immediately east of the phosphorus impoundment on the northern side of the ABG. The other tank contained runoff from the two adjacent TNT and RDX impoundments in the central portion of the ABG. The tanks were removed in 1994 and are currently undergoing closure pursuant to a RCRA closure plan. During excavation and removal of the impoundments and USTs, stained soils were observed in the subsurface in both UST areas. Presumably, these stained soils and fill materials represent older unlined trenches formerly used for flashing explosives and sludge materials.

The "Ash Pile" area (Figure 1-1) was the site of a former stockpile of burn residue. The pile was removed between July 1986 and February 1987, pursuant to a RCRA closure plan. The pile consisted of approximately 12,290 pounds of burn residue.

Prior to approximately 1985, pink water sludge was placed and burned in an unlined pit in the location of the pink water tanks (Figure 1-1). This flashing process was relocated to the burn pads in approximately 1985. The pink color of the water and sludge is caused by the presence of explosives and related chemicals.

Operational History of the Old Jeep Trail

The OJT area was used to burn out bombs and flash powder from the mid-1970s through 1983. Materials were treated at two separate regions of the Jeep Trail Area, the burn area and the burn pit (Figure 1-2). At the burn area, bomb casings from which the bulk explosives had been removed were filled with initiating powder, tilted on end toward a hillside east of the Jeep Trail, and flashed to complete the demilitarization process.

The burn pit was a trench or natural depression, approximately 100 feet long, 30 feet wide, and 10 to 12 feet deep, located just south-southeast of the burn area. Powder was flashed and explosives-contaminated materials were burned in this pit. The contaminated material may have included cardboard, paper, wood, and metal packaging that may have come into contact with explosives, solvent-contaminated rags, or any other material that may have been contaminated with explosives. Small munitions items and components were also reportedly treated. The area has not been used for any operations since 1983 when it was filled with clean fill material and revegetated. The area is now overgrown with brush, trees, and grasses.

The approximate burn area and burn pit locations are shown on Figure 1-2. However, descriptions of the treatment areas in previous reports and interviews with base personnel during the first field event of this investigation indicate that the treatment areas may have covered a larger area, extending from Jeep Trail 25 westward to the LSC stream channel and southward as far as well 03-07 (Figure 41 in Dunbar, 1982; Murphy, 1996).

1.5 PREVIOUS ENVIRONMENTAL INVESTIGATIONS AND CONCLUSIONS

1.5.1 Phase III Soils Study at ABG

In 1993, the USACE collected 33 surface soil grab samples, and subsurface soil samples collected from 32 soil borings scattered across the ABG (Albertson et al., 1998). Samples were taken from depths of 1 to 30 inches (surface), 30 to 60 inches, and 60 to 90 inches (sample locations are shown on Figure 3-1). The soil samples were analyzed for explosive compounds, VOCs, semivolatile organic compounds (SVOCs), and metals.

The results of the soil analyses showed that VOCs were present in only a few locations and only minor concentrations were typically detected (Albertson et al., 1998). Maximum concentrations of TCE, cis-1,2-dichloroethene, and trans-1,2-DCE were 0.2, 2.3, and 0.29 mg/kg, respectively; all of these maximums occurred in boring 03/10-17 (Figure 3-1).

HMX, RDX, trinitrobenzene, TNT, 2,4-dinitrotoluene, 2,6-DNT, 2-amino-DNT, and 4ADNT were detected in the surface and subsurface ABG soils. RDX and TNT occurred at several samples at concentrations greater than 1,000 mg/kg, and HMX occurred in concentrations greater than 200 mg/kg. The remaining energetic compounds had maximum concentrations generally less than 100 mg/kg. Higher concentrations of these explosive compounds seemed to occur at depths of 0 to 60 inches (0 to 5 feet bgs). However, only seven samples were collected at a depth greater than 60 inches, so conclusions regarding the presence of energetic compounds in the deeper soils are limited. Locations where the highest concentrations of energetic compounds were detected include surface grab sample 03/10-61 and boring 03/10-35 (Figure 3-1).

In numerous soil samples, several metals (e.g., cadmium, copper, lead, tin, and zinc) were detected at concentrations that were 10 to 100 times greater than background concentrations.

1.5.2 Phase III Ground Water Release Characterization and RCRA Quarterly Monitoring at the ABG

About 150 monitoring wells exist at the ABG and vicinity. The majority of the wells at the ABG and the LSC watershed are screened in the BC-BC aquifer. These wells were sampled sporadically between 1987 and 1993 (Murphy, 1994). As part of RCRA quarterly monitoring at selected ABG wells, 12 Beech Creek monitoring wells have been sampled between 8 and 20 times since the fall of 1998. The samples have been analyzed for inorganics, VOCs, and explosives.

The primary contaminants in ground water at the ABG include TCE and RDX. The highest concentrations of TCE were detected in wells 03C20, 03C11, 03C15, and 03C03P2 (See Figure 1-1) at 4,500, 2,500, 640, and 321 micrograms per liter (µg/L), respectively. The highest concentrations of RDX were detected in wells 03C03P2, 03C04, 03C05, 03C08P2, and 03C20 (See Figure 1-1) at 709, 400, 400, 300, and 250 µg/L, respectively.

1.5.3 Soil and Ground Water Investigations at the OJT Area

The USACE installed 17 monitoring wells in the OJT area between 1981 and 1983 (Murphy, 1996). TCE concentrations in well 03-07 exceeded 1,000 µg/L on several occasions, and reached as high as 19,000 µg/L in 1982. TCE and Cis-1,2-DCE were measured at 4,000 and 1,000 µg/L in this well, respectively, in September 1994 (Murphy, 1996). TCE contamination was also detected but at lower concentrations in two wells to the northeast (wells 03-15 and 03-24), and two wells to the southwest

(03-12 and 03-20) of well 03-07. In 1994, the highest RDX concentration (365 µg/L) was detected in well 03-21, located north of well 03-07 and southeast of the burn pit (Figure 1-2).

The OJT monitoring wells were resampled in 2001 during the OJT-LSC RFI. The TCE concentration in well 03-07 was 640 µg/L (TtNUS, 2003). The RDX concentration in well 03-21 was 280 µg/L. Thus, the maximum TCE and RDX ground water concentrations dropped significantly between 1994 and 2001.

Forty-eight surface soil and 62 subsurface soil samples were collected from 48 soil borings ranging from 1 to 15 feet bgs at the OJT during the 2001 OJT-LSC RFI. The maximum RDX soil concentration was 4.4 mg/kg in soil boring 03SB24 on the west side of the burn pit. This and other soil RDX concentrations might account for the high RDX concentration detected in well 03-21. The burn pit was identified as the potential source area of energetic contamination (i.e., RDX) and TCE in ground water. However, the levels of TCE concentrations detected in soil were not high enough to account for the TCE concentrations detected in well 03-07.

1.5.4 Dye Tracer Studies and Springs

During early ground water investigations in the LSC watershed, the investigators (Hunt, 1988; Murphy and Ciocco, 1990) surmised that springs at the southern end of the watershed were linked to karst conduits originating to the north. Several dye tracer studies have been performed in order to study the pathways in these conduits and the velocity of travel. The first dye tracer investigation was performed by Murphy and Ciocco (1990). They placed one gallon of fluorescein solution into well 03C02P2 at 10:35 on the morning of January 20, 1990. Approximately 1,200 gallons of water were added to the well during the next 60 minutes (about 20 gpm). The well accepted the water without overflowing. Two gallons of Direct Yellow 96 dye and Phorwrite AR mixture were added to well 03C03P2 at 12:25, also on January 20, 1990. About 500 gallons of water were added to this well at a rate of about 7 gpm. The rate of water addition in this well was less in order to prevent overflowing. Light rain occurred on January 19, preceding the tests, and on January 20, during the tests. Thus, the stream flow and spring flows were above average during the testing. The fluorescein dye (originating from well 03C02P2) appeared in springs A and A' over a period of 5 to 28 hours after injection. The dye persisted in these two springs for at least five days following injection. Based on a mean travel time of 16 hours and assuming a sinuous travel distance of about 8,000 feet, Murphy and Ciocco (1990) estimated a ground water velocity of approximately 500 feet per hour through the conduit system. Based on these results, it was clear that the BC-BC aquifer in the vicinity of well 03C02P2 in the ABG was directly linked to a karst conduit system that transfers water from the ABG south to Springs A and A' through the Beech Creek Limestone. The Yellow

96 and Phorwrite AR dyes did not appear in any of the springs, indicating that well 03C03P2 is not directly connected to a karst conduit system.

Indiana University initiated a second tracer test on the western side of LSC on May 3, 1997 (Baedke, 1998). Between 12:32 pm and 12:59 pm, 1.6 kg of Rhodamine WT dye and 18.3 kg of bromide ion were added to well 03C02P2. At 1:04 pm, 1.6 kg of eosin dye was injected into well 03C10. The springs and the stream were at relatively high flow rates because 2.5 inches of rain fell the previous day. Rhodamine WT dye was visually detected at springs A and A' at 8:00 pm, 7.5 hours after injection at ABG. The bromide tracer appeared at the same time as the Rhodamine WT. Baedke (1998) calculated a travel velocity of 938 feet per hour between well 03C02P2 and Spring A, which is faster than the velocity calculated by Murphy and Ciocco (1990). Although the Rhodamine WT was detected at these two springs up to four days after injection, the bromide tracer dissipated quickly (within 14 hours), presumably because the bromide ion does not sorb and is therefore flushed from the conduit system more quickly. Rhodamine WT was not detected during the entire test period in any other springs that were monitored. Eosin was not detected at all, even in springs A and A'. Therefore, it does not appear that the portion of the BC-BC aquifer located near well 03C10 is directly connected to the conduit system feeding springs A and A'. On October 11, 2000, Rhodamine WT dye was again injected into well 03C02P2, but the flow rates in the stream and the springs were relatively low during this test (Krothe, 2002). Monitoring showed that the dye took 18.5 hours to travel from the well to Springs A and A'. The peak of dye arrived 28 hours after injection. Thus, the travel velocity was slower during dry weather conditions.

Previous dye tracer tests all showed the ABG area does not seem to be hydraulically connected to Spring C, which is a major spring located on the eastern side of the creek, downstream of the OJT area. Ground water elevations indicate a flow direction from the OJT burn pits to the east-northeast toward well 03-24 (Figure 1-2). The geologic log for well 03-24 shows solution cavities in the limestone intercepted by the well screen. It was hypothesized that these solution channels might be linked to a conduit system that leads southward to Spring C, which is separate from but analogous to the conduit system investigated previously on the western side of the creek. A dye tracer test has been performed recently on the eastern side of LSC to determine whether there is a link between the OJT area and Spring C (Jock and Krothe, 2002). Fluorescein dye was injected into well 03-24 on May 24, 2002. The dye was first detected in Spring C 17 hours after injection. The dye concentration peaked 28 to 38 hours after injection and dissipated 58 hours after injection. Thus, the OJT area is linked to the Spring C conduit system in the vicinity of well 03-24. However, this conduit system does not seem to be as well developed, and travel velocities are not as fast as the conduit system on the western side of the creek feeding Springs A and A'.

1.5.5 LSC

A Phase II RFI was conducted for LSC surface water and bottom sediments in 1992 (Murphy and Wade, 1998). Eleven samples were collected in two rounds upgradient of the ABG MTA to the NSWC Crane property boundary. Samples were analyzed for select inorganic and organic chemicals to determine the presence or absence of contaminants in the creek. The significant contaminants detected included metals and explosives-related compounds.

Excluding the pesticide methoxychlor in one deep sediment sample, all pesticide, PCB, and herbicide concentrations in all sampled media were less than analytical detection limits. Also, the detected concentrations were less than human health and ecological risk-based screening levels, or the concentrations were consistent with general appropriate use. The one deep sediment concentration of methoxychlor (17 µg/kg) is less than five times greater than the 3.59 µg/kg risk-based screening level (TtNUS, 2003). Therefore, these compounds are not considered to be significant. Energetic compounds and metals were identified as chemicals of potential concern (COPCs) in LSC surface water during low-flow and high-flow conditions. Sediments exhibited little to no significant contamination. LSC receives dissolved contaminants from the ground water system via springs, seeps, and diffuse seepage through the streambed downstream of Spring C. Any contaminants migrating in the watershed were concluded to discharge to LSC before the creek reaches the facility property line. The only surface water contaminant with concentrations greater than screening levels at the downstream facility property boundary was RDX (7.7 to 10 µg/L). VOCs entering the surface water system appeared to be volatilizing to undetectable concentrations.

1.6 CONCEPTUAL SITE MODEL AND PROBLEM DESCRIPTION

Precipitation infiltrates over portions of the ABG and leaches contaminants from the soils (see zone 1, Figure 1-3). Table 1-2 identifies key operations and potential contaminant source areas at the MTA. The leachate percolates through the overburden soils and recharges the Big Clifty Sandstone. Most of the Big Clifty Sandstone is not fully saturated, so the leachate continues to migrate downward toward the water table (zone 2, Figure 1-3). The water table is near the top of the Beech Creek Limestone and the lower portion of the Big Clifty Sandstone. Having entered the saturated portion of the aquifer, the leachate moves laterally to the east and southeast (zone 3, Figure 1-3). In the area around monitoring wells 03C10, 03C03P2, and 03C11, the Beech Creek Limestone is fractured but devoid of major solution cavities. Thus, ground water flow velocities in this region (i.e., central ABG area) are relatively slow. Toward the east, the Beech Creek Limestone becomes more fractured, solution cavities along fractures and bedding planes become larger and more prevalent, and the flow velocity increases (zone 4, Figure

1-3). Large solution cavities exist in the vicinity of well 03C02P2, and the Beech Creek has partially collapsed (zone 5, Figure 1-3). Well 03C02P2 was used to demonstrate a hydraulic connection between the ABG and Springs A and A' located approximately 1.5 miles south of the ABG (Murphy and Ciocco, 1990; Krothe, 2002). Based on the measured potentiometric surface for the BC-BC aquifer in the watershed, ground water on the western side of the watershed is moving eastward and southeastward toward the conduit. Most of the contaminants migrate through the conduit in solution, but some may also be transported as a sorbed phase on suspended sediment.

In the OJT (Figure 1-2), very low concentrations of RDX, TNT, and TCE were found in some of the surface and subsurface soil samples, with an occasional higher concentration of RDX detected [up to 2,400 micrograms per kilogram (µg/kg)]. RDX and TNT were detected in ground water samples (up to 280 and 17 µg/L, respectively) collected from the Beech Creek collapse breccia near the OJT burn pit. A group of wells centered around well 03-07 (Figure 1-2) on the southern side of the OJT had TCE detections with a maximum concentration of 640 µg/L in 2002. Based on dye tracer studies by the University of Indiana, well 03-24 on the far eastern side of the OJT area is connected hydraulically to Spring C. The flow velocity from the OJT to Spring C is rapid, but not as rapid as the velocity between the ABG MTA and Springs A and A'. Excluding an anomalous result for the pesticide, methoxychlor, in one deep sediment sample, pesticide, PCB, and herbicide concentrations in all sampled media were less than analytical detection limits, were detected at concentrations less than human health and ecological risk-based screening levels, or were consistent with proper pesticide/herbicide use. The anomalous deep sediment methoxychor concentration (17 µg/kg) was less than five times greater than the 3.59 µg/kg risk-based screening level (TtNUS, 2003). Hence, these compounds are not considered to be significant.

In general, all ground water flowing from the ABG enters the western karst conduit and flows southward to Springs A and A' (Figure 1-4). All ground water on the eastern side of LSC enters the eastern karst conduit and flows southward to Spring C. Significant contaminant dilution is occurring within each karst conduit.

Flow rates increase rapidly in Springs A, A', and C during rainstorms and subside quickly (e.g., within a day or two) after storm events. This is evidence that the karst conduits are major pathways of ground water flow in the watershed. Additionally, LSC is dry upstream of Spring C except during major storm events. During most of the year, surface flow in LSC is only evident downstream of Spring C.

Until recently, it was assumed that most of the contaminants emanating from the ABG MTA reside in the shallow (0 to 90 inches bgs) overburden soils, are leached downward, enter the western karst conduit, and reach Springs A and A' relatively quickly. To test this hypothesis as to whether the shallow soil might

be the primary source of contaminants detected in ground water, two different approaches have been used. First, if the soil has major concentrations of contaminants and the leachate migrating downward is in chemical equilibrium with the soil, then the calculated contaminant concentrations in the leachate should approach the concentrations observed in the ground water directly beneath (assuming that there is not any major dilution or degradation taking place in the aquifer beneath the source area). For the ABG area, the highest soil concentrations measured in 1993 and representative soil-water partition coefficients (K_d values) were used to calculate leachate concentrations. These concentrations were compared to maximum ground water concentrations detected in ABG wells. The contaminated soil concentrations could potentially yield the ground water concentrations for RDX and TNT observed in the area because the measured and the predicted concentrations are similar. Again, this assumes that there is no significant degradation or dilution occurring during migration and mixing in the BC-BC aquifer. The measured soil TCE concentrations cannot account for the measured ground water TCE concentrations observed in the ABG MTA. The same analysis for the OJT showed similar results. The estimated OJT soil concentrations might be able to account for the RDX and TNT concentrations in ground water, but the soil TCE concentrations cannot account for the ground water concentrations.

The area and concentrations of contaminants in three different soil layers within the ABG MTA were approximated based on USACE 1993 data (Albertson, et al., 1998). The total mass of each contaminant in shallow soils was then estimated. Based on the conceptual hydrologic system presented above, all or nearly all of the ground water flow leaving the ABG MTA discharges to Springs A and A'. The average flow rate and average contaminant concentrations for these two springs were approximated. The annual contaminant mass discharged per year was then approximated. The amount of mass discharged per year was estimated to be about 25 to 38 percent of the total mass for RDX and TCE, respectively, that was estimated to be present in the soils. Because the rates of contaminant mass discharging from the springs has been relatively steady or decreasing slowly over the past 10 years or more, the shallow soils at the ABG MTA cannot be the only source of contaminants in the ground water. More than likely, deeper subsoil (e.g., 7 to 15 feet bgs) or perhaps the underlying bedrock is a reservoir for a significantly larger mass of contaminants than was detected in the shallow soils. Similarly, the concentrations of RDX and TCE found in the OJT soil samples are not high enough to account for the levels of contamination observed in ground water at the OJT. Therefore, there are probably zones of contaminated soil that have not yet been detected.

The results of these simple mass balance calculations and geochemical predictions have pointed out and accentuated the need to better define the potential contaminant sources at the ABG and OJT. In addition, more effort is needed to relate the observed distributions of contaminants in ground water to the

suspected source areas. Without this information, it will be difficult to develop CMS cleanup options for soils that could potentially remediate the contamination problems in ground water.

1.7 INVESTIGATIVE APPROACH

1.7.1 Investigative Strategy

To support the data collection needs described above, additional soil samples will be collected at the ABG MTA and OJT area. To support an evaluation of natural attenuation as a potential remedial alternative, ground water data will also be collected from various wells in the ABG and OJT area.

1.7.2 Target Parameters and Rationale – Soil Samples

All soil samples will be analyzed for explosive compounds and several will be analyzed for metals. RDX, TNT, and to a lesser extent HMX, have been identified as chemicals of concern (COCs) in the ABG and OJT areas. Several metals in soils have also been identified as COCs.

Because VOCs evaporate from surface and near-surface soils, the likelihood of finding significant VOC contamination in the shallower soils is less than for deeper soils. Furthermore, past investigations have shown VOC concentrations in surface soils to be low. Therefore, VOCs will be analyzed in all soil samples collected from depths of 6 feet or greater. In addition, any soil cores collected between 0 and 6 feet deep will be analyzed for VOCs if the readings from a photoionization detector (PID) used to scan the cores are greater than ambient readings (i.e., the PID suggests the presence of VOCs).

Soil samples collected in the past from the ABG and OJT were not analyzed for perchlorate. This commonly used oxidizing agent will be analyzed in approximately two-thirds of the surface and subsurface soil samples. These analyses will be performed to determine whether or not this compound is present in soils at either of the two study areas.

Approximately one-half of the surface and subsurface soil samples will also be analyzed for RDX degradation products. The results of these analyses will enhance the evaluation of RDX degradation and the factors that might be controlling RDX degradation in soils. This information is critical for evaluating the feasibility of NA during the CMS.

A total of eight soil samples from the ABG will be analyzed for physical and geochemical parameters that are useful during a CMS, specifically total organic carbon (TOC) and cation exchange capacity (CEC). Recent data of this type are already available for soils at the OJT.

The targeted laboratory analytical parameters, the associated laboratory detection and reporting limits, and the risk-based target levels are presented in Table 1-3. Analytical methods selected for use were those used for the 2001/2002 field work (TtNUS, 2001).

A total of 69 soil borings are planned for the ABG MTA. Four additional soil borings are planned for the OJT. Each boring will be advanced to the bedrock surface or refusal. Soil samples will be collected from depth intervals of 0 to 2, 2 to 6, 6 to 10, and greater than 10 feet bgs. Based on known depths to bedrock, a total of four samples, on average, are expected to be collected from each boring, assuming that the boring can reach a depth greater than 10 feet bgs. The borings are concentrated in the following:

- Locations of former unlined flash trenches, USTs, burning pads, and the ash piles.
- At previous soil sample locations at which elevated concentrations of TCE, RDX, or TNT were detected at shallow depths.
- Where contamination patterns in past ground water samples indicate a potential source of soil contaminants in close proximity.

A few of the soil borings are situated to explore small areas that were not sampled in the past. This will complete the evaluation of the extent of contaminants.

The four soil borings planned for the OJT are located between monitoring well 03-07 and the former burn pit. The purpose of these soil borings is to evaluate where TCE-contaminated soils might be located that are contributing to the TCE concentrations observed in well 03-07 and to determine whether RDX originating from the burn pit could be contributing to the RDX contamination in ground water.

1.7.3 Target Parameters and Rationale – Ground Water Samples

Twenty-six wells will be sampled at the ABG MTA and six wells and Spring A' will be sampled at the OJT (Table 1-4). All ground water samples will be analyzed for explosives (excluding RDX degradation products), VOCs, and metals. These analyses are being performed to refine the understanding of contaminant distributions in ground water at the ABG and to obtain more recent information on the levels of TCE and RDX in several wells at the OJT where moderate to high concentrations of RDX and TCE were detected in the past. The wells were selected to provide the greatest amount of information cost effectively.

Samples collected from 12 of the 26 wells to be sampled will be analyzed for perchlorate. Ground water samples collected in the past were not analyzed for perchlorate. These analyses will be used to determine whether perchlorate is a potential COC at the ABG or the OJT area.

1.7.4 Data Use and Decision Logic

Data interpretation will be largely based on professional judgment. New data and existing data (especially the more recent data) will be reviewed, and judgments will be made concerning the apparent existence or absence of localized hot spots and the extent of contamination. The judgments will be based on visually identified patterns of contamination and relative contamination levels in lateral and vertical directions for each chemical. For example, groups of sampling locations with relatively high concentrations surrounded by lower concentrations in downgradient directions will be interpreted to represent the identification of a contaminant source location. The higher the concentrations, the more significant the source will be considered. The lower the chemical concentrations on the perimeter of the sampling pattern, the more completely defined will be the extent of contamination.

TABLE 1-1

SUMMARY OF PREVIOUS INVESTIGATIONS
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Period of Investigation	Area Investigated	Nature of Investigation	Reference
1981-1984	ABG and OJT	Installation of monitoring wells, hydrogeological investigations, ground water sampling	Dunbar, 1982, 1983, 1984
1986-1987	ABG, OJT, and LSC Watershed	Installation of 66 monitoring wells, hydrogeological investigations, ground water sampling	Hunt, 1988
1990	ABG and Springs	Dye tracer test to assess possible hydraulic connection of ABG with various spring locations	Murphy and Ciocco, 1990
1990	ABG	RCRA Phase III Part 1 soils study	USACE, 1992
1990-1994	Primarily ABG	RCRA Phase III ground water release characterization	Murphy, 1994
1993	ABG	Monitored ground water elevations and flow directions in Golconda-Haney Limestone	Duwelius, et al., 1995
1994	Primarily ABG	Geology, lithologic characteristics, and hydraulic properties of the Big Clifty Sandstone and Beech Creek Limestone	Barnhill and Ambers, 1994
1994-1995	ABG	Four pumping tests were performed	Murphy, 1995
1993-1995	OJT Area	Hydrogeological investigations and evaluation of ground water contamination	Murphy, 1996
1994-1996	DBG Area	Evaluation of sedimentary facies and relation to hydrogeologic properties in Mansfield Formation	Fisher, 1996
1987-1993	DBG Area	RCRA Phase III ground water release characterization	Murphy and Wade, 1998
1992-1996	ABG and LSC Watershed	RCRA Phase II surface water release assessment	Murphy and Wade, 1998
1993-1996	ABG	RCRA Phase III Part 2 soils study	Albertson, et al., 1998
1993-1998	ABG and LSC Watershed	Ground water geochemical investigation and dye tracer study	Baedke, 1998
1995-1999	ABG and LSC Watershed	Screening-level human health and environmental risk assessment was performed based on existing data	TtNUS, 1999
1998-2002	ABG and LSC Watershed	Ground water, spring, and surface water monitoring, soils investigations, and phytoremediation studies related to natural attenuation of contaminants	May, et al., 2002
1993-2001	ABG and LSC Watershed	Geophysical investigation of ABG, dye tracer investigation, and investigation of contaminants in Spring A	Krothe, 2002
2002	OJT and Spring C	Dye tracer study of OJT and Spring C	Jock and Krothe, 2002
2001-2002	ABG/OJT/LSC (Primarily OJT/LSC) Area	RCRA RFI	TtNUS, 2003
1998-2004	ABG and LSC Watershed	RCRA quarterly surface water and ground water monitoring program	Quarterly reports

TABLE 1-2

KEY OPERATIONS AND POTENTIAL SOURCE AREAS AT THE AMMUNITION BURNING GROUNDS
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Sampling Area Shown on Figure 3-1	Key ABG Operation Area Considered to be Potential Source Area	Other Reason(s) to Sample Area	Number of New Soil Borings Planned for Area
A	Storage Area	TCE was detected in well 03C01P2 above 50 µg/L in 1989	1
B	None	Encompasses area where two previous soil borings (03/10-17 and 03/10-61) indicated elevated RDX and TCE concentrations	12
C	Former flash pits	TCE was detected in well 03C10 above 50 µg/L in 2000	3
D	Former flash pits, burning pad, and UST	Elevated TCE and RDX concentrations detected in well 03C09P2	7
E	Dewatering units	TCE frequently detected above 5 µg/L in wells 03C07 and 03C26	3
F	Former flash pits, two burning pads, and UST	Area where highest ground water concentrations of RDX and TCE are typically found	10
G	Former ash pile	RDX and TCE ground water concentrations commonly above 50 µg/L in well 03C08P2, located south of the former ash pile	3
H	None	Elevated RDX concentrations detected previously in soil borings 03/10-35 and 03/10-69	9
I	Former flash pits	TCE was detected above 50 µg/L in well 03C04	4
J	Storage area and current solvent burn pan		1

TABLE 1-3

SPECIFIC FIXED-BASED LABORATORY ANALYTICAL METHODOLOGIES AND CORRESPONDING TARGET ANALYTE LISTS[1]
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Parameter	CAS No.	Aqueous Matrix				Solid Matrix				
		Units	Lab RL	Lab TV	Risk-Based Target Level	Units	Lab RL	Lab TV	Risk-Based Soil Target Level	Risk-Based Sediment Target Level
EXPLOSIVES (SW-846 8330)										
1,3,5-Trinitrobenzene	99-35-4	µg/L	0.5	0.25	1100	mg/kg	0.5	0.25	0.25	0.000121
1,3-Dinitrobenzene	99-65-0	µg/L	0.5	0.25	2.36	mg/kg	0.5	0.25	0.00096	0.000924
2,4,6-Trinitrotoluene	118-96-7	µg/L	0.5	0.25	2.2	mg/kg	0.5	0.25	0.00057	NA
2,4-Dinitrotoluene	121-14-2	µg/L	0.5	0.25	73	mg/kg	0.5	0.25	0.000049	0.07513
2,6-Dinitrotoluene	606-20-2	µg/L	0.5	0.25	36	mg/kg	0.5	0.25	0.000042	0.02062
2-Amino-4,6-dinitrotoluene	35572-78-2	µg/L	0.5	0.25	NA	mg/kg	0.5	0.25	NA	NA
2-Nitrotoluene	88-72-2	µg/L	0.5	0.25	61	mg/kg	0.5	0.25	0.15	NA
3-Nitrotoluene	99-08-1	µg/L	0.5	0.25	61	mg/kg	0.5	0.25	0.3	NA
4-Amino-2,6-dinitrotoluene	19406-51-0	µg/L	0.5	0.25	NA	mg/kg	0.5	0.25	NA	NA
4-Nitrotoluene	99-99-0	µg/L	0.5	0.25	61	mg/kg	0.5	0.25	0.15	NA
HMX	2691-41-0	µg/L	0.5	0.25	1800	mg/kg	0.5	0.25	3100	NA
Nitrobenzene	98-95-3	µg/L	0.5	0.25	3.4	mg/kg	0.5	0.25	0.006	0.4876
RDX	121-82-4	µg/L	0.5	0.25	0.61	mg/kg	0.5	0.25	4.4	NA
Tetryl	479-45-8	µg/L	0.5	0.25	360	mg/kg	0.5	0.25	610	NA
RDX DEGRADATION PRODUCTS (SW-846 8330)										
2,4-DA-6-NT	6629-29-4	µg/L	0.5	0.25	NA	mg/kg	0.5	0.25	4700	4700
2,6-DA-4-NT	59229-75-3	µg/L	0.5	0.25	NA	mg/kg	0.5	0.25	4700	4700
3,5-DNA	618-87-1	µg/L	0.5	0.25	NA	mg/kg	0.5	0.25	NA	NA
DNX	NA	µg/L	NA	0.25	NA	mg/kg	0.5	0.25	NA	NA
MNX	NA	µg/L	0.5	0.25	NA	mg/kg	0.5	0.25	NA	NA
TNX	NA	µg/L	0.5	0.25	NA	mg/kg	0.5	0.25	NA	NA
4,4-'TN-AZOXY	NA	µg/L	1.0	0.5	NA	mg/kg	1	0.5	NA	NA

TABLE 1-3

SPECIFIC FIXED-BASED LABORATORY ANALYTICAL METHODOLOGIES AND CORRESPONDING TARGET ANALYTE LISTS[1]
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Parameter	CAS No.	Aqueous Matrix				Solid Matrix				
		Units	Lab RL	Lab TV	Risk-Based Target Level	Units	Lab RL	Lab TV	Risk-Based Soil Target Level	Risk-Based Sediment Target Level
METALS (SW-846 6010B)										
Aluminum	7429-90-5	µg/L	50	8.35	50	mg/kg	25	7.19	76000	NA
Antimony	7440-36-0	µg/L	1	0.085	6	mg/kg	0.5	0.025	0.27	0.1423
Arsenic	7440-38-2	µg/L	1	0.047	0.045	mg/kg	0.5	0.022	0.29	5.7
Barium	7440-39-3	µg/L	1	0.167	2000	mg/kg	0.5	0.16	82	1.04
Beryllium	7440-41-7	µg/L	1	0.015	4	mg/kg	0.5	0.02	32	1.06
Cadmium	7440-43-9	µg/L	1	0.039	0.66	mg/kg	0.5	0.04	0.38	0.00222
Calcium	7440-70-2	µg/L	100	18.4	NA	mg/kg	50	7.8	NA	NA
Chromium	7440-47-3	µg/L	1	0.073	42	mg/kg	0.5	0.01	2	0.4
Cobalt	7440-48-4	µg/L	1	0.088	5	mg/kg	0.5	0.01	900	0.14033
Copper	7440-50-8	µg/L	2	0.074	5	mg/kg	1	0.03	560	2.96
Iron	7439-89-6	µg/L	50	6.15	300	mg/kg	25	4.57	23000	NA
Lead	7439-92-1	µg/L	1	0.069	1.3	mg/kg	0.5	0.01	81	0.05373
Magnesium	7439-95-4	µg/L	100	13.13	NA	mg/kg	50	1.9	NA	NA
Manganese	7439-96-5	µg/L	5	0.752	50	mg/kg	2.5	0.22	110	NA
Mercury	7439-97-6	µg/L	0.2	0.01	0.0013	mg/kg	0.1	0.002	0.1	0.073
Nickel	7440-02-0	µg/L	1	0.1	29	mg/kg	0.5	0.01	48	13.6
Potassium	7440-09-7	µg/L	100	5.55	NA	mg/kg	50	1.67	NA	NA
Selenium	7782-49-2	µg/L	1	0.094	5	mg/kg	0.5	0.03	0.26	0.02765
Silver	7440-22-4	µg/L	1	0.028	1	mg/kg	0.5	0.05	1.6	0.5
Sodium	7440-23-5	µg/L	100	6.79	NA	mg/kg	50	3.69	NA	NA
Thallium	7440-28-0	µg/L	1	0.043	0.56	mg/kg	0.5	0.01	0.04	0.05692
Tin	7440-31-5	µg/L	10	0.048	73	mg/kg	5	0.11	47000	7.62
Titanium	7440-32-6	µg/L	5	1.14	NA	mg/kg	2.5	0.099	NA	NA
Vanadium	7440-62-2	µg/L	2	1.14	19	mg/kg	1	0.01	260	1.59
Zinc	7440-66-6	µg/L	10	0.714	58.9	mg/kg	5	1.2	680	6.62

TABLE 1-3

SPECIFIC FIXED-BASED LABORATORY ANALYTICAL METHODOLOGIES AND CORRESPONDING TARGET ANALYTE LISTS[1]
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Parameter	CAS No.	Aqueous Matrix				Solid Matrix				
		Units	Lab RL	Lab TV	Risk-Based Target Level	Units	Lab RL	Lab TV	Risk-Based Soil Target Level	Risk-Based Sediment Target Level
MISCELLANEOUS PARAMETERS (EPA Method 314.0)										
Cation Exchange Capacity		NA	NA	NA	NA	meq/100gm	1	1	NA	NA
TOC		mg/L	0.5	1	NA	mg/kg	0.1	0.2	NA	NA
pH		NA	NA	NA	NA	Std. Units	1	NA	NA	NA
Perchlorate	14797-73-0	µg/L	4	2	NA	mg/kg	0.08	0.04	NA	NA
PERCHLORATE (SW-846 8321A)										
Perchlorate	14797-73-0	µg/L	0.5	0.5	NA	ug/kg	1	1	NA	NA
VOLATILES (SW-846 8260B)[2]										
1,1,1,2-Tetrachloroethane	630-20-6	µg/L	1	0.3	0.43	µg/kg	3	1	7.1	10.89
1,1,1-Trichloroethane	71-55-6	µg/L	1	0.3	88	µg/kg	3	1	97	246.85
1,1,2,2-Tetrachloroethane	79-34-5	µg/L	1	0.3	0.055	µg/kg	3	1	0.17	29.08
1,1,2-Trichloroethane	79-00-5	µg/L	1	0.3	0.2	µg/kg	3	1	0.91	673.51
1,1-Dichloroethane	75-34-3	µg/L	1	0.3	47	µg/kg	3	1	1000	0.575
1,1-Dichloroethene	75-35-4	µg/L	1	0.3	7	µg/kg	3	1	2.9	23.27
1,2,3-Trichloropropane	96-18-4	µg/L	1	0.3	0.0056	µg/kg	3	1	0.0037	8.35
1,2-Dibromo-3-chloropropane	96-12-8	µg/L	1	0.3	0.048	µg/kg	3	1	0.092	19.98
1,2-Dibromoethane	106-93-4	µg/L	1	0.3	0.00076	µg/kg	3	1	0.029	12.37
1,2-Dichloroethane	107-06-2	µg/L	1	0.3	0.12	µg/kg	3	1	1.2	54.18
1,2-Dichloropropane	78-87-5	µg/L	1	0.3	0.16	µg/kg	3	1	1.5	351.61
2-Butanone	78-93-3	µg/L	5	0.5	1900	µg/kg	10	1	4400	136.96
2-Hexanone	591-78-6	µg/L	5	0.5	1710	µg/kg	10	1	NA	1010
3-Chloro-1-propene	107-05-1	µg/L	5	0.5	1800	µg/kg	10	1	1800	0.266
4-Methyl-2-pentanone	108-10-1	µg/L	5	0.5	160	µg/kg	10	1	620	544.37
Acetone	67-64-1	µg/L	5	0.5	610	µg/kg	10	1	730	453.37
Acrolein	107-02-8	µg/L	5	0.5	0.042	µg/kg	10	1	0.23	0.0144
Acrylonitrile	107-13-1	µg/L	5	0.5	0.039	µg/kg	10	1	0.032	0.0157
Benzene	71-43-2	µg/L	1	0.3	0.34	µg/kg	3	1	1.7	141.57
Bromodichloromethane	75-27-4	µg/L	1	0.3	0.18	µg/kg	3	1	32	1.13

TABLE 1-3

SPECIFIC FIXED-BASED LABORATORY ANALYTICAL METHODOLOGIES AND CORRESPONDING TARGET ANALYTE LISTS[1]
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Parameter	CAS No.	Aqueous Matrix				Solid Matrix				
		Units	Lab RL	Lab TV	Risk-Based Target Level	Units	Lab RL	Lab TV	Risk-Based Soil Target Level	Risk-Based Sediment Target Level
VOLATILES (SW-846 8260B)[2] (Continued)										
Bromoform	75-25-2	µg/L	1	0.3	8.5	µg/kg	3	1	38	996.27
Bromomethane	74-83-9	µg/L	1	0.3	8.7	µg/kg	3	1	12	235.16
Carbon disulfide	75-15-0	µg/L	1	0.3	84.1	µg/kg	3	1	1500	94.12
Carbon tetrachloride	56-23-5	µg/L	1	0.3	0.17	µg/kg	3	1	3.3	35.73
Chlorobenzene	108-90-7	µg/L	1	0.3	10	µg/kg	3	1	65	61.94
Chloroethane	75-00-3	µg/L	1	0.5	4.6	µg/kg	3	1	330	58600
Chloroform	67-66-3	µg/L	1	0.3	6.2	µg/kg	3	1	29	27
Chloromethane	74-87-3	µg/L	1	0.3	1.5	µg/kg	3	1	2	0.0785
Chloroprene	126-99-8	µg/L	5	0.5	14	µg/kg	10	1	560	1.06
cis-1,2-Dichloroethene	156-59-2	µg/L	1	0.3	61	µg/kg	3	1	20	208.94
cis-1,3-Dichloropropene	10061-01-5	µg/L	1	0.3	0.4	µg/kg	3	1	0.3	2.96
Dibromochloromethane	124-48-1	µg/L	1	0.3	0.13	µg/kg	3	1	20	267.61
Dibromomethane	74-95-3	µg/L	1	0.3	61	µg/kg	3	1	77	0.0859
Dichlorodifluoromethane	75-71-8	µg/L	1	0.3	390	µg/kg	3	1	28000	1.33
Ethyl methacrylate	97-63-2	µg/L	5	0.5	550	µg/kg	10	1	810	0.602
Ethylbenzene	100-41-4	µg/L	1	0.3	2.9	µg/kg	3	1	670	0.1
Iodomethane	74-88-4	µg/L	5	0.5	NA	µg/kg	10	1	NA	0.305
Methacrylonitrile	126-98-7	µg/L	5	0.3	1	µg/kg	10	1	1	0.0297
Methyl methacrylate	80-62-6	µg/L	5	0.5	1400	µg/kg	10	1	12000	167.56
Methylene chloride	75-09-2	µg/L	1	0.3	4.3	µg/kg	3	1	1.2	1260
Styrene	100-42-5	µg/L	1	0.3	56	µg/kg	3	1	180	444.96
Tetrachloroethene	127-18-4	µg/L	1	0.3	0.66	µg/kg	3	1	2.9	195.83
Toluene	108-88-3	µg/L	1	0.3	253	µg/kg	3	1	590	5450
trans-1,2-Dichloroethene	156-60-5	µg/L	1	0.3	100	µg/kg	3	1	34	208.94
trans-1,3-Dichloropropene	10061-02-6	µg/L	1	0.3	0.4	µg/kg	3	1	0.3	2.96
trans-1,4-Dichloro-2-butene	110-57-6	µg/L	5	0.5	NA	µg/kg	10	1	NA	1.82
Trichloroethene	79-01-6	µg/L	1	0.3	0.028	µg/kg	3	1	2.8	179.56

TABLE 1-3

SPECIFIC FIXED-BASED LABORATORY ANALYTICAL METHODOLOGIES AND CORRESPONDING TARGET ANALYTE LISTS[1]
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Parameter	CAS No.	Aqueous Matrix				Solid Matrix				
		Units	Lab RL	Lab TV	Risk-Based Target Level	Units	Lab RL	Lab TV	Risk-Based Soil Target Level	Risk-Based Sediment Target Level
VOLATILES (SW-846 8260B)[2] (Continued)										
Trichlorofluoromethane	75-69-4	µg/L	1	0.3	1300	µg/kg	3	1	8000	3.07
Vinyl acetate	108-05-4	µg/L	5	0.5	248.03	µg/kg	10	1	2300	12.95
Vinyl chloride	75-01-4	µg/L	1	0.3	0.02	µg/kg	3	1	0.67	2
Xylenes, Total	1330-20-7	µg/L	1	0.3	117	µg/kg	3	1	71000	1880

1 - Risk-based target levels for solid and aqueous matrices are the lowest of the criteria presented in Appendix B, Tables B-1 (aqueous) and B-2 (solids) (TtNUS, 2001). All results will be reported to the TVs. Results between the TV and the RL will be J-flagged.
2 - The compounds (propionitrile, 1,4-dioxane, acetonitrile, and isobutyl alcohol) usually analyzed by SW-846 Method 8015 have been removed.
Shaded values exceed at least one of the associated risk-based target levels. See Table 4-1 for sample preparation methods.
CAS No. = Chemical abstracts registry service number.
NA = Not applicable.
RL = Reporting limit.
TV = Threshold Value (realistic estimate of method detection limit after accounting for matrix variability).

TABLE 1-4

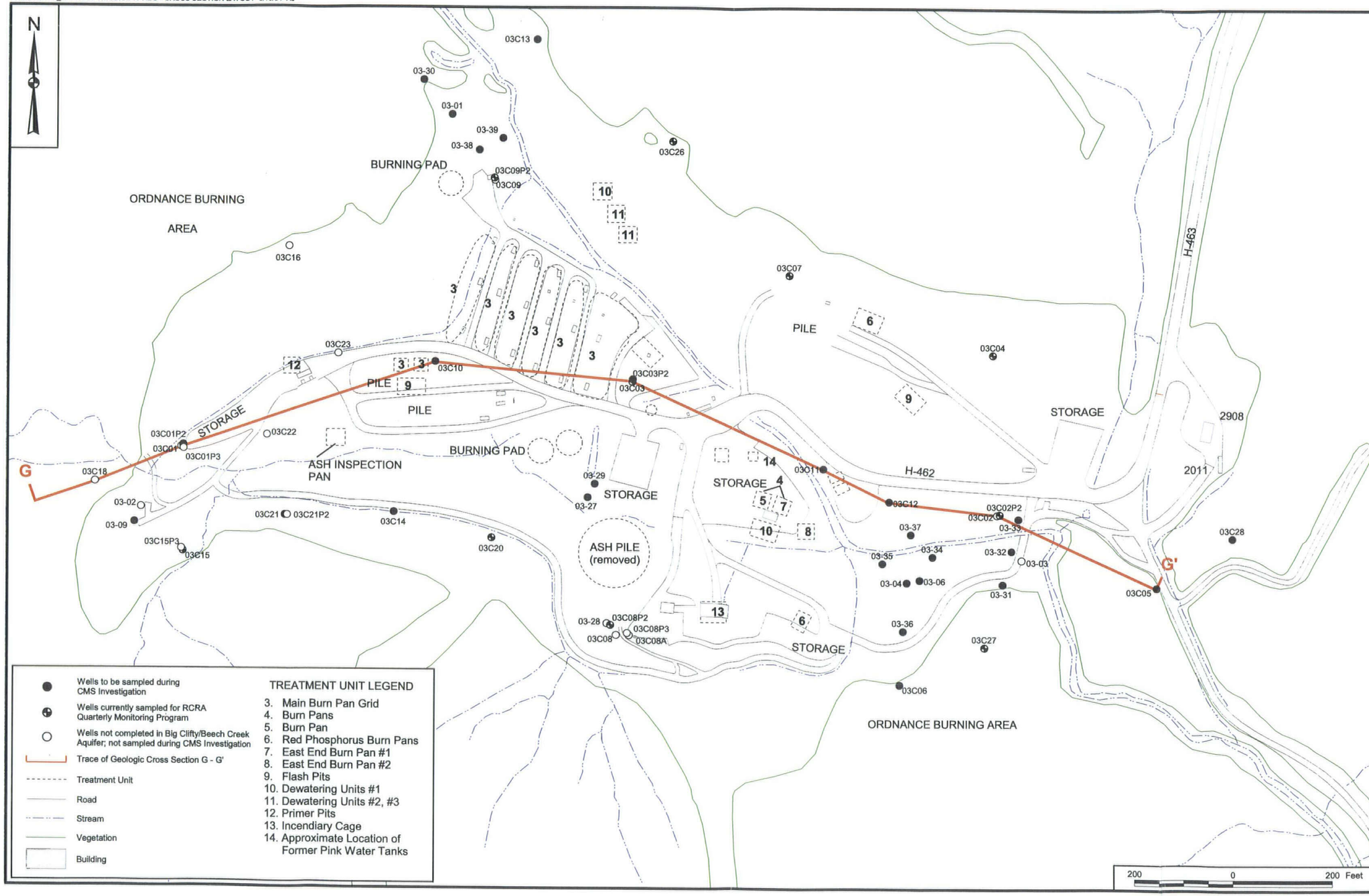
MONITORING WELLS AND SPRINGS TO BE SAMPLED DURING THE CMS
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Well No.	RCRA Quarterly Monitoring, Rounds 1 through 8			RCRA Quarterly Monitoring, Rounds 9 through 30			RCRA Annual Monitoring,	Water Level Measured in June 2002 Survey	Proposed for Sampling During CMS
	VOCs [1]	Expl. [1]	Others [2]	VOCs [1]	Expl. [1]	Others [2]	VOCs [1]		
Ammunition Burning Grounds									
03-01	-	-	-	-	-	-	-	x	x
03-04	-	-	-	-	-	-	-	-	x
03-06	-	-	-	-	-	-	-	-	x
03-09	-	-	-	-	-	-	-	x	x
03-27	-	-	-	-	-	-	-	-	x
03-29	-	-	-	-	-	-	-	-	x
03-30	-	-	-	-	-	-	-	x	x
03-32	-	-	-	-	-	-	-	-	x
03-33	-	-	-	-	-	-	-	x	x
03-34	-	-	-	-	-	-	-	-	x
03-35	-	-	-	-	-	-	-	-	x
03-36	-	-	-	-	-	-	-	-	x
03-37	-	-	-	-	-	-	-	-	x
03-38	-	-	-	-	-	-	-	x	x
03-39	-	-	-	-	-	-	-	x	x
03C01P2	-	-	-	-	-	-	-	x	x
03C02P2	B	A	Y	B	A	Y	A	x	-
03C03P2	-	-	-	-	-	-	-	x	x
03C04	B,C	A,B	Y	B	A	Y	A	x	-
03C05	-	-	-	-	-	-	-	x	x
03C06	-	-	-	-	-	-	-	x	x
03C07	B	A	Y	B	A	Y	A	x	-
03C08P2	B	A	Y	B	A	Y	A	x	-
03C09P2	B	A	Y	B	A	Y	A	x	-
03C10	B,C	A,B	Y	-	-	-	-	x	x
03C11	B,C	A,B	Y	-	-	-	-	x	x
03C12	B,C	A,B	Y	-	-	-	-	x	x
03C13	-	-	-	-	-	-	-	x	x
03C14	-	-	-	-	-	-	-	x	x
03C15	B	A	Y	B	A	Y	A	x	-
03C20	B	A	Y	B	A	Y	A	x	-
03C21	-	-	-	-	-	-	-	x	x
03C26	B	A	Y	B	A	Y	A	x	-
03C27	B	A	Y	B	A	Y	A	x	-
03C28	-	-	-	-	-	-	-	x	x
Old Jeep Trail									
03-07	-	-	-	-	-	-	-	x	x
03-12	-	-	-	-	-	-	-	x	x
03-15	-	-	-	-	-	-	-	x	x
03-16	-	-	-	-	-	-	-	x	x
03-21	-	-	-	-	-	-	-	x	x
03-24	-	-	-	-	-	-	-	x	x
Springs									
Spring A	B,C	A,B	Y	B	A	Y	A	-	-
Spring A'	-	-	-	-	-	-	-	-	x
Spring C	B,C	A,B	Y	B	A	Y	A	-	-

1 The letters A, B, and C indicate subsets of the parameter group as listed in the Field Sampling Plan (TtNUS, September 1999, Appendix D)

2 Y indicates that total organic halides, total organic carbon, sulfate, chloride, phosphorus, and other analytes are analyzed quarterly

P:\GIS\NSWC_CRANE\APR\7651.APR ABG - CROSS SECTION LAYOUT 3/19/04 AJ



Wells to be sampled during CMS Investigation

Wells currently sampled for RCRA Quarterly Monitoring Program

Wells not completed in Big Clifty/Beech Creek Aquifer; not sampled during CMS Investigation

Trace of Geologic Cross Section G - G'

Treatment Unit

Road

Stream

Vegetation

Building

TREATMENT UNIT LEGEND

3. Main Burn Pan Grid
4. Burn Pans
5. Burn Pan
6. Red Phosphorus Burn Pans
7. East End Burn Pan #1
8. East End Burn Pan #2
9. Flash Pits
10. Dewatering Units #1
11. Dewatering Units #2, #3
12. Primer Pits
13. Incendiary Cage
14. Approximate Location of Former Pink Water Tanks

CONTRACT NO. N8383

APPROVED BY — DATE

APPROVED BY — DATE

DRAWING NO. FIGURE 1 - 1

REV 0

PHYSICAL FEATURES OF
AMMUNITION BURNING GROUNDS
SWMU 03 - AMMUNITION BURNING GROUNDS, OLD JEEP TRAIL,
AND LITTLE SULPHUR CREEK
QAPP ADDENDUM NO. 1
NSWC CRANE
CRANE, INDIANA

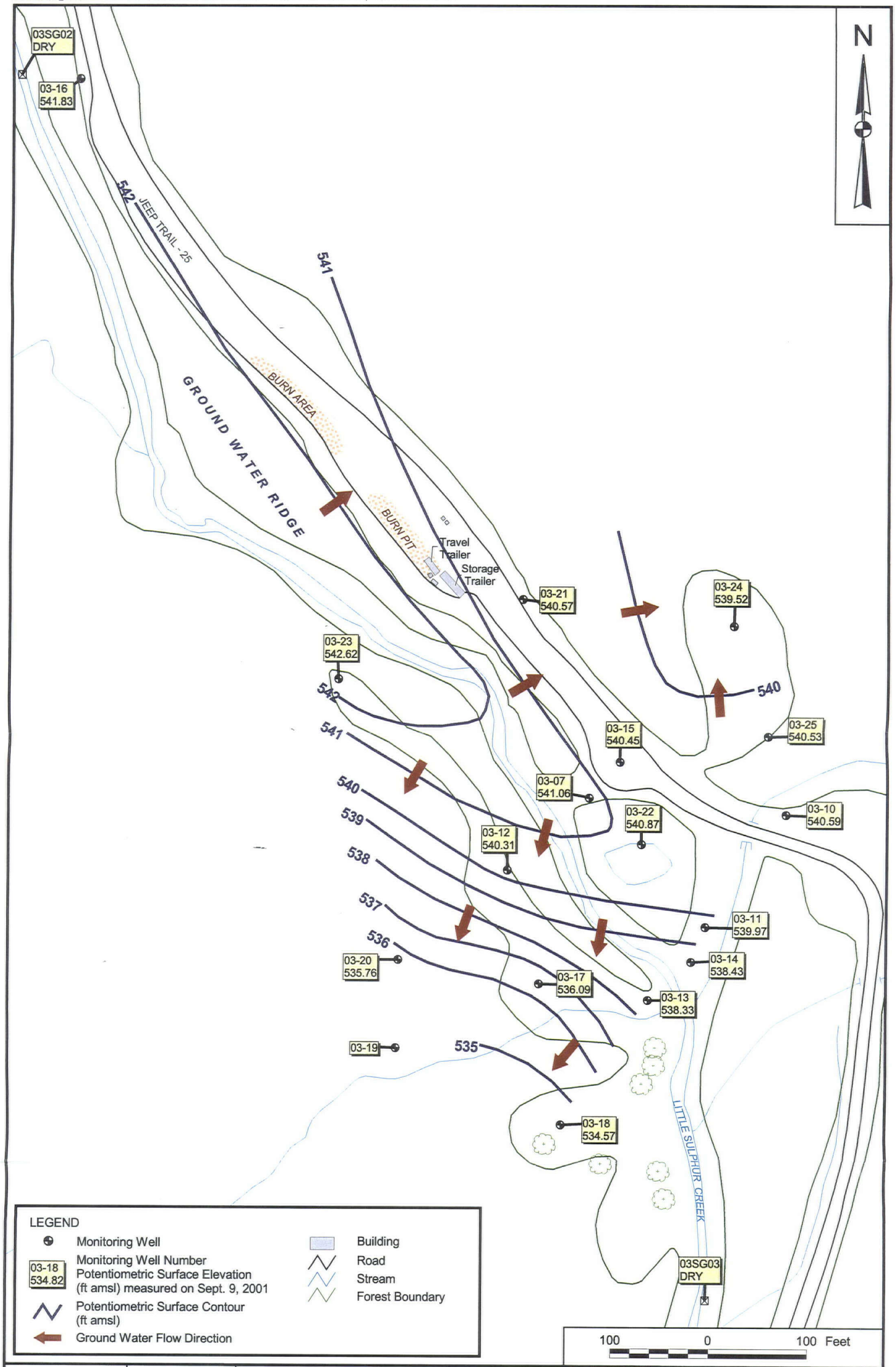
DRAWN BY A. JANOCHA — DATE 3/03/04

CHECKED BY J. GOERDT — DATE 3/19/04

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\NSWC_CRANE\JEEPTRAILSITE.APR JTS QAPP POTENTIOMETRIC CONTOURS - SEPTEMBER 9, 2001 LAYOUT 3/08/04 AJ

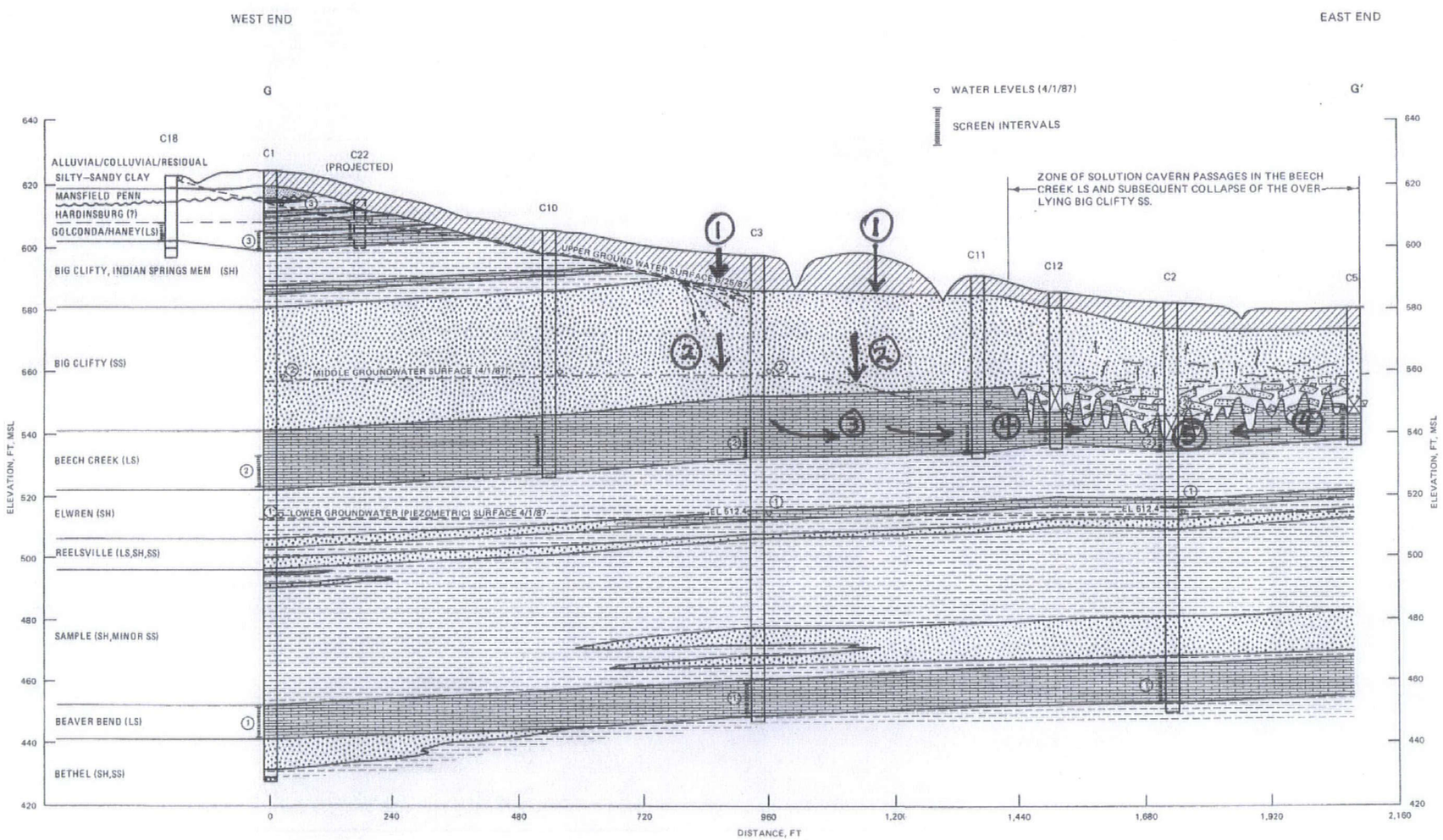


DRAWN BY	DATE
J. LAMEY	10/19/01
CHECKED BY	DATE
J. SCHUBERT	3/08/04
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

LOCAL SHALLOW GROUND WATER POTENTIOMETRIC SURFACE MAP
FOR OLD JEEP TRAIL AREA ON SEPTEMBER 9, 2001
SWMU 03 - AMMUNITION BURNING GROUNDS, OLD JEEP TRAIL,
AND LITTLE SULPHUR CREEK
QAPP ADDENDUM NO. 1
NSWC CRANE
CRANE, INDIANA

CONTRACT NUMBER	
N8383	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 1 - 2	0

P:/GIS/NSWC_CRANE/APR/7651.APR ABG - CONCEPTUAL FLOW AND CONTAMINANT TRANSPORT LAYOUT 3/19/04 AJ



NOTE: This figure in modified from Geologic Section G - G' developed previously by the USACE (Hunt, 1988, Vol. II, Plate 9).

LEGEND

- UNDIFFERENTIATED
- CLAY SYMBOL
- SHALE AND SANDSTONE
- SANDSTONE
- SHALE
- LIMESTONE

Zones

1. Infiltration and vertical flow through overburden soils
2. Vertical flow downward through unsaturated Big Clifty Sandstone
3. Lateral flow through fractured Beech Creek Limestone
4. Rapid flow and dilution in rubble and karstic Beech Creek Limestone
5. Flow into main karst conduit

CONTRACT NO. N8383

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 1 - 3

REV 0

GEOLOGIC CROSS SECTION AND CONCEPTUAL FLOW DIAGRAM, AMMUNITION BURNING GROUNDS
SWMU 03 - AMMUNITION BURNING GROUNDS, OLD JEEP TRAIL, AND LITTLE SULPHUR CREEK
QAPP ADDENDUM NO. 1
NSWC CRANE
CRANE, INDIANA

DEPARTMENT OF THE NAVY * EFD03 SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

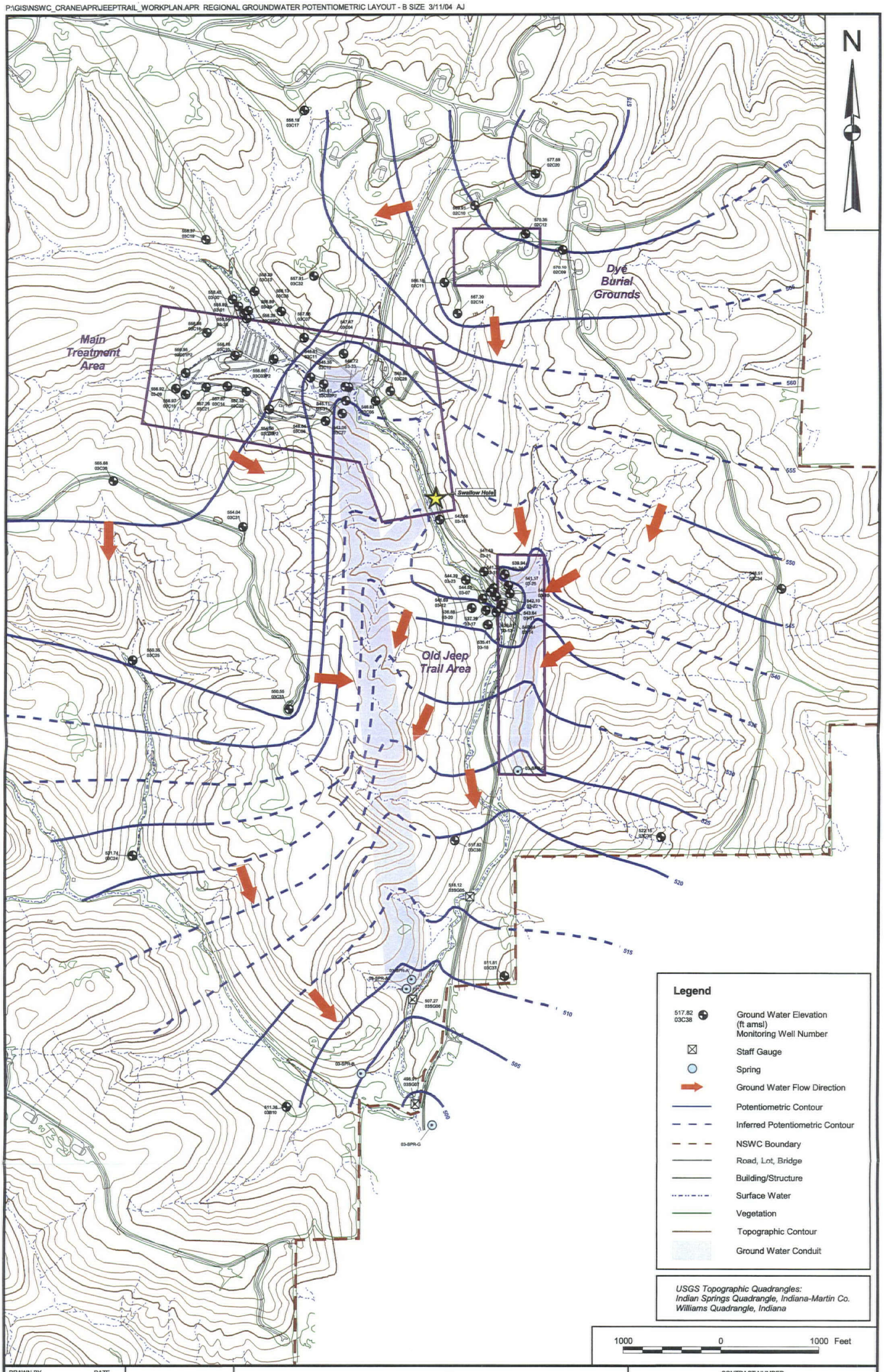
DRAWN BY A. JANOCHA DATE 3/03/04

CHECKED BY J. GOERDT DATE 3/19/04

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\NSWC_CRANE\APR\JEEPTRAIL_WORKPLAN.APR REGIONAL GROUNDWATER POTENTIOMETRIC LAYOUT - B SIZE 3/11/04 AJ



DRAWN BY	DATE
A. JANOCHA	3/11/04
CHECKED BY	DATE
J. GOERDT	3/12/04
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

REGIONAL GROUND WATER POTENTIOMETRIC MAP
FOR THE BIG CLIFTY - BEECH CREEK AQUIFER, JUNE 2002
SWMU 03 - AMMUNITION BURNING GROUNDS, OLD JEEP TRAIL,
AND LITTLE SULPHUR CREEK
QAPP ADDENDUM NO. 1
NSWC CRANE
CRANE, INDIANA

CONTRACT NUMBER	
N8383	
APPROVED BY	DATE
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APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 1 - 4	0

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

This section presents the project management and organization for conducting field operations. Staffing and coordination requirements are described in Section 2.0 of the approved Contract Task Order (CTO) 0126 QAPP (TtNUS, 2001). Table 2-1 and Figure 2-1 include the most current contact information for the involved parties.

Laucks Testing Laboratories, Inc. of Seattle, Washington will perform all fixed-base sample analyses for this field activity.

The subcontracted laboratories are responsible for analyzing all samples in accordance with the analytical methods and additional requirements specified in the other sections of this QAPP Addendum No. 1. It also will be the analytical laboratory's responsibility to properly dispose of unused sample aliquots. Responsibilities of key laboratory personnel are outlined in Section 2.2.5 of the approved CTO 0126 QAPP (TtNUS, 2001). All other personnel and training requirements identified in the approved CTO 0126 QAPP also apply to this investigation.

TABLE 2-1

KEY PROJECT PERSONNEL
NAMES, PHONE NUMBERS, AND ADDRESSES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

PERSON / TITLE / ORGANIZATION	ADDRESS	TELEPHONE
Peter Ramanauskas Project Manager U.S. EPA Region 5	U.S. EPA Region 5 77 West Jackson Blvd. Chicago, Illinois 60604	(312) 886-7890 FAX: (312) 353-4788
Allen Debus QA Coordinator U.S. EPA Region 5	U.S. EPA Region 5 77 West Jackson Blvd. Chicago, Illinois 60604	(312) 886-6186
Marty Harmless Office of Solid and Hazardous Waste Management IDEM	Office of Solid and Hazardous Waste Management 100 N. Senate Avenue Indianapolis, Indiana 46206-6015	(317) 234-0597
Doug Griffin Corrective Action Section Office of Land Quality Hazardous Waste Permits IDEM	Corrective Action Section Office of Land Quality Hazardous Waste Permits 100 N. Senate Avenue P. O. Box 6015 Indianapolis, Indiana 46206-6015	(317) 233-2710
Bill Gates Remedial Project Manager U.S. Navy NAVFAC EFD SOUTH	Department of Navy NAVFAC EFD SOUTH Code 1864 2155 Eagle Drive Charleston, South Carolina 29406	(843) 820-7360 FAX: (843) 820-7465
Tom Brent Environmental Site Manager NSWC Crane	NSWC Crane Code RP3-TB Building 3245 300 Highway 361 Crane, Indiana 47522-5009	(812) 854-6160 FAX: (812) 854-3981
Debbie Wroblewski Program Manager Tetra Tech NUS	Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, Pennsylvania 15220-2745	(412) 921-8968 FAX: (412) 921-4040
Paul Frank Quality Assurance Manager Tetra Tech NUS	Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, Pennsylvania 15220-2745	(412) 921-8950 FAX: (412) 921-4040
Matt Soltis Health and Safety Manager Tetra Tech NUS	Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, Pennsylvania 15220-2745	(412) 921-8912 FAX: (412) 921-4040
Ralph Basinski Task Order Manager Tetra Tech NUS	Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, Pennsylvania 15220-2745	(412) 921-8308 FAX: (412) 921-4040

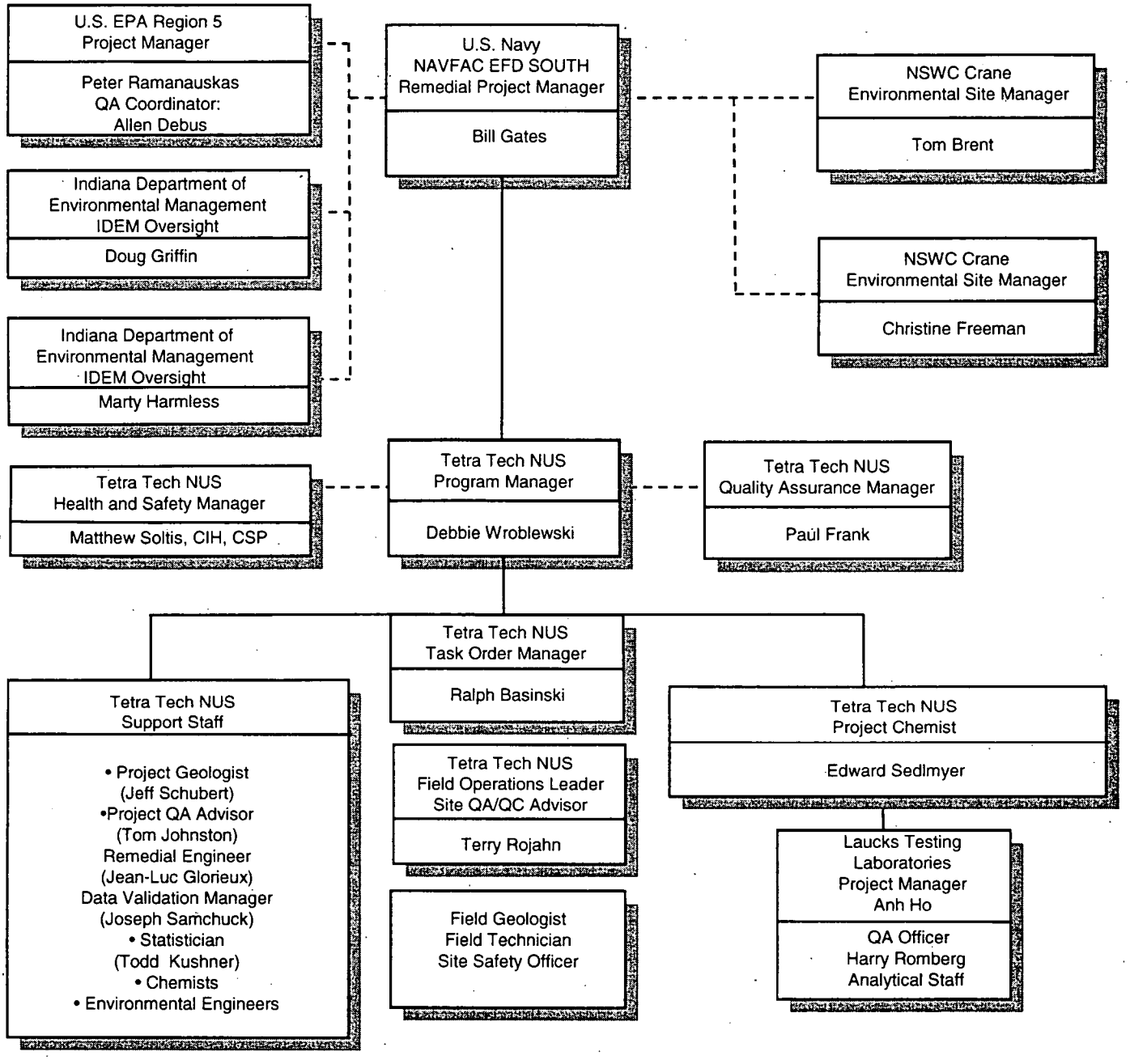
TABLE 2-1

KEY PROJECT PERSONNEL
NAMES, PHONE NUMBERS, AND ADDRESSES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA
PAGE 2 OF 2

PERSON / TITLE / ORGANIZATION	ADDRESS	TELEPHONE
Terry Rojahn Field Operations Leader Tetra Tech NUS	Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, Pennsylvania 15220-2745	(412) 921-8857 FAX: (412) 921-4040
Joseph Samchuck Data Validation Manager Tetra Tech NUS	Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, Pennsylvania 15220-2745	(412) 921-8510 FAX: (412) 921-4040
Jeff Schubert Project Geologist Tetra Tech NUS	Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, Pennsylvania 15220-2745	(412) 921-8794 FAX: (412) 921-4040
Ed Sedlmyer Project Chemist Tetra Tech NUS	Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, Pennsylvania 15220-2745	(412) 921-7273 FAX: (412) 921-4040
Tom Johnston Quality Assurance Advisor Tetra Tech NUS	Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, Pennsylvania 15220-2745	(412) 921-8615 FAX: (412) 921-4040
Todd Kushner Statistician Tetra Tech NUS	Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, Pennsylvania 15220-2745	(412) 921-8539 Fax: (412) 921-4040
Anh Ho Project Manager Laucks Testing	Laucks Testing Laboratories, Inc. 940 South Harney Street Seattle, Washington 98108	(206) 957-2433 FAX: (206)767-5063
Harry Romberg Lab QA Manager Laucks Testing	Laucks Testing Laboratories, Inc. 940 South Harney Street Seattle, Washington 98108	(206) 767-5060 FAX: (206)767-5063

FIGURE 2-1

PROJECT ORGANIZATION CHART
SWMU 03 – ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA



3.0 SAMPLING AND ANALYSIS PLAN

3.1 GENERAL APPROACH

This section describes sampling locations and rationales for sampling activities and the equipment and procedures to be used for collecting, handling, preserving, and shipping samples to Laucks Testing Laboratories, Inc. The text references field SOPs (included in Appendix A) and the revised OJT Health and Safety Plan (HASP) (TtNUS, 2004), when applicable.

Prior to sampling, the Task Order Manager (TOM) will ensure that all field personnel read and understand QAPP Addendum No. 1 and the revised OJT HASP (TtNUS, 2004), the Field Operations Leader (FOL) will ensure that all required field equipment for non-health-and-safety-related operations is available and operational, and the Site Safety Officer (SSO) will ensure that all health-and-safety-related equipment is available and operational.

Investigations at the following areas are described in this Sampling and Analysis Plan (SAP):

- ABG MTA
- OJT
- LSC

To better delineate the nature and extent of contamination in specific areas of the ABG and OJT, Direct Push Technology (DPT) (e.g., Geoprobe®) will be used to collect 73 soil cores down to the bedrock surface or refusal, whichever occurs first in each boring. An average of four soil samples is expected to be collected from each boring for analysis. If perched ground water is encountered near the bottom of any DPT boring and sufficient flow into the boring is evident, a perched ground water sample will be collected for laboratory analysis. Up to six of these perched ground water samples will be collected.

Up to 26 monitoring wells at the ABG MTA and 6 wells at the OJT area will be redeveloped, if necessary, and sampled. It is not certain whether some of the wells scheduled for sampling at the ABG MTA still exist or can be sampled. Therefore, the total number of wells that will be sampled may be less than 26.

Springs A and C and LSC are sampled frequently for the RCRA Quarterly Monitoring Program, but Spring A' is not. Therefore, Spring A' will be sampled during this CMS.

3.2 SAMPLE IDENTIFICATION SYSTEM

All samples will be properly labeled with an adhesive-backed sample label affixed and a tag tied to each sample container in accordance with SOP CTO126-01. Each sample will be assigned a unique sample tracking number as described in SOP CTO126-02. Sample custody and documentation will follow the procedures described in SOP CTO126-03.

3.3 FIELD MEASUREMENTS

Field measurements (Table 3-1) will be made at various times during the field work. All of these measurements will be recorded on boring log sheets and/or sample collection log sheets in accordance with the applicable SOPs or HASP.

3.4 AVOIDANCE OF UNEXPLODED ORDNANCE

Unexploded ordnance (UXO) has not been encountered during any of the intrusive activities conducted as part of previous environmental investigations at the ABG. Nevertheless, the potential still exists for encountering UXO. Therefore, borings located in the ABG area will be screened for the presence of UXO during installation (See Section 3.6.1).

3.5 SAMPLING LOCATIONS, ANALYSES, AND RATIONALES

This section presents sampling locations, quality assurance (QA)/quality control (QC) samples to be collected, analyses to be performed, and rationales for the sampling and analytical program. Details regarding the preservation, packaging, and shipping of samples are included in Section 3.8. Sampling locations are shown on Figures 3-1 through 3-3.

Regular field samples and QA/QC samples will be collected and analyzed in the quantities shown in Tables 3-2 through 3-4. Duplicate samples collected to satisfy QC requirements will be preferentially collected from those soil borings and monitoring wells that appear to be contaminated (based on visual evidence, odor, screening data, or analytical data from a previous field effort). This will provide the greatest opportunity for computing a precision estimate with detectable analyte concentrations.

and the associated QC samples are listed in Tables 3-2 and 3-4. The rationales for the selected analyses are presented in Section 1.7.

Surface and subsurface soil sampling will be performed using DPT, in accordance with SOP CTO126-04 included in Appendix A. Soils will be continuously cored to bedrock, if possible, in each boring. The DPT borings will proceed downward to the bedrock surface or refusal, whichever occurs first. A surface soil sample will be collected from 0 to 2 feet bgs in each boring. Subsurface soil samples will be collected from 2 to 6, 6 to 10, and in 4-foot intervals below that, when possible.

Only subsurface soils collected from depths greater than 6 feet bgs will be sampled and analyzed for VOCs because it is assumed that most VOCs should have volatilized from the upper soil materials. However, **all** soil cores will be screened for VOCs using a PID (SOP CTO126-06). If an elevated PID reading is measured at any interval less than 6 feet bgs, soil from this interval will also be sampled and analyzed for VOCs.

3.5.1.1 ABG MTA

Figure 3-1 presents approximate locations of the 69 soil borings to be completed within the ABG MTA during this investigation. Tables 3-2 and 3-4 list the samples to be collected and the analyses to be conducted on those samples.

The boring locations associated with the MTA were selected to better define the horizontal and vertical extent of contamination in soils at the MTA. Most of the borings are located close to possible source areas, former operational activities, or areas previously identified as contaminated.

Eight soil samples (see Table 3-2) will be collected and analyzed for geochemical properties (TOC, CEC, and pH).

If perched ground water is encountered at the bottom of any DPT borings, up to six perched ground water samples for laboratory analysis will be collected near the overburden/bedrock interface. These samples are identified in Table 3-3. If perched ground water is encountered in more than six borings, the field geologist will determine where the samples will be collected. The six samples will be collected preferentially from borings located close to suspected source areas or from borings that display elevated PID readings along the soil core.

3.5.1.2 OJT Area

Figure 3-2 presents locations for the four soil borings to be completed at the OJT Area. These borings are located between well 03-07 and the burn pit. The purpose of the samples collected from these borings is to identify soils contaminated with TCE that are contributing to the TCE observed in ground water in well 03-07. The soil samples from these borings will be used to help delineate the horizontal and vertical extent of TCE.

The soil samples will be analyzed for the parameters listed in Table 3-2.

3.5.2 Ground Water

The objectives of the ground water investigation will be to determine the current status of ground water contamination at the ABG MTA and the OJT areas. Many of the wells at the ABG MTA have not been sampled in over 10 years. Only wells screened in the BC-BC or the collapsed breccia material along the LSC valley will be sampled. However, monitoring wells that are part of the NSWC Crane quarterly RCRA ground water monitoring program will NOT be sampled. No new wells will be installed during this field effort.

Excluding QC samples, one ground water sample will be collected from each well identified in Table 3-3. The analyses to be performed on each sample and the associated QC samples to be collected are listed in Tables 3-3 and 3-4.

During low-flow well sampling, the temperature, specific conductance, pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), and turbidity of the ground water will be measured and recorded on the sample collection log sheets for each well (SOPs CTO126-05 and CTO126-16). If the turbidity of the ground water samples cannot be reduced to less than 10 nephelometric turbidity units (NTUs) during low-flow sampling, an aliquot of water will be filtered (SOP CTO126-05) and analyzed for dissolved metals in addition to total metals.

3.5.2.1 ABG MTA

Twenty-six monitoring wells will be sampled at the ABG MTA. The wells and respective sample numbers are listed in Table 3-3. Well locations are shown on Figure 3-3. The monitoring wells that are routinely sampled during the RCRA quarterly monitoring program are also shown on Figure 3-3; however, these wells will not be sampled during the CMS.

sampled during the RCRA quarterly monitoring program are also shown on Figure 3-3; however, these wells will not be sampled during the CMS.

3.5.2.2 OJT Area

Six monitoring wells at the OJT area will be sampled. The locations of these wells are shown on Figure 3-2. The samples and the appropriate analyses for each sample are listed in Table 3-3.

3.5.2.3 Spring A'

Spring A' is located very close to Spring A but is not sampled as a part of the RCRA quarterly sampling program. One sample will be collected from Spring A' to determine the current levels of contamination in that spring.

3.5.3 Surface Water / Sediment

No surface water or sediment samples will be collected during this field effort.

3.6 INVESTIGATION EQUIPMENT AND PROCEDURES

3.6.1 UXO Screening of Selected Drilling Sites

UXO was not encountered during any of the intrusive activities conducted as part of the previous RFI field investigations. However, UXO screening will be conducted in conjunction with the DPT soil boring activities at the ABG MTA and OJT, in accordance with the revised OJT HASP (TtNUS, 2004). **If potential ordnance is encountered during UXO screening activities, the activities will stop and the Crane Point of Contact will be notified. UXO clearance may be further conducted by Crane personnel, depending on materials found.**

3.6.2 DPT Sampling for Surface and Subsurface Soil Samples

DPT (e.g., Geoprobe® or similar method) will be used to collect surface and subsurface soil samples from the unconsolidated overburden. The procedure for soil sampling using DPT is included in SOP CTO126-04. A new acetate liner will be used for each 2-foot section of soil core. As each soil core is removed from the ground, the clear acetate liner will be sliced open in a lengthwise direction, and the soil core will be scanned for VOCs using a PID (SOP CTO126-06). The soil core will be visually inspected and logged by the field geologist, and the soil texture, grain size (sand, silt, or clay), color (and any unusual discoloration), moisture content, and soil type will be identified by the field geologist based on the

Unified Soil Classification System (USCS). All observations and PID screening measurements will be recorded on the soil boring log (see SOP CTO126-07).

For the soil sampling intervals of 0 - 2 and 2 - 6 feet bgs, collection of soil samples for VOC analyses are not planned (Table 3-2). However, when the core material from these shallow depth intervals are brought to the surface and cut open, they will be scanned with a PID. If the PID readings indicate that VOCs may be present, then a soil sample will be collected from the specific depth indicated by the above-background PID reading. For soil sampling intervals greater than 6 feet bgs that require VOC analysis (see Table 3-2), the VOC sample will be collected from a specific point along the soil core that has the greatest PID reading. If no above-background PID readings are measured in soil cores collected below 6 feet bgs, then the VOC sample will be collected from those intervals at a depth where discolored soil or other visual observations indicate that contaminated soil might be present. If no above-background PID reading is measured and no visual indicators of soil contamination are observed in the soil core, then the VOC sample will be collected from near the middle of the soil sample interval. Encore™ samplers will be used to collect and ship all soil samples for VOC analysis (SOP CTO126-08). The Encore™ samples will be collected from each core immediately after PID readings are measured.

After the soil sample aliquot for VOC analysis has been collected, the remaining soil core material for the interval specified for sampling will be placed in a decontaminated stainless-steel mixing bowl; rocks, gravel, and other coarse debris will be removed; and the sample will be mixed using a decontaminated stainless-steel spoon. The appropriate sample jars for remaining analyses will then be filled and properly labeled. The bowl and spoon will be decontaminated between each sample. Details regarding the collection and labeling of soil samples are included in SOPs CTO126-01 and CTO126-08.

Soil sample analytical information is presented in Table 3-2, and appropriate containers to be used for each sample aliquot are listed in Table 3-5. After the samples are containerized, labeled, tagged, and bagged (SOPs CTO126-01 and CTO126-03), they will be placed in a cooler containing ice until they can be packaged and prepared for shipment (Section 3.8).

For each cooler containing soil samples identified for VOC analysis (i.e., Encore™ samplers), a trip blank will also be stored in the cooler and will continuously accompany the VOC samples until they have been analyzed. As samples are added to a cooler, the chain-of-custody form will be updated to include each new sample (SOP CTO126-03; see also Section 4.1).

Duplicate samples (field duplicates) will be collected for those soil samples that have the greatest probability of containing contaminants (e.g., elevated levels of VOCs as indicated by PID readings). The

duplicate samples will be placed in the same type of containers and handled in the same manner as the regular soil samples (See Table 3-5). The duplicate samples will be given unique QC sample identifications (SOP CTO126-02).

After a soil coring tube (e.g., Macrocore sampler) is used to collect a soil core, it will be decontaminated in accordance with SOP CTO126-17 before being reused.

For soil samples, the rinsate blank will consist of running distilled water over a decontaminated sampling spoon into a decontaminated mixing bowl. This water will be used to fill sample bottles for the rinsate blank. This process will continue until all the necessary bottles are filled for the rinsate sample.

Soil borings will be backfilled with either the soil cuttings (if visually uncontaminated) or bentonite pellets (if visually contaminated) in accordance with Section 3.12.

When a boring has been sampled and backfilled, it will be identified by a tall wooden lath driven into the soil near the boring. In addition, a 2-by 2-inch wooden stake will be driven into the center of the backfilled boring. The stake and the lath will both have brightly colored flagging attached to them to increase visibility, and both will be labeled using a waterproof marker with a unique soil boring number corresponding to the boring log.

3.6.3 Inspection and Repair of Existing Monitoring Wells

Existing monitoring wells that are not part of the routine monitoring program will be sampled as part of this investigation (see Table 3-3). These wells may have broken casings, bent casings, missing caps, no locks, broken locks, obstructions, or other problems. In addition, it is likely that some of the wells may contain enough sediment at the bottom that the well screen may be partially or totally clogged. Therefore, at the beginning of field activities, the existing wells will be located, inspected, and repaired if possible. For example, damaged polyvinyl chloride (PVC) riser pipes above the ground surface may be sawed off and new riser pipes added. Caps and locks will be replaced if necessary. The height of casing above ground surface and the depth to the bottom of the well will be measured and recorded. This information will be compared to the boring logs and well construction logs to confirm that the wells are open through the screened interval. These activities are addressed in SOP CTO126-09.

3.6.4 Well Development

As necessary, existing wells will be redeveloped (SOP CTO126-10) prior to sampling to remove fine sediment from inside and around the well screens. The method used to perform well development can be either vigorous on-and-off pumping or surge block and pumping, depending on which technique is most effective. Field measurements of pH, specific conductance, temperature, and turbidity will be collected at 5- to 10-minute intervals on the water retrieved from the well, in accordance with SOP CTO126-10. Well development will continue until the well water is clear to the unaided eye and until three subsequent consecutive readings of pH, specific conductance, and temperature are within 10 percent of each other and three consecutive turbidity readings are within 5 NTUs of each other. If the water-quality parameter criteria cannot be met after five well volumes of water have been removed, one additional well volume will be removed and well development will be considered complete.

All water removed from the well during the development process will be stored in a portable holding tank (already present at NSWC Crane) and discharged into a designated man-hole for treatment at the NSWC Crane water treatment facility (SOP CTO126-15).

3.6.5 Water-Quality Field Measurements

Temperature, pH, ORP, DO, specific conductance, and turbidity will be measured for every aqueous sample collected. Field measurements of water-quality parameters will be collected from ground water in a flow-through cell attached to the pump discharge line. These measurements (except for DO and ORP) will be performed during well development (SOP CTO126-10), and will be performed during low-flow well stabilization and sampling (SOP CTO126-16 and Section 3.5.2). Calibration and measurements made with the field instruments will be in accordance with Section 4.2 and SOPs CTO126-14 and CTO126-16.

Each calibration of an instrument will be recorded on an equipment calibration log sheet (SOP CTO126-14). Water-quality measurements, along with date, time, instrument operator, and visual and other observations (e.g., weather conditions), will be recorded on well development logs, sample collection logs, an/or field notebooks, as appropriate (SOP CTO126-03).

3.6.6 Low-Flow Sampling of Monitoring Wells

Low-flow sampling procedures will be used to collect ground water samples from existing wells (SOP CTO126-05 and -16). If the depth to ground water is greater than 25 feet, a compressed air bladder pump or submersible pump will be used to slowly pump ground water from the well at about 100 milliliters

per minute (mL/minute). If the depth to ground water is less than 25 feet, a peristaltic or air bladder pump will be used for low-flow purging and sampling.

Low-flow pumping will proceed until readings of temperature, pH, specific conductance, DO, ORP, and turbidity stabilize but for no longer than 4 hours. See SOP CTO126-16 for criteria for well stabilization. Appropriate sample bottles will be filled directly from the pump discharge tube. The bottles will be properly labeled, tagged, bagged, and placed in an ice-filled cooler as quickly as possible (SOPs CTO126-01 and CTO126-03). A ground water collection log sheet will be completed for each ground water sample collected (SOP CTO126-05).

The wells will be sampled in order of least contaminated to most contaminated based on historical data, whenever possible. This approach will lessen the possibility of cross contamination between wells. After each ground water sample is collected, the pump will be decontaminated (SOP CTO126-17). The rinsate blank will be collected by pumping distilled water through the pump and placing the pump discharge water directly into sample jars. The appropriate sample jars and preservatives for each analyte group are listed in Table 3-5.

For each cooler containing ground water samples identified for VOC analysis, a trip blank will be included in the cooler. The trip blank will accompany the VOC samples until they have been analyzed for VOCs. As samples are added to a cooler, the chain-of-custody form should be updated to include each new sample container (SOP CTO126-03).

3.6.7 Ground Water-Level Measurements

One synoptic round of water-level measurements and total well depth soundings will be obtained from the approximately 150 existing ground water monitoring wells located within and around the study area. These wells are identified in Table 3-6. All ground water-level measurements will be taken within a maximum 2-day period of consistent weather conditions (no precipitation) using an electronic water-level meter. In addition, water-level measurements will be made at seven existing staff gages. Water-level elevations will be recorded to within 0.01-foot accuracy from a marked reference point on the well riser pipe. Detailed procedures regarding water-level measurements are included in SOP CTO126-18. Water levels will be recorded on a TtNUS water-level form. A blank water-level form is provided in SOP CTO126-18 for reference purposes. The water-level meter will be decontaminated between each well; decontamination procedures are addressed in SOP CTO126-17.

3.7 QUALITY CONTROL SAMPLES

Table 3-4 presents the types and numbers of required field QC samples to be collected for soil and ground water sampling activities during the field investigation.

Descriptions of the types and purposes of the various QC samples are provided in Section 8.0 of the original QAPP for the OJT/LSC (TtNUS, 2001).

3.8 SAMPLE HANDLING, PACKAGING, AND SHIPPING

SOP CTO126-24 provides a detailed description of sample handling, packaging, and shipping procedures required for this project.

3.8.1 Sample Preservation

Preservation requirements for each of the chemicals analyses of interest are provided in Table 3-5. Sample bottles for aqueous samples will contain the proper amounts and types of preservatives before they are shipped to NSWC Crane. The preservatives placed in the sample bottles will be certified free of analytes being tested in the samples. All samples will be promptly chilled with ice to 4 degrees Celsius (°C) ± 2°C and packaged in an insulated cooler. Each cooler will include a temperature blank. Ice will be sealed in containers to prevent water leakage. Samples will not be frozen.

3.8.2 Sample Labeling

Before samples are packaged, the sample labels and tags will be checked to ensure that all information on the labels and tags is complete and correct (SOP CTO126-01) and that it matches the information on the sample collection log sheets and the chain-of-custody form.

3.8.3 Sample Packaging

The completed field chain-of-custody document will be signed, placed in a sealed plastic envelope, and taped to the top inside cover of the shipping container (SOP CTO126-03).

The FOL will be responsible for ensuring the completion of the following forms:

- Sample labels and tags
- Chain-of-custody forms

- Custody seals for coolers
- Shipping labels for coolers
- Express mail air bills

3.8.4 Sample Shipping

Shipping containers (i.e., coolers) will be sealed with nylon strapping tape in at least two places, and custody seals will be signed, dated, and affixed in a manner that will allow the receiver to quickly identify any tampering that may have occurred during transport to the laboratory (SOPs CTO126-01 and -03).

Shipment will be made by a public courier at the next scheduled pickup following completion of sample collection. Copies of the air bills should be retained by the FOL for tracking purposes, if needed, and for communications with the laboratory. Air bills will be retained for the permanent record file.

3.8.5 Sample Custody

Custody of samples must be maintained and documented at all times, in accordance with SOP CTO126-03, beginning with the collection of samples in the field. Sample custody procedures are addressed in Section 4.1.

3.9 RECORD KEEPING

Standard forms, field notebooks, and a field logbook will be used to record all sample collection activities, field measurements, observations concerning site conditions, and other project-related information. These records include boring logs, sample log sheets, daily activity records, field logbooks, and field instrument calibration log sheets, among others. More details regarding record keeping are included in SOP CTO126-03.

3.9.1 Field Log Books

Bound, weatherproof field notebooks will be maintained by sampling personnel. All information related to sampling and other field activities will be recorded in field notebooks. This information will include, but is not limited to, sampling time, weather conditions, unusual events, field measurements, and descriptions of photographs.

A bound, weatherproof logbook will be maintained by the FOL. This book will contain a summary of each day's activities and will reference the field notebooks when applicable.

3.9.2 Direct Push Technology Boring Installation

A boring log will be completed for every boring installed during these field activities. A geologist will complete the boring log, which will include information regarding date, time, personnel present, boring and sampling equipment, geologic materials encountered, fracture locations and frequency (where appropriate), water yields, color, texture, odors, and readings made with the screening instruments (SOP CTO126-07).

3.9.3 Well Development Log Sheets

During the development or redevelopment of each monitoring well, the date, times of events, development method and equipment, personnel present, amounts of water produced, measurements made by field water-quality meters, and depths to water will be recorded on a well development log sheet, as described in SOP CTO126-10.

3.9.4 Equipment Calibration Logs

An equipment calibration log sheet will be used to record each time an instrument is calibrated, recalibrated, or checked against a standard or background. The procedures and standards to be used for instrument calibration are discussed in Section 4.2 and SOPs CTO126-06 and CTO126-14.

3.9.5 Sample Collection Logs

All sample log sheets will be completed in accordance with SOP CTO126-03.

3.9.6 Chain-of-Custody Forms

A chain-of-custody form will be completed for every cooler that contains samples being shipped to an off-site laboratory for analyses. These forms are a record of the people having custody of the samples from the time the samples are collected to the time they are analyzed and disposed (SOP CTO126-03 and Section 4.1). The completed field chain-of-custody document will be signed, placed in a sealed plastic envelope, and taped to the top inside cover of the shipping container before it is shipped. A copy of the chain-of-custody document will be retained by the FOL.

3.9.7 Shipping Forms/Air Bills

Copies of all forms and/or air bills related to the shipment of coolers will be retained by the FOL in order to track the shipment, if necessary, and to communicate with the receiving laboratory.

3.9.8 Permanent Record File

At the completion of the field activities, the FOL will submit to the TOM all field records, data, field notebooks, logbooks, chain-of-custody records, sample log sheets, daily activity logs, and other records concerning the project, including all the forms and log sheets listed above. The FOL will check these records for legibility and completeness before submitting them to the TOM. These forms, data, and field notes will become part of the permanent project record.

3.10 SURVEYING

The location of every soil boring will be marked with a wooden lath and flagging, and a boring hole number or sample ID will be marked on the lath. In addition, a 2- by 2-inch wooden stake, 6 inches long, will be driven into the ground at the center of each backfilled boring. This stake will have a piece of brightly colored flagging tacked onto its top, and the boring hole number will be indelibly marked on the side of the stake.

The horizontal locations and vertical elevations of all soil borings will be surveyed. In addition, any monitoring well for which repairs have changed the top of the riser elevation will be surveyed. Horizontal locations will be surveyed to the Indiana State Plane Coordinates System within the nearest foot and referenced to North American Datum (NAD) 83. The vertical elevations of the ground surface and tops of casing for repaired wells, and the ground surface for the soil borings will be measured to the nearest 0.01 foot and referenced to the North American Vertical Datum (NAVD) of 1988.

The surveyor should identify to the FOL any survey point for which the corresponding stake could not be located.

3.11 EQUIPMENT DECONTAMINATION

All equipment used to collect soil and ground water samples will be decontaminated in accordance with SOP CTO126-17.

3.12 MANAGEMENT OF INVESTIGATION-DERIVED WASTE

It is anticipated that this investigation will generate the following five types of potentially contaminated residues or investigation-derived waste (IDW):

- Personal protective equipment (PPE)
- Ground water sample tubing and DPT sample liners
- Well development and purge fluids
- Equipment decontamination fluids
- Waste cuttings from drilling activities

IDW will be handled as follows:

- All PPE, tubing, and DPT sample liners will be decontaminated and double bagged and placed in trash receptacles at NSWC Crane.

- All well development and purge fluids will be collected, stored, and discharged to the NSWC Crane permitted sanitary sewer system in accordance with SOP CTO126-15.

- All drilling equipment decontamination fluids will be combined with well development and purge fluids and handled in the same manner.

- All equipment decontamination fluids will be combined with well development and purge fluids and handled in the same manner.

- For each boring, waste cuttings will be scanned for VOCs. If all readings from screening instruments are at background levels and there is no visible evidence of staining, the soil cuttings from soil borings will be mixed with bentonite, placed back into the hole, and tamped for compaction or spread on the ground adjacent to the borehole. Borings with contaminated cuttings or rock cores will be backfilled with bentonite pellets or a cement-bentonite slurry. Contaminated cuttings or rock cores from borings will be placed in black plastic trash bags (or directly in drums if in larger quantities), labeled, and placed in 55-gallon sealable drums. The bags will be tagged, and the drums will be clearly labeled with the dates, locations, and depths from which the soils originated and the personnel (including phone number) placing the cuttings in the drum. When analytical results from soil samples are received from the laboratory, decisions will be made as to how to dispose of the soil materials (SOP CTO126-15).

3.13 SAFETY

The health and safety activities described in the following sections will ensure that field activities are performed at a high level of safety.

3.13.1 Health and Safety Plan

A separate HASP has been prepared that describes specific health and safety requirements, concerns, and information related to the site activities. This document will be read and understood by each person working at the site. Each worker or visitor to the site must sign an acknowledgment that he or she has read and understands the revised OJT HASP (TtNUS, 2004).

3.13.2 Health and Safety Training

All workers involved with the site investigations shall have successfully completed the Occupational Safety and Health Administration (OSHA)-mandated 40-hour health and safety training and the follow-up annual 8-hour refresher courses when appropriate.

Tetra Tech NUS, Inc. (TtNUS) and subcontractor personnel will supply OSHA documentation to the FOL before beginning work. Personnel who do not comply with this requirement must receive verbal approval to work from TtNUS corporate health and safety personnel.

3.13.3 Personal Protective Clothing and Equipment

Workers at the site must be part of a medical monitoring program and must be medically approved to perform their duties without physical limitations. Protective clothing and equipment, as specified in the revised HASP, will be worn while performing site activities.

3.13.4 Safety Meetings

Safety tailgate briefings will be held each morning and additional meetings will be held among on-site workers whenever the SSO feels it is appropriate. The SSO will discuss safety issues related to activities being performed and will make site workers aware of any new conditions that could potentially affect health or safety.

3.14 ORGANIZATION AND LOGISTICS OF FIELD INVESTIGATIONS

3.14.1 Personnel

The duties, responsibilities, and line of command for each person working on the project are described in Section 2.0 and displayed on Figure 2-1. Persons working on the project will be intimately familiar with their roles and responsibilities. In addition, they will be familiar with the mechanisms and procedures for coordinating tasks, improving communications, and reporting incidences or irregularities. The FOL is responsible for coordinating all on-site personnel and activities (Section 2.0). The SSO is responsible for health and safety monitoring and ensures that the revised HASP is adhered to during all field activities. The SSO has the authority to stop work if an imminent safety hazard is encountered.

3.14.2 Subcontractors

Subcontractors will perform site activities involving DPT work and surveying. The FOL will direct all subcontractor activities.

3.14.3 Mobilization and Demobilization

Following approval of this QAPP Addendum No.1, TtNUS will begin mobilization activities. All field team members will review the QAPP Addendum No. 1 (including the revised HASP) prior to mobilization. In addition, a field team orientation meeting will be held to familiarize personnel with the scope of the field activities. Items to be presented during that meeting include the following:

- Identification of the QAPP Addendum No. 1, the revised HASP, and applicable field SOPs (Appendix A).
- Site-specific safety concerns and requirements.
- Project objectives.
- Sampling designs and strategies for soil and ground water (including the relationship of soil data from this project to NSWC Crane background soils data).
- Site-specific particulars of field operations (e.g., locations of utilities, physical access to sampling locations, communication mechanisms, lines of authority and responsibility, scheduling requirements, sample shipping concerns, etc.).

- Laboratory and other subcontractor coordination.
- Site access requirements.
- Travel requirements.

The FOL will coordinate the mobilization activities for this project. The equipment required for the field activities will be mobilized from the TtNUS Pittsburgh office or a third-party vendor. The FOL and crew will demobilize from the site upon completion of the field operations and ship field equipment back to the point of origin, as necessary. All areas will be thoroughly checked, and trash will be removed and disposed properly.

If necessary, restoration of boring sites will be performed to repair tire ruts and restore vegetation.

TABLE 3-1

FIELD SCREENING AND MEASUREMENTS
SWMU 03 –ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Parameter	Equipment	SOP	Calibration
Unexploded ordnance - Ferrous (Surface)	GA-52 Cx, GA-72CV Magnetic Locator or comparable	Per Manufacturer	Per Manufacturer
Unexploded ordnance - Nonferrous (Surface)	White XLT, Fisher CZ-70, or comparable	Per Manufacturer	Per Manufacturer
Unexploded ordnance - Ferrous (Subsurface)	MG-230, MG-220 Magnetic Gradiometer or comparable	Per Manufacturer	Per Manufacturer
Volatile organics	Perkin-Elmer Photovac 2020 Photoionization Detector or comparable	SOP CTO126-06	Per Manufacturer
pH, Temperature, oxidation-reduction potential, specific conductance, dissolved oxygen (water-quality parameters)(1)	YSI 6-Series Environmental Monitoring System or comparable	SOP CTO126-11	Per Manufacturer
Turbidity (water-quality parameter)(1)	LaMotte Turbidity Meter or comparable	SOP CTO126-11	Per Manufacturer
Water-level measurements	Heron Dipper-T (or comparable)(2)	SOP CTO126-15	Per Manufacturer

1 Field measurements used to establish well stabilization prior to collecting ground water samples.
2 Any electronic water-level indicator may be used with the capability of measuring to depths of 100 feet.

TABLE 3-2

SOIL SAMPLES AND LABORATORY ANALYSES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
OJT	03SB049	03SS0490002	-	X	X	X	X	-	-	-
OJT	03SB049	03SB0490206	-	X	X	X	X	-	-	-
OJT	03SB049	03SB0490610	X	X	X	X	X	-	-	-
OJT	03SB049	03SB049xxxx	X	X	X	X	X	-	-	-
OJT	03SB050	03SS0500002	-	X	-	X	-	-	-	-
OJT	03SB050	03SB0500206	-	X	-	X	-	-	-	-
OJT	03SB050	03SB0500610	X	X	-	X	-	-	-	-
OJT	03SB050	03SB050xxxx	X	X	-	X	-	-	-	-
OJT	03SB051	03SS0510002	-	X	X	X	X	-	-	-
OJT	03SB051	03SB0510206	-	X	X	X	X	-	-	-
OJT	03SB051	03SB0510610	X	X	X	X	X	-	-	-
OJT	03SB051	03SB051xxxx	X	X	X	X	X	-	-	-
OJT	03SB052	03SS0520002	-	X	-	X	-	-	-	-
OJT	03SB052	03SB0520206	-	X	-	X	-	-	-	-
OJT	03SB052	03SB0520610	X	X	-	X	-	-	-	-
OJT	03SB052	03SB052xxxx	X	X	-	X	-	-	-	-
A	03SB053	03SS0530002	-	X	X	X	X	-	-	-
A	03SB053	03SB0530206	-	X	X	X	X	-	-	-
A	03SB053	03SB0530610	X	X	X	X	X	-	-	-
A	03SB053	03SB053xxxx	X	X	X	X	X	-	-	-
B	03SB054	03SS0540002	-	X	-	X	-	-	-	-
B	03SB054	03SB0540206	-	X	-	X	-	-	-	-
B	03SB054	03SB0540610	X	X	-	X	-	-	-	-
B	03SB054	03SB054xxxx	X	X	-	X	-	-	-	-
B	03SB055	03SS0550002	-	X	X	-	X	-	-	-
B	03SB055	03SB0550206	-	X	X	-	X	-	-	-
B	03SB055	03SB0550610	X	X	X	-	X	-	-	-
B	03SB055	03SB055xxxx	X	X	X	-	X	-	-	-
B	03SB056	03SS0560002	-	X	-	X	-	-	-	-
B	03SB056	03SB0560206	-	X	-	X	-	-	-	-
B	03SB056	03SB0560610	X	X	-	X	-	-	-	-
B	03SB056	03SB056xxxx	X	X	-	X	-	-	-	-
B	03SB057	03SS0570002	-	X	-	-	-	-	-	-
B	03SB057	03SB0570206	-	X	-	-	-	-	-	-
B	03SB057	03SB0570610	X	X	-	-	-	-	-	-
B	03SB057	03SB057xxxx	X	X	-	-	-	-	-	-
B	03SB058	03SS0580002	-	X	-	X	-	-	-	-
B	03SB058	03SB0580206	-	X	-	X	-	-	-	-
B	03SB058	03SB0580610	X	X	-	X	-	-	-	-
B	03SB058	03SB058xxxx	X	X	-	X	-	-	-	-
B	03SB059	03SS0590002	-	X	X	-	X	-	-	-

TABLE 3-2

SOIL SAMPLES AND LABORATORY ANALYSES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
B	03SB059	03SB0590206	-	X	X	-	X	-	-	-
B	03SB059	03SB0590610	X	X	X	-	X	-	-	-
B	03SB059	03SB059xxxx	X	X	X	-	X	-	-	-
B	03SB060	03SS0600002	-	X	-	X	-	-	-	-
B	03SB060	03SB0600206	-	X	-	X	-	-	-	-
B	03SB060	03SB0600610	X	X	-	X	-	-	-	-
B	03SB060	03SB060xxxx	X	X	-	X	-	-	-	-
B	03SB061	03SS0610002	-	X	X	-	X	-	-	-
B	03SB061	03SB0610206	-	X	X	-	X	-	-	-
B	03SB061	03SB0610610	X	X	X	-	X	-	-	-
B	03SB061	03SB061xxxx	X	X	X	-	X	-	-	-
B	03SB062	03SS0620002	-	X	-	X	-	-	-	-
B	03SB062	03SB0620206	-	X	-	X	-	-	-	-
B	03SB062	03SB0620610	X	X	-	X	-	-	-	-
B	03SB062	03SB062xxxx	X	X	-	X	-	-	-	-
B	03SB063	03SS0630002	-	X	-	-	-	-	-	-
B	03SB063	03SB0630206	-	X	-	-	-	-	-	-
B	03SB063	03SB0630610	X	X	-	-	-	-	-	-
B	03SB063	03SB063xxxx	X	X	-	-	-	-	-	-
B	03SB064	03SS0640002	-	X	-	X	-	-	-	-
B	03SB064	03SB0640206	-	X	-	X	-	-	-	-
B	03SB064	03SB0640610	X	X	-	X	-	-	-	-
B	03SB064	03SB064xxxx	X	X	-	X	-	-	-	-
B	03SB065	03SS0650002	-	X	X	-	X	-	-	-
B	03SB065	03SB0650206	-	X	X	-	X	-	-	-
B	03SB065	03SB0650610	X	X	X	-	X	-	-	-
B	03SB065	03SB065xxxx	X	X	X	-	X	-	-	-
C	03SB066	03SS0660002		X	-	X	-	-	-	-
C	03SB066	03SB0660206		X	-	X	-	-	-	-
C	03SB066	03SB0660610	X	X	-	X	-	-	-	-
C	03SB066	03SB066xxxx	X	X	-	X	-	-	-	-
C	03SB067	03SS0670002	-	X	X	-	X	-	-	-
C	03SB067	03SB0670206	-	X	X	-	X	-	-	-
C	03SB067	03SB0670610	X	X	X	-	X	-	-	-
C	03SB067	03SB067xxxx	X	X	X	-	X	-	-	-
C	03SB068	03SS0680002	-	X	-	X	-	-	-	-
C	03SB068	03SB0680206	-	X	-	X	-	-	-	-
C	03SB068	03SB0680610	X	X	-	X	-	-	-	-
C	03SB068	03SB068xxxx	X	X	-	X	-	-	-	-
D	03SB069	03SS0690002	-	X	-	-	-	-	-	-
D	03SB069	03SB0690206	-	X	-	-	-	-	-	-

TABLE 3-2

SOIL SAMPLES AND LABORATORY ANALYSES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
D	03SB069	03SB0690610	X	X	-	-	-	-	-	-
D	03SB069	03SB069xxxx	X	X	-	-	-	-	-	-
D	03SB070	03SS0700002	-	X	-	X	-	-	-	-
D	03SB070	03SB0700206	-	X	-	X	-	-	-	-
D	03SB070	03SB0700610	X	X	-	X	-	-	-	-
D	03SB070	03SB070xxxx	X	X	-	X	-	-	-	-
D	03SB071	03SS0710002	-	X	X	-	X	-	-	-
D	03SB071	03SB0710206	-	X	X	-	X	-	-	-
D	03SB071	03SB0710610	X	X	X	-	X	-	-	-
D	03SB071	03SB071xxxx	X	X	X	-	X	-	-	-
D	03SB072	03SS0720002	-	X	-	X	-	-	-	-
D	03SB072	03SB0720206	-	X	-	X	-	-	-	-
D	03SB072	03SB0720610	X	X	-	X	-	-	-	-
D	03SB072	03SB072xxxx	X	X	-	X	-	-	-	-
D	03SB073	03SS0730002	-	X	X	-	X	-	-	-
D	03SB073	03SB0730206	-	X	X	-	X	-	-	-
D	03SB073	03SB0730610	X	X	X	-	X	-	-	-
D	03SB073	03SB073xxxx	X	X	X	-	X	-	-	-
D	03SB074	03SS0740002	-	X	-	X	-	-	-	-
D	03SB074	03SB0740206	-	X	-	X	-	-	-	-
D	03SB074	03SB0740610	X	X	-	X	-	-	-	-
D	03SB074	03SB074xxxx	X	X	-	X	-	-	-	-
D	03SB075	03SS0750002	-	X	-	-	-	-	-	-
D	03SB075	03SB0750206	-	X	-	-	-	-	-	-
D	03SB075	03SB0750610	X	X	-	-	-	-	-	-
D	03SB075	03SB075xxxx	X	X	-	-	-	-	-	-
E	03SB076	03SS0760002	-	X	-	X	-	-	-	-
E	03SB076	03SB0760206	-	X	-	X	-	-	-	-
E	03SB076	03SB0760610	X	X	-	X	-	-	-	-
E	03SB076	03SB076xxxx	X	X	-	X	-	-	-	-
E	03SB077	03SS0770002	-	X	X	-	X	-	-	-
E	03SB077	03SB0770206	-	X	X	-	X	-	-	-
E	03SB077	03SB0770610	X	X	X	-	X	-	-	-
E	03SB077	03SB077xxxx	X	X	X	-	X	-	-	-
E	03SB078	03SS0780002	-	X	-	X	-	X	X	X
E	03SB078	03SB0780206	-	X	-	X	-	X	X	X
E	03SB078	03SB0780610	X	X	-	X	-	X	X	X
E	03SB078	03SB078xxxx	X	X	-	X	-	X	X	X
F	03SB079	03SS0790002	-	X	X	-	X	-	-	-
F	03SB079	03SB0790206	-	X	X	-	X	-	-	-
F	03SB079	03SB0790610	X	X	X	-	X	-	-	-

TABLE 3-2

SOIL SAMPLES AND LABORATORY ANALYSES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
F	03SB079	03SB079xxxx	X	X	X	-	X	-	-	-
F	03SB080	03SS0800002	-	X	-	X	-	-	-	-
F	03SB080	03SB0800206	-	X	-	X	-	-	-	-
F	03SB080	03SB0800610	X	X	-	X	-	-	-	-
F	03SB080	03SB080xxxx	X	X	-	X	-	-	-	-
F	03SB081	03SS0810002	-	X	-	-	-	-	-	-
F	03SB081	03SB0810206	-	X	-	-	-	-	-	-
F	03SB081	03SB0810610	X	X	-	-	-	-	-	-
F	03SB081	03SB081xxxx	X	X	-	-	-	-	-	-
F	03SB082	03SS0820002	-	X	-	X	-	-	-	-
F	03SB082	03SB0820206	-	X	-	X	-	-	-	-
F	03SB082	03SB0820610	X	X	-	X	-	-	-	-
F	03SB082	03SB082xxxx	X	X	-	X	-	-	-	-
F	03SB083	03SS0830002	-	X	X	-	X	-	-	-
F	03SB083	03SB0830206	-	X	X	-	X	-	-	-
F	03SB083	03SB0830610	X	X	X	-	X	-	-	-
F	03SB083	03SB083xxxx	X	X	X	-	X	-	-	-
F	03SB084	03SS0840002	-	X	-	X	-	-	-	-
F	03SB084	03SB0840206	-	X	-	X	-	-	-	-
F	03SB084	03SB0840610	X	X	-	X	-	-	-	-
F	03SB084	03SB084xxxx	X	X	-	X	-	-	-	-
F	03SB085	03SS0850002	-	X	-	-	-	-	-	-
F	03SB085	03SB0850206	-	X	-	-	-	-	-	-
F	03SB085	03SB0850610	X	X	-	-	-	-	-	-
F	03SB085	03SB085xxxx	X	X	-	-	-	-	-	-
F	03SB086	03SS0860002	-	X	-	X	-	-	-	-
F	03SB086	03SB0860206	-	X	-	X	-	-	-	-
F	03SB086	03SB0860610	X	X	-	X	-	-	-	-
F	03SB086	03SB086xxxx	X	X	-	X	-	-	-	-
F	03SB087	03SS0870002	-	X	X	-	X	-	-	-
F	03SB087	03SB0870206	-	X	X	-	X	-	-	-
F	03SB087	03SB0870610	X	X	X	-	X	-	-	-
F	03SB087	03SB087xxxx	X	X	X	-	X	-	-	-
G	03SB088	03SS0880002	-	X	-	X	-	-	-	-
G	03SB088	03SB0880206	-	X	-	X	-	-	-	-
G	03SB088	03SB0880610	X	X	-	X	-	-	-	-
G	03SB088	03SB088xxxx	X	X	-	X	-	-	-	-
G	03SB089	03SS0890002	-	X	X	-	X	-	-	-
G	03SB089	03SB0890206	-	X	X	-	X	-	-	-
G	03SB089	03SB0890610	X	X	X	-	X	-	-	-
G	03SB089	03SB089xxxx	X	X	X	-	X	-	-	-

TABLE 3-2

SOIL SAMPLES AND LABORATORY ANALYSES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
G	03SB090	03SS0900002	-	X	-	X	-	-	-	-
G	03SB090	03SB0900206	-	X	-	X	-	-	-	-
G	03SB090	03SB0900610	X	X	-	X	-	-	-	-
G	03SB090	03SB090xxxx	X	X	-	X	-	-	-	-
H	03SB091	03SS0910002	-	X	X	-	X	-	-	-
H	03SB091	03SB0910206	-	X	X	-	X	-	-	-
H	03SB091	03SB0910610	X	X	X	-	X	-	-	-
H	03SB091	03SB091xxxx	X	X	X	-	X	-	-	-
H	03SB092	03SS0920002	-	X	-	X	-	-	-	-
H	03SB092	03SB0920206	-	X	-	X	-	-	-	-
H	03SB092	03SB0920610	X	X	-	X	-	-	-	-
H	03SB092	03SB092xxxx	X	X	-	X	-	-	-	-
H	03SB093	03SS0930002	-	X	-	-	-	-	-	-
H	03SB093	03SB0930206	-	X	-	-	-	-	-	-
H	03SB093	03SB0930610	X	X	-	-	-	-	-	-
H	03SB093	03SB093xxxx	X	X	-	-	-	-	-	-
H	03SB094	03SS0940002	-	X	-	X	-	-	-	-
H	03SB094	03SB0940206	-	X	-	X	-	-	-	-
H	03SB094	03SB0940610	X	X	-	X	-	-	-	-
H	03SB094	03SB094xxxx	X	X	-	X	-	-	-	-
H	03SB095	03SS0950002	-	X	X	-	X	-	-	-
H	03SB095	03SB0950206	-	X	X	-	X	-	-	-
H	03SB095	03SB0950610	X	X	X	-	X	-	-	-
H	03SB095	03SB095xxxx	X	X	X	-	X	-	-	-
H	03SB096	03SS0960002	-	X	-	X	-	-	-	-
H	03SB096	03SB0960206	-	X	-	X	-	-	-	-
H	03SB096	03SB0960610	X	X	-	X	-	-	-	-
H	03SB096	03SB096xxxx	X	X	-	X	-	-	-	-
H	03SB097	03SS0970002	-	X	X	-	X	-	-	-
H	03SB097	03SB0970206	-	X	X	-	X	-	-	-
H	03SB097	03SB0970610	X	X	X	-	X	-	-	-
H	03SB097	03SB097xxxx	X	X	X	-	X	-	-	-
H	03SB098	03SS0980002	-	X	-	X	-	-	-	-
H	03SB098	03SB0980206	-	X	-	X	-	-	-	-
H	03SB098	03SB0980610	X	X	-	X	-	-	-	-
H	03SB098	03SB098xxxx	X	X	-	X	-	-	-	-
H	03SB099	03SS0990002	-	X	-	-	-	-	-	-
H	03SB099	03SB0990206	-	X	-	-	-	-	-	-
H	03SB099	03SB0990610	X	X	-	-	-	-	-	-
H	03SB099	03SB099xxxx	X	X	-	-	-	-	-	-
I	03SB100	03SS1000002	-	X	-	X	-	-	-	-

TABLE 3-2

SOIL SAMPLES AND LABORATORY ANALYSES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
I	03SB100	03SB1000206	-	X	-	X	-	-	-	-
I	03SB100	03SB1000610	X	X	-	X	-	-	-	-
I	03SB100	03SB100xxxx	X	X	-	X	-	-	-	-
I	03SB101	03SS1010002	-	X	X	X	X	-	-	-
I	03SB101	03SB1010206	-	X	X	X	X	-	-	-
I	03SB101	03SB1010610	X	X	X	X	X	-	-	-
I	03SB101	03SB101xxxx	X	X	X	X	X	-	-	-
I	03SB102	03SS1020002	-	X	-	-	-	-	-	-
I	03SB102	03SB1020206	-	X	-	-	-	-	-	-
I	03SB102	03SB1020610	X	X	-	-	-	-	-	-
I	03SB102	03SB102xxxx	X	X	-	-	-	-	-	-
I	03SB103	03SS1030002	-	X	X	X	X	-	-	-
I	03SB103	03SB1030206	-	X	X	X	X	-	-	-
I	03SB103	03SB1030610	X	X	X	X	X	-	-	-
I	03SB103	03SB103xxxx	X	X	X	X	X	-	-	-
J	03SB104	03SS1040002	-	X	-	-	-	-	-	-
J	03SB104	03SB1040206	-	X	-	-	-	-	-	-
J	03SB104	03SB1040610	X	X	-	-	-	-	-	-
J	03SB104	03SB104xxxx	X	X	-	-	-	-	-	-
MISC	03SB105	03SS1050002	-	X	X	X	X	-	-	-
MISC	03SB105	03SB1050206	-	X	X	X	X	-	-	-
MISC	03SB105	03SB1050610	X	X	X	X	X	-	-	-
MISC	03SB105	03SB105xxxx	X	X	X	X	X	-	-	-
MISC	03SB106	03SS1060002	-	X	-	-	-	-	-	-
MISC	03SB106	03SB1060206	-	X	-	-	-	-	-	-
MISC	03SB106	03SB1060610	X	X	-	-	-	-	-	-
MISC	03SB106	03SB106xxxx	X	X	-	-	-	-	-	-
MISC	03SB107	03SS1070002	-	X	X	-	X	-	-	-
MISC	03SB107	03SB1070206	-	X	X	-	X	-	-	-
MISC	03SB107	03SB1070610	X	X	X	-	X	-	-	-
MISC	03SB107	03SB107xxxx	X	X	X	-	X	-	-	-
MISC	03SB108	03SS1080002	-	X	-	X	-	-	-	-
MISC	03SB108	03SB1080206	-	X	-	X	-	-	-	-
MISC	03SB108	03SB1080610	X	X	-	X	-	-	-	-
MISC	03SB108	03SB108xxxx	X	X	-	X	-	-	-	-
MISC	03SB109	03SS1090002	-	X	-	-	-	-	-	-
MISC	03SB109	03SB1090206	-	X	-	-	-	-	-	-
MISC	03SB109	03SB1090610	X	X	-	-	-	-	-	-
MISC	03SB109	03SB109xxxx	X	X	-	-	-	-	-	-
MISC	03SB110	03SS1100002	-	X	-	X	-	-	-	-
MISC	03SB110	03SB1100206	-	X	-	X	-	-	-	-

TABLE 3-2

SOIL SAMPLES AND LABORATORY ANALYSES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
MISC	03SB110	03SB1100610	X	X	-	X	-	-	-	-
MISC	03SB110	03SB110xxxx	X	X	-	X	-	-	-	-
MISC	03SB111	03SS1110002	-	X	X	-	X	-	-	-
MISC	03SB111	03SB1110206	-	X	X	-	X	-	-	-
MISC	03SB111	03SB1110610	X	X	X	-	X	-	-	-
MISC	03SB111	03SB111xxxx	X	X	X	-	X	-	-	-
MISC	03SB112	03SS1120002	-	X	-	X	-	-	-	-
MISC	03SB112	03SB1120206	-	X	-	X	-	-	-	-
MISC	03SB112	03SB1120610	X	X	-	X	-	-	-	-
MISC	03SB112	03SB112xxxx	X	X	-	X	-	-	-	-
MISC	03SB113	03SS1130002	-	X	X	-	X	-	-	-
MISC	03SB113	03SB1130206	-	X	X	-	X	-	-	-
MISC	03SB113	03SB1130610	X	X	X	-	X	-	-	-
MISC	03SB113	03SB113xxxx	X	X	X	-	X	-	-	-
MISC	03SB114	03SS1140002	-	X	-	X	-	-	-	-
MISC	03SB114	03SB1140206	-	X	-	X	-	-	-	-
MISC	03SB114	03SB1140610	X	X	-	X	-	-	-	-
MISC	03SB114	03SB114xxxx	X	X	-	X	-	-	-	-
MISC	03SB115	03SS1150002	-	X	-	-	-	-	-	-
MISC	03SB115	03SB1150206	-	X	-	-	-	-	-	-
MISC	03SB115	03SB1150610	X	X	-	-	-	-	-	-
MISC	03SB115	03SB115xxxx	X	X	-	-	-	-	-	-
MISC	03SB116	03SB1160002	-	X	-	X	-	X	X	X
MISC	03SB116	03SB1160206	-	X	-	X	-	X	X	X
MISC	03SB116	03SB1160610	X	X	-	X	-	X	X	X
MISC	03SB116	03SB116xxxx	X	X	-	X	-	X	X	X
MISC	03SB117	03SS1170002	-	X	X	-	X	-	-	-
MISC	03SB117	03SB1170206	-	X	X	-	X	-	-	-
MISC	03SB117	03SB1170610	X	X	X	-	X	-	-	-
MISC	03SB117	03SB117xxxx	X	X	X	-	X	-	-	-
MISC	03SB118	03SS1180002	-	X	-	X	-	-	-	-
MISC	03SB118	03SB1180206	-	X	-	X	-	-	-	-
MISC	03SB118	03SB1180610	X	X	-	X	-	-	-	-
MISC	03SB118	03SB118xxxx	X	X	-	X	-	-	-	-
MISC	03SB119	03SS1190002	-	X	-	-	-	-	-	-
MISC	03SB119	03SB1190206	-	X	-	-	-	-	-	-
MISC	03SB119	03SB1190610	X	X	-	-	-	-	-	-
MISC	03SB119	03SB119xxxx	X	X	-	-	-	-	-	-
MISC	03SB120	03SS1200002	-	X	X	X	X	-	-	-
MISC	03SB120	03SB1200206	-	X	X	X	X	-	-	-
MISC	03SB120	03SB1200610	X	X	X	X	X	-	-	-

TABLE 3-2

SOIL SAMPLES AND LABORATORY ANALYSES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Soil Boring Group[1]	Boring Location	Sample Number[2,3]	VOCs[4]	Explosives[4]	RDX Degradation Products[4]	Target Analyte List Metals[4]	Perchlorate	Total Organic Carbon	pH	Cation Exchange Capacity
MISC	03SB120	03SB120xxxx	X	X	X	X	X	-	-	-
MISC	03SB121	03SS1210002	-	X	-	X	-	-	-	-
MISC	03SB121	03SB1210206	-	X	-	X	-	-	-	-
MISC	03SB121	03SB1210610	X	X	-	X	-	-	-	-
MISC	03SB121	03SB121xxxx	X	X	-	X	-	-	-	-
		TOTALS	**146**	**292**	**104**	**160**	**104**	**8**	**8**	**8**

VOC Volatile organic compound.
MISC Miscellaneous.

1 Soil Boring Groups correspond to Figure 3-1. "OJT" indicates borings located at the OJT; "MISC" indicates borings located in the spaces between soil boring groups on Figure 3-1.
2 Sample numbers with "xxxx" will be collected between 10 feet bgs and bedrock if bedrock is deeper than 10 feet bgs. Actual depth will be determined at time of sampling.
3 For sample numbers ending in 0002 or 0206 VOC samples will be collected at the highest PID reading if a reading higher than background is obtained. See Section 3.5.1 of the text.
4 See Table 1-3 of this QAPP Addendum No. 1 for specific analysis requirements and analyte list.

TABLE 3-3

GROUND WATER SAMPLES AND LABORATORY ANALYSES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Location	Sample Number	VOCs[1]	Explosives[1]	Metals[1][2]	Perchlorate[1]
Ammunition Burning Grounds Main Treatment Area					
03-01	03GW0101	X	X	X	-
03-04	03GW0401	X	X	X	-
03-06	03GW0601	X	X	X	-
03-09	03GW0901	X	X	X	X
03-27	03GW2701	X	X	X	-
03-29	03GW2901	X	X	X	-
03-30	03GW3001	X	X	X	X
03-31	03GW3101	X	X	X	-
03-32	03GW3201	X	X	X	-
03-33	03GW3301	X	X	X	X
03-34	03GW3401	X	X	X	-
03-35	03GW3501	X	X	X	-
03-36	03GW3601	X	X	X	-
03-37	03GW3701	X	X	X	-
03-38	03GW3801	X	X	X	X
03-39	03GW3901	X	X	X	-
03C01P2	03GWC01P201	X	X	X	-
03C03P2	03GWC03P201	X	X	X	-
03C05	03GWC0501	X	X	X	X
03C06	03GWC0601	X	X	X	-
03C11	03GWC1101	X	X	X	X
03C13	03GWC1301	X	X	X	X
03C14	03GWC1401	X	X	X	-
03C21	03GWC2101	X	X	X	-
03C28	03GWC2801	X	X	X	-
03TW01[3]	03GWTW01[3]	X	X	X	X
03TW02[3]	03GWTW02[3]	X	X	X	-
03TW03[3]	03GWTW03[3]	X	X	X	-
03TW04[3]	03GWTW04[3]	X	X	X	-
03TW05[3]	03GWTW05[3]	X	X	X	-
Old Jeep Trail					
03-07	03GW0702	X	X	X	X
03-12	03GW1202	X	X	X	-
03-15	03GW1502	X	X	X	X
03-16	03GW1602	X	X	X	-

TABLE 3-3

GROUND WATER SAMPLES AND LABORATORY ANALYSES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA
PAGE 2 OF 2

Location	Sample Number	VOCs[1]	Explosives[1]	Metals[1][2]	Perchlorate[1]
03-21	03GW2102	X	X	X	-
03-24	03GW2402	X	X	X	-
03TW06[3]	03GWTW06[3]	X	X	X	-
Spring A'					
03SPA'	03SPAp01	X	X	X	-
Totals		39	39	39	10

1 See Table 1-3 of this QAPP Addendum No. 1 for specific analysis requirements and analyte list.
2 Unfiltered samples will be analyzed for total metals. If turbidity of water is greater than 10 nephelometric turbidity units, a filtered sample will also be collected and analyzed for dissolved metals.
3 "TW" refers to temporary wells, which are actually DPT borings from which ground water will be extracted from near the bedrock-overburden interface. Since it is not known where ground water will be encountered in the DPT borings ahead of time, their locations have not been placed on Figures 3-1, 3-2, or 3-3.

VOCs – Volatile organic compounds

TABLE 3-4

SUMMARY OF SOIL AND AQUEOUS SAMPLE ANALYSES AND QUALITY CONTROL SAMPLES
SWMU 03 – ABG.OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Parameter[1]	Samples	Field Duplicates[2]	Trip Blanks[3]	Source Water Blanks[4]	Rinsate Blanks	Matrix Spike/ Matrix Spike Duplicates[5]	Total[6]
SOIL SAMPLES							
Appendix IX VOCs	146	8	12	1	6	8/8	189
Explosives	292	15	NA	1	6	15/15	344
RDX Degradation Products	104	6	NA	1	6	6/6	129
TAL Metals plus Tin (total)	160	8	NA	1	6	8/8	191
Perchlorate	104	6	NA	1	6	6/8	129
Total Organic Carbon	8	1	NA	NA	NA	1/1	11
pH	8	1	NA	NA	NA	NA	9
Cation Exchange Capacity	8	1	NA	NA	NA	NA	9
AQUOUES SAMPLES (GROUND WATER, SPRING A', AND WATER AT OVERBURDEN-BEDROCK INTERFACE)							
Appendix IX VOCs	39	4	3	1	2	2/2	53
Explosives	39	4	NA	1	2	2/2	50
TAL Metals plus Tin (total)	39	4	NA	1	2	2/2	50
Perchlorate	10	1	NA	1	1	1/1	15

NA Not applicable.
TAL U.S. EPA Contract Laboratory Program Target Analyte List.
VOCs Volatile organic compounds.

1 See Table 1-3 of this QAPP Addendum No. 1 for specific analysis requirements and analyte lists.
2 Field duplicates will be collected at a frequency of 1 per every 20 samples.
3 Trip blanks will be submitted for analysis at a frequency of one per cooler containing samples for volatile organics analysis. Because the number of sample coolers shipped may vary, the number of trip blanks are estimated to be 10.
4 Source water blanks consist of analyte-free water and potable water used for decontamination.
5 Matrix spike (MS) and matrix spike duplicate (MSD) samples will be collected at a frequency of 1 per every 20 samples. MS/MSDs are not applicable for field analyses.
6 Actual totals may vary due to estimates made for trip blanks and rinsate blanks.

TABLE 3-5

SUMMARY OF SAMPLE ANALYSIS, CONTAINER TYPES AND VOLUMES, PRESERVATION REQUIREMENTS, AND HOLDING TIMES FOR AQUEOUS AND SOILS
SWMU 03 – ABG/OJT/LSC
QAPP ADDENDUM NO.1
NSWC CRANE, CRANE, INDIANA

Parameter	Sample Container	Container Volume	Preservation	Maximum Holding Time[1]	Analytical Laboratory
SOIL SAMPLES					
Appendix IX Volatile Organic Compounds	3 Encore™ samplers	Three 5-gram containers	Cool to 4 °C	48 hours to preservation; 14 days to analysis	Laucks
Explosives (including RDX Degradation Products)	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	Extraction 14 days; analysis within 40 days of extraction	Laucks
Target Analyte List Metals plus tin (total)	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	Analysis within 180 days (exoept mercury); mercury analysis within 28 days	Laucks
Perchlorate	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	28 days to analysis	Laucks
Total Organic Carbon	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	28 days	Laucks
pH	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	Cool to 4 °C	As soon as possible	Laucks
Cation Exchange Capacity	Wide-mouth jar, Teflon-lined plastic cap	8 ounce	None	TBD	TBD
AQUEOUS SAMPLES					
Appendix IX Volatile Organic Compounds	Glass, black phenolic plastic screw cap, Teflon-lined septum	(6) 40 mL	Cool to 4 °C, dark, zero headspace, HCl to pH <2	14 days to analysis	Laucks
RDX Degradation Products	Amber glass, Teflon-lined cap	(2) 1000 mL	Cool to 4 °C, dark	Extraction 7 days; analysis within 40 days of extraction	Laucks
Explosives	Amber glass, Teflon-lined cap	(2) 1000 mL	Cool to 4 °C, dark	Extraction 7 days; analysis within 40 days of extraction	Laucks

TABLE 3-5

SUMMARY OF SAMPLE ANALYSIS, CONTAINER TYPES AND VOLUMES, PRESERVATION REQUIREMENTS, AND HOLDING TIMES FOR AQUEOUS AND SOILS
SWMU 03 – ABG/OJT/LSC
QAPP ADDENDUM NO.1
NSWC CRANE, CRANE, INDIANA

Parameter	Sample Container	Container Volume	Preservation	Maximum Holding Time[1]	Analytical Laboratory
Target Analyte List Metals plus tin (total)	Polyethylene, plastic cap w/ plastic liner	1000 mL	Cool to 4 °C, HNO_3 to pH <2	Analysis within 180 days (except mercury); mercury analysis within 28 days	Laucks
Perchlorate	Polyethylene, plastic cap w/ plastic liner	500 mL	Cool to 4 °C, dark	Analysis within 28 days	Laucks

HCl = Hydrochloric acid, H2SO4 = Sulfuric Acid, HNO3 = Nitric Acid.
Laucks = Laucks Testing Laboratories, Inc.
TBD = To be determined.
1 All holding times are from date of collection.
mL = milliliters.

TABLE 3-6

PHYSICAL CHARACTERISTICS OF MONITORING WELLS FOR WATER LEVEL MEASUREMENTS
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Monitoring Well Number	Date Installed	Horizontal Location		Ground Surface Elevation* (feet amsl)	Top of Riser or Measuring Reference Point Elevation* (feet amsl)	Well Screen Interval		Well Screen Interval		Monitored Unit	Ground Water Depth & Elevation June 2002	
		North Coord. (feet NAD 27)	East Coord. (feet NAD 27)			Depth to Top (feet btor)	Depth to Bottom (feet btor)	Elevation* of Top (feet amsl)	Elevation* of Bottom (feet amsl)		Depth to Water (feet btor)	Ground Water Elevation*(1) (feet amsl)
02-01	8/26/1981	491384.48	596550.97	743.47	746.17	23.52	33.12	722.65	713.05	Upper Pennsylvanian	25.76	720.41
02-02	9/2/1981	491143.00	596074.00	724.67	727.67	42.70	52.30	684.97	675.37	Lower Pennsylvanian	45.31	682.36
02-03	9/3/1981	491058.00	595916.00	719.38	722.38	54.20	63.30	668.18	659.08	Hardinsburg	43.09	679.29
02-04	9/4/1981	490919.00	595915.00	716.02	719.02	38.90	48.10	680.12	670.92	Lower Pennsylvanian	37.77	681.25
02-05	9/5/1981	491491.00	596645.00	738.28	741.28	53.20	62.70	688.08	678.58	Lower Pennsylvanian	56.43	684.85
02-06	9/23/1981	491298.24	596384.94	742.56	744.65	59.48	68.78	685.17	675.87	Lower Pennsylvanian	59.87	684.78
02-07	9/24/1981	491192.73	596232.83	735.55	738.42	53.36	61.56	685.06	676.86	Lower Pennsylvanian	54.37	684.05
02-08	9/24/1981	491092.55	596224.65	730.06	732.20	48.88	56.14	683.32	676.06	Lower Pennsylvanian	48.52	683.68
02C09	1/23/1987	491331.00	597056.00	737.86	740.36	169.50	179.50	570.86	560.86	Beech Creek	170.26	570.10
02C09P2	1/26/1987	491331.00	597056.00	738.16	740.66	94.50	99.50	646.16	641.16	Golconda	N/A	N/A
02C10	2/13/1988	491789.00	596142.00	713.97	716.47	144.50	154.50	571.97	561.97	Beech Creek	146.56	569.91
02C10P2	2/16/1988	491789.00	596147.00	713.89	716.39	64.00	74.00	652.39	642.39	Golconda	40.46	675.93
02C10P3	2/22/1988	491784.00	596142.00	713.86	716.36	34.20	39.20	682.16	677.16	Lower Pennsylvanian	28.77	687.59
02C11	2/29/1988	490987.00	595829.00	712.81	715.31	150.50	160.50	564.81	554.81	Beech Creek	149.13	566.18
02C11P2	3/2/1988	490987.00	595823.00	712.86	715.36	72.30	82.30	643.06	633.06	Golconda	73.55	641.81
02C11P3	3/5/1988	490987.00	595817.00	713.16	715.66	38.80	43.80	676.86	671.86	Lower Pennsylvanian	34.65	681.01
02C12	3/14/1988	491496.00	596670.00	739.07	741.57	174.10	184.10	567.47	557.47	Beech Creek	171.22	570.35
02C12P2	3/21/1988	491496.00	596681.00	739.32	741.82	95.70	105.70	646.12	636.12	Golconda	89.22	652.60
02C12P3	3/18/1988	491496.00	596676.00	739.33	741.83	31.50	36.50	710.33	705.33	Upper Pennsylvanian	23.31	718.52
02C13	3/28/1988	491692.00	596436.00	722.61	725.11	71.80	81.80	653.31	643.31	Golconda	61.82	663.29
02C13P2	3/29/1988	491695.00	596439.00	722.28	724.78	36.50	46.50	688.28	678.28	Lower Pennsylvanian	39.82	684.96
02C13P3	3/30/1988	491698.00	596434.00	723.01	725.51	17.50	22.50	708.01	703.01	Upper Pennsylvanian	10.23	715.28
02C14	4/13/1988	490671.00	595964.00	713.90	716.40	156.40	166.40	560.00	550.00	Beech Creek	149.10	567.30
02C14P2	4/15/1988	490675.00	595964.00	713.93	716.43	76.90	86.90	639.53	629.53	Golconda	63.60	652.83
02C14P3	4/19/1988	490665.00	595964.00	713.76	716.26	39.60	49.60	676.66	666.66	Lower Pennsylvanian	36.58	679.68
02C15	5/10/1988	491186.00	595880.00	713.38	715.88	68.80	78.80	647.08	637.08	Golconda	69.88	646.00
02C15P2	5/11/1988	491181.00	595880.00	713.27	715.77	31.70	41.70	684.07	674.07	Lower Pennsylvanian	33.02	682.75
02C16	5/16/1988	490893.00	596177.00	722.86	725.36	81.10	91.10	644.26	634.26	Golconda	84.90	(640.46)
02C16P2	5/17/1988	490899.00	596177.00	722.68	725.18	46.00	56.00	679.18	669.18	Lower Pennsylvanian	42.67	682.51
02C17	5/23/1988	491022.00	596473.00	730.46	732.96	88.60	98.50	644.36	634.46	Golconda	84.53	648.43
02C17P2	5/26/1988	491027.00	596473.00	730.34	732.84	52.20	62.20	680.64	670.64	Lower Pennsylvanian	48.53	684.31
02C17P3	5/27/1988	491022.00	596473.00	730.34	733.38	23.10	28.10	710.28	705.28	Upper Pennsylvanian	Dry	Dry
02C18	6/6/1988	491103.00	596611.00	734.81	737.31	90.80	100.80	646.51	636.51	Golconda	88.73	648.58
02C18P2	6/7/1988	491107.00	596614.00	734.74	737.24	54.90	64.90	682.34	672.34	Lower Pennsylvanian	52.53	684.71
02C18P3	6/7/1988	491107.00	596614.00	734.74	737.45	15.50	20.50	721.95	716.95	Upper Pennsylvanian	20.98	716.47
02C19	6/14/1988	491338.00	596225.00	730.85	733.35	82.70	92.70	650.65	640.65	Golconda	87.10	646.25
02C19P2	6/15/1988	491332.00	596225.00	730.78	733.28	48.10	58.10	685.18	675.18	Lower Pennsylvanian	48.62	684.66
02C19P3	6/16/1988	491338.00	596225.00	730.78	733.63	13.20	18.20	720.43	715.43	Upper Pennsylvanian	Dry	Dry
02C20	6/29/1988	492114.00	596769.00	712.56	715.06	134.71	144.70	580.35	570.36	Beech Creek	137.47	577.59
02C20P2	6/22/1988	492120.00	596763.00	712.42	714.92	58.50	68.50	656.42	646.42	Golconda	57.69	657.23

TABLE 3-6

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Monitoring Well Number	Date Installed	Horizontal Location		Ground Surface Elevation* (feet amsl)	Top of Riser or Measuring Reference Point Elevation* (feet amsl)	Well Screen Interval		Well Screen Interval		Monitored Unit	Ground Water Depth & Elevation June 2002	
		North Coord. (feet NAD 27)	East Coord. (feet NAD 27)			Depth to Top (feet btor)	Depth to Bottom (feet btor)	Elevation* of Top (feet amsl)	Elevation* of Bottom (feet amsl)		Depth to Water (feet btor)	Ground Water Elevation*(1) (feet amsl)
02C20P3	6/23/1988	492120.00	596769.00	712.27	714.78	30.50	40.50	684.28	674.28	Lower Pennsylvanian	17.30	697.48
02C21	9/12/1990	491004.00	597187.00	726.48	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
02C22	10/15/1990	490129.00	597610.00	740.13	742.99	179.20	189.20	563.79	553.79	Beech Creek	Dry	Dry
02C22P2	10/17/1990	490124.00	597613.00	740.13	742.63	102.50	107.50	640.13	635.13	Golconda	Dry	Dry
02C22P3	10/18/1990	490119.00	597617.00	740.00	742.50	61.10	71.10	681.40	671.40	Lower Pennsylvanian	58.33	684.17
03C01	12/12/1986	490064.00	593140.00	624.58	627.28	176.70	186.70	450.58	440.58	Beaver Bend	114.86	512.42
03C01P2	9/22/1986	490068.00	593146.00	624.35	626.85	94.50	104.50	532.35	522.35	Beech Creek	69.90	556.95
03C01P3	4/87	490061.00	593147.00	624.00	626.50	22.10	27.10	604.40	599.40	Golconda	14.15	612.35
03C02	10/24/1986	489931.00	594793.00	580.99	583.49	122.00	132.00	461.49	451.49	Beaver Bend	71.28	512.21
03C02P2	10/29/1986	489931.82	594798.08	580.65	583.15	40.50	50.50	542.65	532.65	Beech Creek	37.54	545.61
03C03	9/13/1986	490202.94	594055.53	597.58	600.08	141.50	151.50	458.58	448.58	Beaver Bend	87.50	512.58
03C03P2	10/23/1986	490208.00	594056.00	597.70	600.20	58.30	68.30	541.90	531.90	Beech Creek	41.55	558.65
03C04	11/25/1986	490260.55	594783.22	621.92	624.42	76.00	86.00	548.42	538.42	Beech Creek	76.95	547.47
03C05	10/29/1986	489782.00	595114.00	578.86	581.36	34.50	44.50	546.86	536.86	Beech Creek	34.75	546.61
03C06	10/16/1986	489581.00	594596.00	622.90	625.40	89.50	99.50	535.90	525.90	Beech Creek	76.76	548.64
03C07	10/21/1986	490422.52	594370.95	633.97	636.47	91.20	101.20	545.27	535.27	Beech Creek	78.61	557.86
03C08AP2	11/26/1986	489701.00	594014.00	626.84	629.34	92.50	102.50	536.84	526.84	Beech Creek	74.48	554.86
03C08A	4/3/1987	489680.00	594051.00	628.00	630.50	173.50	183.50	457.00	447.00	Beaver Bend	118.47	512.03
03C08AP3	4/5/1987	489685.00	594047.00	627.93	630.43	17.00	22.00	613.43	608.43	Golconda	16.48	613.95
03C09	12/5/1986	490615.00	593777.00	600.89	603.39	147.50	157.50	455.89	445.89	Beaver Bend	91.05	512.34
03C09P2	12/7/1986	490619.57	593775.83	601.06	603.56	64.50	74.50	539.06	529.06	Beech Creek	45.17	558.39
03C10	1/22/1987	490242.71	593656.93	605.53	608.03	68.50	78.50	539.53	529.53	Beech Creek	49.85	558.18
03C11	1/28/1987	490024.65	594440.55	589.86	592.36	50.00	60.00	542.36	532.36	Beech Creek	43.75	548.61
03C12	2/3/1987	489957.37	594574.22	584.70	587.20	41.50	51.50	545.70	535.70	Beech Creek	41.85	545.35
03C13	2/9/1987	490901.00	593860.00	615.25	617.75	72.70	82.70	545.05	535.05	Beech Creek	59.46	558.29
03C14	2/20/1987	489932.00	593575.00	640.29	642.79	107.00	117.00	535.79	525.79	Beech Creek	84.92	557.87
03C15	2/26/1987	489849.54	593146.29	618.51	621.34	91.33	101.33	530.01	520.01	Beech Creek	64.37	556.97
03C15P3	4/87	489855.00	593143.00	618.61	621.11	18.10	23.10	603.01	598.01	Golconda	6.20	614.91
03C16	3/12/1987	490478.00	593362.00	680.75	683.25	148.50	158.50	534.75	524.75	Beech Creek	125.17	558.08
03C17	3/19/1987	492763.63	594371.09	693.65	696.15	141.00	151.00	555.15	545.15	Beech Creek	137.97	558.18
03C18	4/87	489992.00	592967.00	622.59	625.09	18.00	23.00	607.09	602.09	Golconda	4.49	620.60
03C19	5/8/1987	491442.00	593351.00	648.00	650.50	113.30	123.30	537.20	527.20	Beech Creek	92.13	558.37
03C19P3	5/13/1987	491431.00	593354.00	647.20	649.70	39.50	44.50	610.20	605.20	Golconda	32.74	616.96
03C20	5/24/1987	489880.21	593773.34	644.12	646.62	110.50	120.50	536.12	526.12	Beech Creek	89.29	557.33
03C21	5/28/1987	489925.00	593356.00	639.72	642.22	110.90	120.90	531.32	521.32	Beech Creek	84.96	557.26
03C21P2	5/29/1987	489925.00	593361.00	639.72	642.22	36.10	41.10	606.12	601.12	Golconda	34.08	608.14
03C22	6/4/1987	490090.00	593319.00	615.08	617.58	12.50	17.50	605.08	600.08	Golconda	9.66	607.92
03C23	6/9/1987	490259.00	593462.00	616.11	618.61	11.00	16.00	607.61	602.61	Golconda	5.70	612.91
03C24	6/16/1987	485159.00	592615.00	550.64	553.24	24.60	29.60	528.64	523.64	Beech Creek	21.50	531.74
03C25	6/18/1987	487148.51	592610.07	594.53	597.03	62.20	72.20	534.83	524.83	Beech Creek	46.68	550.35

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		North Coord. (feet NAD 27)	East Coord. (feet NAD 27)			Depth to Top (feet btor)	Depth to Bottom (feet btor)	Elevation* of Top (feet amsl)	Elevation* of Bottom (feet amsl)		Depth to Water (feet btor)	Ground Water Elevation*(1) (feet amsl)
03C26	8/3/1987	490695.18	594134.16	638.07	640.57	96.50	106.50	544.07	534.07	Beech Creek	82.44	558.13
03C27	8/14/1987	489658.33	594767.37	601.34	603.84	63.00	73.00	540.84	530.84	Beech Creek	60.78	543.06
03C28	8/22/1987	489884.00	595269.00	610.76	612.96	67.20	77.20	545.76	535.76	Beech Creek	67.41	545.55
03C29	9/1/1987	488529.00	591095.00	794.67	797.37	270.20	280.20	527.17	517.17	Beech Creek	242.40	554.97
03C30	9/17/1987	488967.44	592402.75	776.41	778.91	253.00	263.00	525.91	515.91	Beech Creek	223.23	555.68
03C31	11/1/1987	488492.00	593743.00	789.70	792.10	257.40	267.40	534.70	524.70	Beech Creek	238.06	554.04
03C32	11/14/1987	491056.00	594471.00	709.06	711.56	166.50	176.50	545.06	535.06	Beech Creek	153.65	557.91
03C33	11/31/87	486651.00	594224.00	782.53	785.03	241.00	251.00	544.03	534.03	Beech Creek	234.48	550.55
03C34	8/11/1989	487870.00	599301.00	724.57	727.07	180.00	190.00	547.07	537.07	Beech Creek	178.56	548.51
03C35	8/19/1989	485347.00	598082.00	695.50	697.00	166.00	176.00	531.00	521.00	Beech Creek	174.85	522.15
03C36	9/6/1989	485203.00	599202.00	715.74	718.24	171.50	181.50	546.74	536.74	Beech Creek	Dry	Dry
03C37	9/21/1989	483933.00	596471.00	617.78	620.28	107.00	117.00	513.28	503.28	Beech Creek	108.47	511.81
03C38	9/29/1989	485309.00	595951.00	570.47	572.97	45.50	55.50	527.47	517.47	Beech Creek	55.15	517.82
03B01	6/19/1987	482590.00	595584.00	501.97	504.47	10.00	15.00	494.47	489.47	Alluvium	6.96	497.51
03B02	6/27/1987	482573.03	595505.44	501.46	503.96	12.10	17.10	491.86	486.86	Alluvium	6.10	497.86
03B03	6/29/1987	482578.00	595406.00	502.46	504.96	11.00	16.00	493.96	488.96	Alluvium	5.74	499.22
03B04	6/30/1987	482630.95	595292.56	503.97	506.47	12.00	17.00	494.47	489.47	Alluvium	6.92	499.55
03B05	7/1/1987	482623.00	595192.00	504.55	507.05	11.50	16.50	495.55	490.55	Alluvium	7.05	500.00
03B06	7/2/1987	482666.00	594960.00	506.76	509.26	10.50	15.50	498.76	493.76	Alluvium	7.75	501.51
03B07	8/4/1987	482672.00	594768.00	508.22	510.72	6.50	11.50	504.22	499.22	Alluvium	6.60	504.12
03B08	8/5/1987	482667.00	594594.00	510.90	513.40	8.50	13.50	504.90	499.90	Alluvium	8.45	504.95
03B09	8/7/1987	482657.00	594417.00	513.54	516.04	8.00	13.00	508.04	503.04	Alluvium	9.82	506.22
03B10	10/22/1987	482607.00	594209.00	559.46	561.96	51.00	61.00	510.96	500.96	Beech Creek	50.60	511.36
03-01	9/4/1981	490748.00	593688.00	601.67	604.67	44.60	53.80	560.07	550.87	Big Clifty and Beech Creek	45.78	558.89
03-02	9/7/1981	489940.00	593060.00	619.67	622.67	6.50	13.00	616.17	609.67	Mansfield	N/A	N/A
03-03	9/8/1981	489838.00	594843.00	581.29	584.29	88.90	98.00	495.39	486.29	Sample Shale	N/A	N/A
03-04	9/24/1981	489791.00	594610.00	591.17	594.17	58.10	67.50	536.07	526.67	Beech Creek	N/A	N/A
03-05	9/29/1981	N/A	N/A	592.75	595.75	48.40	57.70	547.35	538.05	Beech Creek	N/A	N/A
03-06	10/6/1981	489796.00	594636.00	586.71	589.71	40.30	49.60	549.41	540.11	Beech Creek	N/A	N/A
03-07	10/8/1981	487837.91	596315.43	553.46	556.48	15.42	24.72	541.06	531.76	Alluvium and Beech Creek (breccia zone)	11.93	544.55
03-08	10/9/1981	N/A	N/A	583.76	586.76	35.40	44.80	551.36	541.96	Beech Creek	N/A	N/A
03-09	10/28/1981	489909.00	593047.00	621.72	624.72	68.90	78.10	555.82	546.62	Big Clifty	67.80	556.92
03-10	11/3/1982	487821.20	596515.84	554.94	557.99	15.25	24.55	542.74	533.44	Beech Creek (breccia zone)	16.60	541.39
03-11	11/4/1982	487708.67	596434.59	550.05	553.41	9.06	18.46	544.35	534.95	Beech Creek (breccia zone)	9.77	543.64
03-12	11/4/1982	487765.38	596231.91	554.99	558.24	15.45	24.85	542.79	533.39	Beech Creek (breccia zone)	16.55	541.69
03-13	11/5/1982	487633.96	596376.32	549.24	552.26	15.02	24.42	537.24	527.84	Beech Creek (breccia zone)	12.95	539.31
03-14	11/6/1982	487672.86	596420.54	549.37	552.41	8.24	17.74	544.17	534.67	Beech Creek (breccia zone)	11.57	540.84
03-15	11/22/1982	487874.92	596346.66	556.09	559.31	18.92	28.32	540.39	530.99	Breccia zone and Beech CreeK	17.98	541.33
03-16	11/23/1982	488566.76	595786.62	568.61	571.70	26.29	35.69	545.41	536.01	Beech Creek (breccia zone)	29.14	542.56
03-17	11/24/1982	487650.31	596264.68	550.44	553.47	15.33	24.73	538.14	528.74	Beech Creek (breccia zone)	16.18	537.29

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Monitoring Well Number	Date Installed	Horizontal Location		Ground Surface Elevation* (feet amsl)	Top of Riser or Measuring Reference Point Elevation* (feet amsl)	Well Screen Interval		Well Screen Interval		Monitored Unit	Ground Water Depth & Elevation June 2002	
		North Coord. (feet NAD 27)	East Coord. (feet NAD 27)			Depth to Top (feet btor)	Depth to Bottom (feet btor)	Elevation* of Top (feet amsl)	Elevation* of Bottom (feet amsl)		Depth to Water (feet btor)	Ground Water Elevation*(1) (feet amsl)
03-18	1/14/1983	487508.18	596288.23	549.80	553.12	17.92	27.22	535.20	525.90	Beech Creek (breccia zone)	17.71	535.41
03-19	1/15/1983	N/A	N/A	556.37	559.37	23.10	32.50	536.27	526.87	Beech Creek (breccia zone)	N/A	N/A
03-20	1/17/1983	487674.48	596119.27	551.83	554.76	17.33	26.63	537.43	528.13	Beech Creek (breccia zone)	18.28	536.48
03-21	1/27/1983	488039.00	596246.09	557.12	560.11	15.79	25.09	544.32	535.02	Beech Creek	18.92	541.19
03-22	1/27/1983	487791.08	596369.15	555.72	558.68	17.46	26.86	541.22	531.82	Beech Creek (breccia zone)	16.58	542.10
03-23	1/28/1983	487958.48	596055.94	559.34	562.49	18.05	26.45	544.44	536.04	Breccia zone and Beech Creek	18.10	544.39
03-24	2/6/1983	488012.65	596461.97	586.04	589.28	45.24	54.64	544.04	534.64	Beech Creek	49.34	539.94
03-25	2/7/1983	487901.68	596498.01	570.64	573.97	27.53	36.83	546.44	537.14	Beech Creek	32.80	541.17
03-26	10/1/1983	N/A	N/A	592.89	595.89	38.90	48.00	556.99	547.89	Big Clifty	N/A	N/A
03-27	10/3/1983	489964.00	593967.00	596.08	599.08	21.50	30.60	577.58	568.48	Big Clifty	N/A	N/A
03-28	10/6/1983	489705.00	594006.00	624.49	627.49	15.50	24.60	611.99	602.89	Hardinsburg/Golconda	11.16	616.33
03-29	10/8/1983	489992.00	593981.00	595.61	598.61	39.60	48.60	559.01	550.01	Big Clifty	N/A	N/A
03-30	10/4/1985	490818.00	593630.00	N/A	608.60	N/A	N/A	N/A	N/A	Big Clifty	50.15	558.45
03-31	10/10/1985	489788.00	594804.00	N/A	582.84	N/A	N/A	N/A	N/A	Big Clifty	37.73	545.11
03-32	10/11/1985	489857.00	594822.00	N/A	583.54	N/A	N/A	N/A	N/A	Big Clifty	N/A	N/A
03-33	10/13/1985	489923.00	594836.00	N/A	583.39	N/A	N/A	N/A	N/A	Big Clifty	36.67	546.72
03-34	10/21/1985	489844.00	594662.00	N/A	585.06	N/A	N/A	N/A	N/A	Big Clifty	N/A	N/A
03-35	10/23/1985	489830.00	594561.00	N/A	586.60	N/A	N/A	N/A	N/A	Beech Creek	N/A	N/A
03-36	10/25/1985	489691.00	594603.00	N/A	617.54	N/A	N/A	N/A	N/A	Beech Creek	N/A	N/A
03-37	10/27/1985	489890.00	594618.00	N/A	586.52	N/A	N/A	N/A	N/A	Beech Creek	N/A	N/A
03-38	11/2/1985	490676.00	593744.00	N/A	604.79	N/A	N/A	N/A	N/A	Big Clifty	46.25	558.54
03-39	11/2/1985	490700.00	593792.00	N/A	603.25	N/A	N/A	N/A	N/A	Big Clifty	44.36	558.89
03SG01	6/9/2001	490124.27	594313.10	N/A	587.20	N/A	N/A	N/A	N/A	N/A	2.80	584.40
03SG02	6/9/2001	488570.67	595726.88	555.50	561.84	N/A	N/A	N/A	N/A	N/A	Dry	Dry
03SG03	6/9/2001	487330.50	596436.67	541.07	547.42	N/A	N/A	N/A	N/A	N/A	Dry	Dry
03SG04	6/9/2001	485646.58	596328.42	525.94	533.32	N/A	N/A	N/A	N/A	N/A	Dry	Dry
03SG05	6/9/2001	484740.20	596109.74	N/A	525.05	N/A	N/A	N/A	N/A	N/A	6.93	518.12
03SG06	6/9/2001	483694.26	595518.08	N/A	513.57	N/A	N/A	N/A	N/A	N/A	6.30	507.27
03SG07	6/9/2001	482632.16	595545.26	N/A	499.95	N/A	N/A	N/A	N/A	N/A	1.04	498.91

amsl = Above mean sea level.
N/A = Not available or not applicable.
btor = Below top of riser.
1 = Ground water elevation estimated due to well riser damage.
* All elevations are based on National Geodetic Vertical Datum of 1929 (NGVD 29).

TABLE 3-7

NON-CALIBRATION QUALITY CONTROL SAMPLE USAGE FREQUENCIES, ACCEPTANCE LIMITS, AND CORRECTIVE ACTIONS
SWMU 03 – ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

QC Sample Type	Collection Frequency	Acceptance Limit	Corrective Action
Field Duplicate	1 per 20 investigative samples collected.	Aqueous = 30% RPD Soil/Sediment = 50% RPD	Qualify data according to data validation requirements.
Equipment Rinsate Blank	A maximum of eight rinsate blanks are scheduled. 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.	< RL (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.
Source Water Blank	One per source of water used for sampling equipment decontamination.	< RL (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 Blank	One per cooler containing samples for volatile organics analysis.	< RL (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 analysis.	Retention times stable to ±30 seconds; area counts stable to within factor of 2.	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols and Section 4.8.
Laboratory Control Sample	1 per 20 environmental samples per matrix.	See Tables 4-3, 4-5, 4-7, 4-9	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols and Section 4.8.
Laboratory Duplicate	1 per 20 environmental samples analyzed for inorganic target analytes.	See Tables 4-11	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols and Section 4.8.

TABLE 3-7

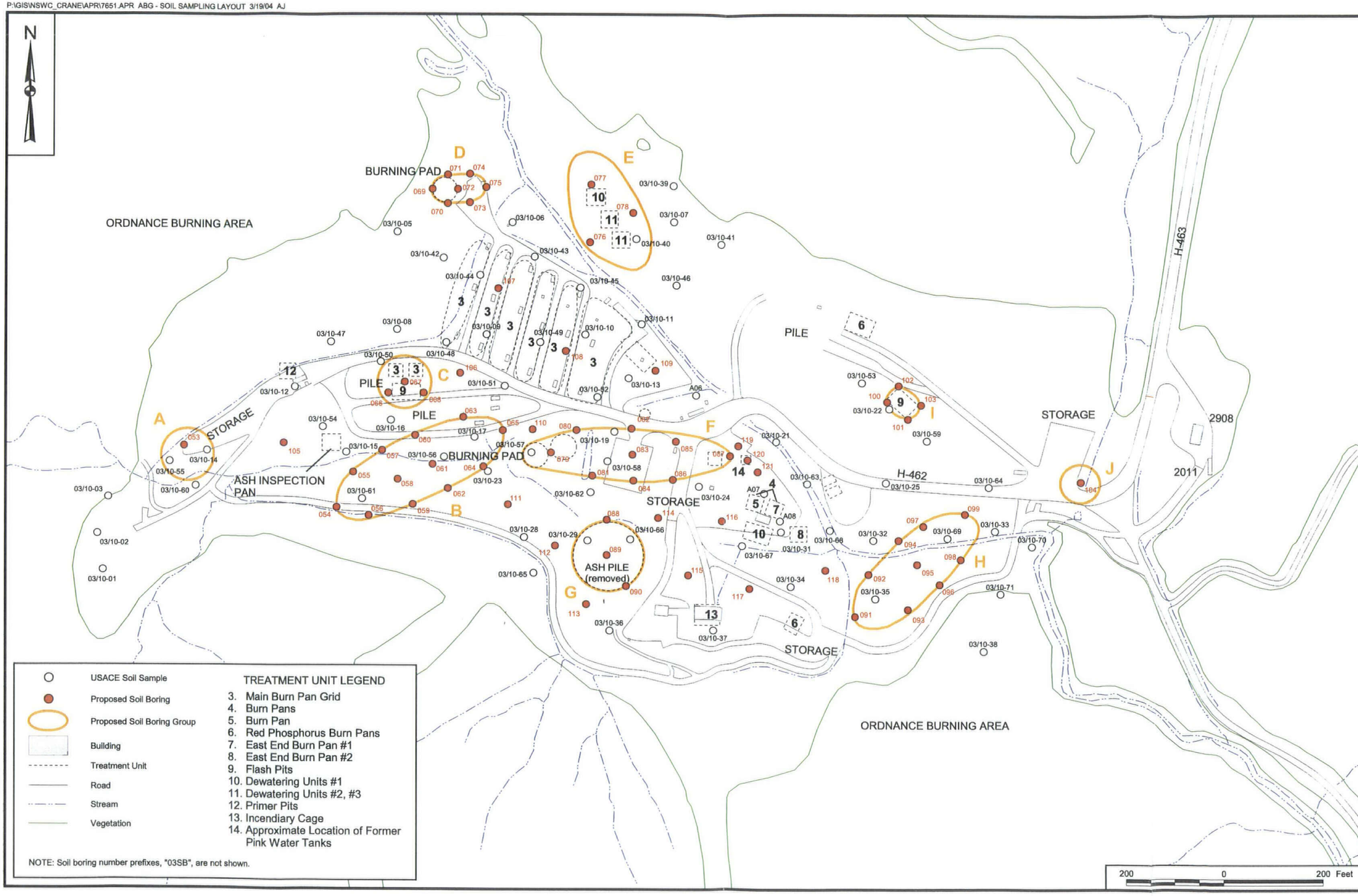
NON-CALIBRATION QUALITY CONTROL SAMPLE USAGE FREQUENCIES, ACCEPTANCE LIMITS, AND CORRECTIVE ACTIONS
SWMU 03 – ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

QC Sample Type	Collection Frequency	Acceptance Limit	Corrective Action
Laboratory Method Blank	1 per 20 environmental samples or per preparation batch, whichever is more frequent.	< RL (soil and water)	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols and Section 4.8.
Matrix Spike[1]	1 per 20 environmental samples.	See Tables 4-2, 4-4, 4-6, 4-8	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols and Section 4.8.
Matrix Spike Duplicate[1]	1 per 20 environmental samples analyzed for organic target analytes.	See Tables 4-2, 4-4, 4-6, 4-8	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols and Section 4.8.
Post-digestion Spike	Only if out-of-control matrix spike exists (metals only)	100 ± 20%	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols and Section 4.8.
Surrogate	At least one per sample for organic chromatographic analyses (GC, GC/MS, and HPLC).	See Table 4-10	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols and Section 4.8.
Temperature Blank	One blank per sample cooler.	4°C ± 2 °C	Laboratory action taken per LTL-1008. TtNUS action taken per validation protocols and Section 4.8.

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.

QC = Quality control.
RPD = Relative percent difference.
RL = Reporting limit.
FOL = Field Operations Leader.
GC/MS = Gas chromatograph/mass spectrometer.
HPLC = High-performance liquid chromatography.

P:\GIS\NSWC_CRANE\APR\7651.APR ABG - SOIL SAMPLING LAYOUT 3/19/04 AJ



CONTRACT NO. N8383

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 3 - 1

REV 0

PROPOSED SOIL SAMPLING LOCATIONS,
AMMUNITION BURNING GROUNDS MAIN TREATMENT AREA
SWMU 03 - AMMUNITION BURNING GROUNDS, OLD JEEP TRAIL,
AND LITTLE SULPHUR CREEK
QAPP ADDENDUM NO. 1
NSWC CRANE
CRANE, INDIANA

DRAWN BY A. JANOCHA DATE 3/01/04

CHECKED BY J. GOERDT DATE 3/19/04

COST/SCHED-AREA

SCALE AS NOTED

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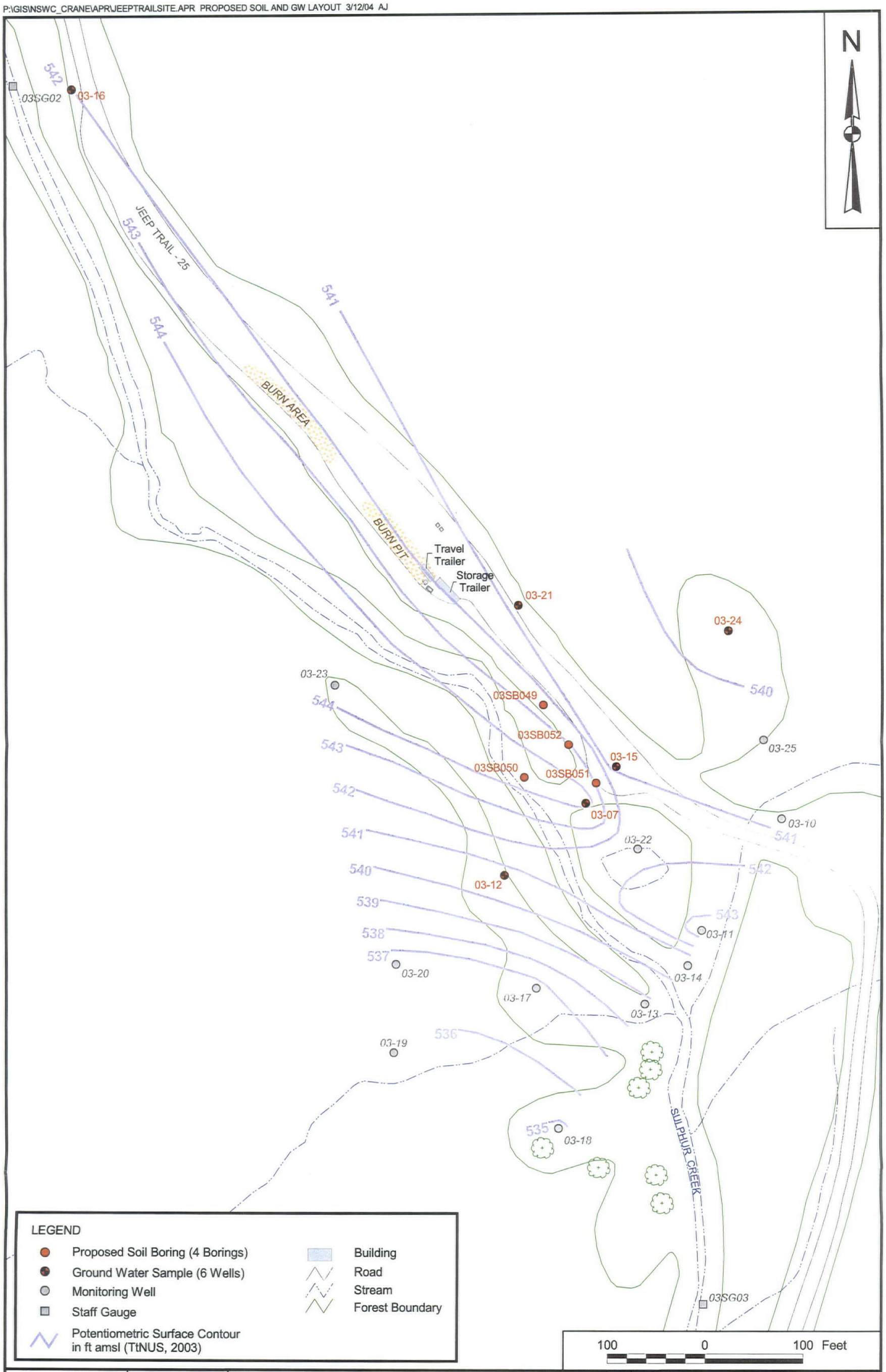

DRAWN BY	DATE
A. JANOCHA	3/01/04
CHECKED BY	DATE
J. GOERDT	3/12/04
COST/SCHEDULE-AREA	
SCALE AS NOTED	

PROPOSED SOIL AND GROUND WATER SAMPLING LOCATIONS,
OLD JEEP TRAIL AREA
SWMU 03 - AMMUNITION BURNING GROUNDS, OLD JEEP TRAIL, AND LITTLE SULPHUR CREEK
QAPP ADDENDUM NO. 1
NSWC CRANE
CRANE, INDIANA

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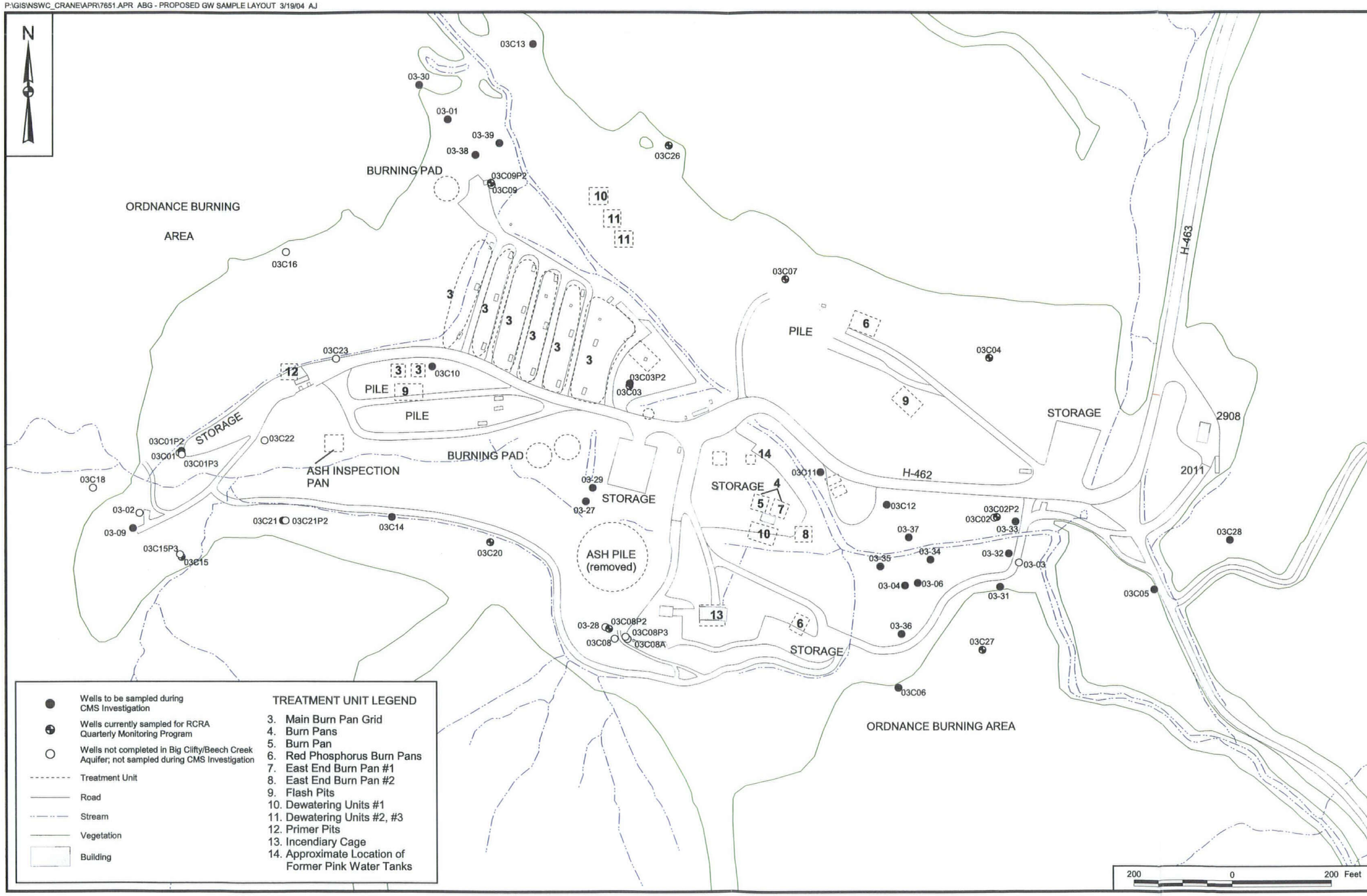
APPROVED BY —	DATE —
DRAWING NO. FIGURE 3 - 2	REV 0

P:\GIS\NSWC_CRANE\APR\7651.APR ABG - PROPOSED GW SAMPLE LAYOUT 3/19/04 AJ



Wells to be sampled during CMS Investigation

Wells currently sampled for RCRA Quarterly Monitoring Program

Wells not completed in Big Clifty/Beech Creek Aquifer; not sampled during CMS Investigation

Treatment Unit

Road

Stream

Vegetation

Building

TREATMENT UNIT LEGEND

3. Main Burn Pan Grid
4. Burn Pans
5. Burn Pan
6. Red Phosphorus Burn Pans
7. East End Burn Pan #1
8. East End Burn Pan #2
9. Flash Pits
10. Dewatering Units #1
11. Dewatering Units #2, #3
12. Primer Pits
13. Incendiary Cage
14. Approximate Location of Former Pink Water Tanks

CONTRACT NO. N8383

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 3 - 3

REV 0

PROPOSED GROUND WATER SAMPLING LOCATIONS,
AMMUNITION BURNING GROUNDS
SWMU 03 - AMMUNITION BURNING GROUNDS, OLD JEEP TRAIL,
AND LITTLE SULPHUR CREEK
QAPP ADDENDUM NO. 1
NSWC CRANE
CRANE, INDIANA

DRAWN BY A. JANOCHA DATE 3/01/04

CHECKED BY J. GOERDT DATE 3/19/04

COST/SCHED-AREA

SCALE AS NOTED

4.0 SAMPLE CUSTODY, EQUIPMENT CALIBRATION, DATA MANAGEMENT, AND GENERAL QA/QC PROCEDURES

References are made in this section to the original ABG, LSC, and OJT QAPP (TtNUS, 2001), which governed activities conducted by Laucks Testing Laboratories, Inc., Triangle Laboratories, and APC Laboratories. Triangle Laboratories, and APC Laboratories are not involved in this CMS data collection effort.

4.1 SAMPLE CUSTODY

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 requirements are presented in Section 5.0 of the approved ABG, LSC, and OJT QAPP (TtNUS, 2001).

Laucks Testing Laboratories, Inc. will be responsible for analysis of the samples generated under this QAPP Addendum No. 1.

The laboratory contact information, including shipping addresses, is provided in Table 2-1 of this QAPP Addendum No.1.

4.2 CALIBRATION PROCEDURES AND FREQUENCIES

All instrumentation used to perform chemical measurements must be properly calibrated prior to use in order to obtain valid and usable results. Instruments used in the field and in the laboratory will be calibrated in accordance with the procedures governing the use of the instruments (Appendix A). Calibration procedures and frequencies are described in Section 6.0 of the approved ABG, LSC, and OJT QAPP (TtNUS, 2001).

4.3 ANALYTICAL AND MEASUREMENT PROCEDURES

Field measurements and laboratory analytical requirements are presented in this section.

4.3.1 Field Measurement Procedures

Parameters to be measured using field instrumentation include sample depth, sample location, and the parameters listed in Table 3-1 of Section 3.0. Measurement of field parameters is governed by the applicable SOPs included in Appendix A. NA parameters will **not** be measured as part of this field effort. Instead, that type of data will be collected as part of the NSWC Crane quarterly ground water monitoring program that includes the ABG monitoring wells.

4.3.2 Laboratory Analytical and Measurement Procedures

Laucks Testing Laboratories, Inc. has successfully completed the laboratory evaluation process required as part of the Naval Facilities Engineering Service Center (NFESC) QA Program as described in the Department of Defense (DoD) Environmental Data Quality Systems Manual for Environmental Laboratories (DoD, 2002). Table 4-1 provides a summary of the laboratory analytical methods and associated laboratory SOPs to be used during this investigation. Laboratory SOPs are included in Appendix I of the approved ABG, LSC, and OJT QAPP (TtNUS, 2001). Any SOPs that have been updated between the Round 1 sampling effort for which that QAPP was developed and the generation of this QAPP Addendum are provided in Appendix C of this Addendum No. 1.

4.3.2.1 List of Project Target Compounds and Detection Limits

A list of the laboratory target analytes, project-specific risk-based target levels, and reporting limits (RLs) is provided in Table 1-3 of this QAPP Addendum No. 1. Only the laboratory analyses listed in Table 1-3 and field analyses listed in Table 3-1 of this QAPP Addendum No. 1 will be conducted for this CMS data collection effort.

4.3.2.2 List of Associated Quality Control Samples

Field and laboratory QC samples to be analyzed in support of this project are identified in Section 4.4. The analytical SOPs included in Appendix C of this QAPP Addendum No. 1 address minimum QC requirements for each associated analytical method. The SOPs include calibration QC requirements.

4.4 INTERNAL QUALITY CONTROL CHECKS

Field and laboratory QC samples will be analyzed routinely to evaluate overall data quality. Table 3-4 of this QAPP Addendum No.1 presents the numbers of QC samples anticipated to be collected in the field. Section 6.0 of the approved ABG, LSC, and OJT QAPP (TtNUS, 2001) addresses instrument calibrations;

and Section 8.0 of that QAPP describes field and laboratory QC sample types and level of effort associated with them for this project. All laboratory QC limits applicable to this CMS field effort are presented in Tables 4-2 through 4-11 of this section.

Definitions and descriptions of various field and laboratory QC samples are presented in Section 8.0 of the approved ABG, LSC, and OJT QAPP (TtNUS, 2001).

Completeness goals for this field effort are 90 percent for laboratory data and 100 percent for well stabilization data. See Section 3.0 of the approved ABG, LSC, and OJT QAPP (TtNUS, 2001) for a discussion of completeness and other QA objectives for measurement data.

4.5 DATA REPORTING , MANAGEMENT, REDUCTION, AND VALIDATION

Data reporting conventions will be consistent with the Round 1 RFI Phase III investigation reporting conventions and as described in Sections 1.4 and 9.0 of the approved ABG, LSC, and OJT QAPP (TtNUS, 2001).

Appendix F and Section 9.0 of the approved ABG, LSC, and OJT QAPP (TtNUS, 2001) describe the procedures to be used for data management (Appendix F), reduction (Section 9.0), and validation (Section 9.0). Those requirements that govern analytical laboratory performance apply to Laucks Testing Laboratories, Inc. for all analyses conducted in conjunction with this field effort.

Concentration measurements in the field will be reported in the units indicated in Table 1-10 of the approved ABG, LSC, and OJT QAPP (TtNUS, 2001). Units of measure for laboratory analyses will be as indicated in Table 1-3 of this QAPP Addendum No. 1.

The calculations that will be used to quantitate completeness, precision, and accuracy are presented in Section 12.0 of the approved ABG, LSC, and OJT QAPP (TtNUS, 2001). In addition, the comparability and representativeness of collected data will be assessed as described in that section, and the results of the data collection will be reconciled with project objectives to ensure that the data support the project goals.

4.6 PERFORMANCE AND SYSTEM AUDITS

Performance and system audits are conducted routinely in accordance with Section 10.0 of the approved ABG, LSC, and OJT QAPP (TtNUS, 2001).

4.7 PREVENTIVE MAINTENANCE PROCEDURES

Equipment used to collect samples will be maintained in accordance with the manufacturers' operation and maintenance manuals. The preventive maintenance requirements for field and laboratory equipment are presented in Section 11.0 of the approved ABG, LSC, and OJT QAPP (TtNUS, 2001). These operations will occur in accordance with the applicable analytical SOPs of Appendix C to this QAPP Addendum No. 1.

4.8 CORRECTIVE ACTION

The TtNUS QA/QC program requires that any and all personnel noting conditions adverse to quality should report these conditions immediately to the TOM and Quality Assurance Manager (QAM). These parties, in turn, are charged with implementing appropriate corrective action in a timely manner. It is ultimately the responsibility of the QAM to document all findings and corrective actions taken and to monitor the effectiveness of the corrective measures performed. Corrective action requirements for field, laboratory, and data validation and reporting non-conformances are presented in Section 13.0 of the approved ABG, LSC, and OJT QAPP (TtNUS, 2001).

4.9 QUALITY ASSURANCE REPORTS TO MANAGEMENT

QA reports to management will be provided in four primary formats during the course of this investigation: data validation reports, reports summarizing accomplishments and QA/QC issues during the field investigation, project-wide progress reports, and laboratory QA reports. The report frequencies, content, preparers, and recipients are summarized in Section 14.0 of the approved ABG, LSC, and OJT QAPP (TtNUS, 2001).

TABLE 4-1

SUMMARY OF ORGANIC, INORGANIC, AND MISCELLANEOUS ANALYTICAL LABORATORY PROCEDURES FOR SOLID AND AQUEOUS SAMPLES SWMU 03 - ABG/OJT/LSC QAPP ADDENDUM NO. 1 NSWC CRANE, CRANE, INDIANA

Analytical Parameter [1]	Preparation Method [2,3]	Analytical Method [2,3]	Preparation/Analytical SOP(s) [4]
EXPLOSIVES AND DEGRADATION PRODUCTS			
Explosives SW-846 8330	Aqueous SW-846 3535/8330 Solid SW-846 8330	Aqueous SW-846 8330 Solid SW-846 8330	Aqueous LTL-3077 / LTL-8330 Solid LTL-3161 / LTL-8330
Miscellaneous explosives and RDX degradation products by modified SW-846 Method 8330	Solid SW-846 8330	Solid SW-846 8330	Solid LTL-3077/LTL-8330
APPENDIX IX AND TAL METALS			
Metals (except antimony, tin, and mercury), total or dissolved, as applicable (See Table 1-3)	Aqueous SW-846 Methods 3010A (**no** HCl) or 3015 (**no** HCl) Solid SW-846 Method 3050B (include H_2O_2 but **no** HCl)	Aqueous and Solid SW-846 Method 6020	Aqueous LTL-7009 or LTL-7010/ LTL-7202 Solid LTL-7015/ LTL-7202
Antimony and tin, total or dissolved, as applicable (See Table 1-3)	Aqueous SW-846 Methods 3010A or 3015 (**no** H_2O_2) Solid SW-846 Method 3050B (include HCl but **no** H_2O_2)	Aqueous and Solid SW-846 Method 6020	Aqueous LTL-7009 or LTL-7010/ LTL-7202 Solid LTL-7015/ LTL-7202
Mercury, total or dissolved, as applicable (See Table 1-3)	Aqueous SW-846 Method 7470A Solid SW-846 Method 7471A	Aqueous SW-846 Method 7470A Solid SW-846 Method 7471A	Aqueous LTL-7501 Solid LTL-7501
VOLATILES			
VOCs SW-846 8260B[5]	Aqueous SW-846 Method 5030B (25 mL purge) Solid SW-846 Method 5035A (5 g purge)	Aqueous SW-846 Method 8260B (25 mL purge) Solid SW-846 Method 8260B (5 g purge)	Aqueous LTL-8265 (low level) Solid LTL-8265

TABLE 4-1

SUMMARY OF ORGANIC, INORGANIC, AND MISCELLANEOUS ANALYTICAL LABORATORY PROCEDURES FOR SOLID AND AQUEOUS SAMPLES SWMU 03 - ABG/OJT/LSC QAPP ADDENDUM NO. 1 NSWC CRANE, CRANE, INDIANA

Analytical Parameter [1]	Preparation Method [2,3]	Analytical Method [2,3]	Preparation/Analytical SOP(s) [4]
MISCELLANEOUS PARAMETERS			
Total Organic Carbon	Aqueous SW-846 Method 9060 Solid SW-846 Method 9060	Aqueous SW-846 Method 9060 Solid SW-846 Method 9060	Aqueous LTL-9115 Solid LTL-9116
pH	Solid SW-846 Method 9045	Solid SW-846 Method 9045	Solid LTL-9113
Cation Exchange Capacity	Solid SW-846 Method 9081	Solid SW-846 Method 9081	Solid LTL-6006
Perchlorate	Aqueous EPA 314.0 Solid EPA 314.0	Aqueous EPA 314.0 Solid EPA 314.0	Aqueous LTL-9136 Solid LTL-9136
PERCHLORATE 8321A (Confirmatory analysis only, for perchlorate detected by Method 314.0)			
Perchlorate	Aqueous SW-846 8321A Solid SW-846 8321A	Aqueous SW-840 8321A Solid SW-846 8321A	Aqueous SW-846 8321A Solid SAC-LC-0012

TAL = US EPA Contract Laboratory Program Target Analyte List
VOCs = Volatile Organic Compounds

1 Reference Table 1-3 of Section 1.0 for the specific compounds.
2 U.S. EPA, 1986. Test methods for Evaluating Solid Wastes, Physical/Chemical Methods. SW-846, Third Edition and subsequent updates.
3 U.S. EPA Chemical Analyses of Water and Wastewater, March 1983.
4 Laboratory SOPs revised or added since preparation of the original QAPP (TtNUS, 2001) are included in Appendix C of this QAPP Addendum No. 1.
5 The compounds propionitrile, 1,4-dioxane, acetonitrile, and isobutyl alcohol usually analyzed by SW-846 Method 8015 have been removed. See Table 1-3.

TABLE 4-2

METALS QUALITY CONTROL LIMITS[1], MATRIX SPIKE, AND LABORATORY DUPLICATE SAMPLES SWMU 03 - ABG/OJT/LSC QAPP ADDENDUM NO. 1 NSWC CRANE, CRANE, INDIANA

Chemical	CAS No.	Aqueous Matrix		Solid Matrix	
		Accuracy (%R)	Precision (RPD)	Accuracy (%R)	Precision (RPD)
Aluminum	7429-90-5	75-125	20	75-125	20
Antimony	7440-36-0	75-125	20	75-125	20
Arsenic	7440-38-2	75-125	20	75-125	20
Barium	7440-39-3	75-125	20	75-125	20
Beryllium	7440-41-7	75-125	20	75-125	20
Cadmium	7440-43-9	75-125	20	75-125	20
Calcium	7440-70-2	75-125	20	75-125	20
Chromium	7440-47-3	75-125	20	75-125	20
Cobalt	7440-48-4	75-125	20	75-125	20
Copper	7440-50-8	75-125	20	75-125	20
Iron	7439-89-6	75-125	20	75-125	20
Lead	7439-92-1	75-125	20	75-125	20
Magnesium	7439-95-4	75-125	20	75-125	20
Manganese	7439-96-5	75-125	20	75-125	20
Mercury	7439-97-6	75-125	20	75-125	20
Nickel	7440-02-0	75-125	20	75-125	20
Potassium	7440-09-7	75-125	20	75-125	20
Selenium	7782-49-2	75-125	20	75-125	20
Silver	7440-22-4	75-125	20	75-125	20
Sodium	7440-23-5	75-125	20	75-125	20
Thallium	7440-28-0	75-125	20	75-125	20
Tin	7440-31-5	75-125	20	75-125	20
Titanium	7440-32-6	70-130	25	70-130	25
Vanadium	7440-62-2	75-125	20	75-125	20
Zinc	7440-66-6	75-125	20	75-125	20

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
CAS No. = Chemical Abstracts Services Registry Number.
QC = Quality control.
%R = Percent recovery.
RPD = Relative percent difference.

TABLE 4-3

METALS QUALITY CONTROL LIMITS[1] FOR LABORATORY CONTROL SAMPLES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Chemical	CAS No.	Aqueous Matrix	Solid Matrix
		Accuracy (%R)	Accuracy (%R)
Aluminum	7429-90-5	80-120	80-120
Antimony	7440-36-0	80-120	80-120
Arsenic	7440-38-2	80-120	80-120
Barium	7440-39-3	80-120	80-120
Beryllium	7440-41-7	80-120	80-120
Cadmium	7440-43-9	80-120	80-120
Calcium	7440-70-2	80-120	80-120
Chromium	7440-47-3	80-120	80-120
Cobalt	7440-48-4	80-120	80-120
Copper	7440-50-8	80-120	80-120
Iron	7439-89-6	80-120	80-120
Lead	7439-92-1	80-120	80-120
Magnesium	7439-95-4	80-120	80-120
Manganese	7439-96-5	80-120	80-120
Mercury	7439-97-6	75-125	90-110
Nickel	7440-02-0	80-120	80-120
Potassium	7440-09-7	80-120	80-120
Selenium	7782-49-2	80-120	80-120
Silver	7440-22-4	80-120	80-120
Sodium	7440-23-5	80-120	80-120
Thallium	7440-28-0	80-120	80-120
Tin	7440-31-5	80-120	80-120
Titanium	7440-32-6	80-120	80-120
Vanadium	7440-62-2	80-120	80-120
Zinc	7440-66-6	80-120	80-120

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
CAS No. = Chemical Abstracts Services Registry Number.

TABLE 4-4

EXPLOSIVES (8330) QUALITY CONTROL LIMITS[1] FOR MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES SWMU 03 - ABG/OJT/LSC QAPP ADDENDUM NO. 1 NSWC CRANE, CRANE, INDIANA

Chemical	CAS No.	Aqueous Matrix		Solid Matrix	
		Accuracy (%R)	Precision (RPD)	Accuracy (%R)	Precision (RPD)
1,3,5-Trinitrobenzene	99-35-4	50-140	30	50-140	50
1,3-Dinitrobenzene	99-65-0	50-140	30	50-140	50
2,4,6-Trinitrotoluene	118-96-7	50-140	30	50-140	50
2,4-DA-6-NT	6629-29-4	30-160	30	30-160	50
2,4-Dinitrotoluene	121-14-2	50-140	30	50-140	50
2,6-DA-4-NT	59229-75-3	30-160	30	30-160	50
2,6-Dinitrotoluene	606-20-2	50-140	30	50-140	50
2-Amino-4,6-dinitrotoluene	355-72-78-2	50-140	30	50-140	50
2-Nitrotoluene	88-72-2	50-140	30	50-140	50
3,5-DNA	618-87-1	30-160	30	30-160	50
3-Nitrotoluene	99-08-1	50-140	30	50-140	50
DNX	NA	30-160	30	30-160	50
4-Amino-2,6-dinitrotoluene	1946-51-0	50-140	30	50-140	50
4-Nitrotoluene	99-99-0	50-140	30	50-140	50
HMX	2691-41-0	50-140	30	50-140	50
MNX	NA	30-160	30	30-160	50
Nitrobenzene	98-95-3	50-140	30	50-140	50
RDX	121-82-4	50-140	30	50-140	50
Tetryl	479-45-8	50-140	30	50-140	50
TNX	NA	30-160	30	30-160	50
4,4'-TN-AZOXY	NA	30-160	30	30-160	50

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
CAS No. = Chemical Abstracts Services Registry Number.
NA = Not applicable.
QC = Quality control.
%R = Percent recovery.
RPD = Relative percent difference.

TABLE 4-5

EXPLOSIVES (8330) QUALITY CONTROL LIMITS[1] FOR
LABORATORY CONTROL SAMPLES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Chemical	CAS No.	Aqueous Matrix	Solid Matrix
		Accuracy (%R)	Accuracy (%R)
1,3,5-Trinitrobenzene	99-35-4	60-120	55-125
1,3-Dinitrobenzene	99-65-0	60-120	55-125
2,4,6-Trinitrotoluene	118-96-7	60-120	55-125
2,4-DA-6-NT	6629-29-4	30-160	30-160
2,4-Dinitrotoluene	121-14-2	60-120	55-125
2,6-DA-4-NT	59229-75-3	30-160	30-160
2,6-Dinitrotoluene	606-20-2	60-120	55-125
2-Amino-4,6-dinitrotoluene	355-72-78-2	60-120	55-125
2-Nitrotoluene	88-72-2	60-120	55-125
3,5-DNA	618-87-1	30-160	30-160
3-Nitrotoluene	99-08-1	60-120	55-125
DNX	NA	30-160	30-160
4-Amino-2,6-dinitrotoluene	1946-51-0	60-120	55-125
4-Nitrotoluene	99-99-0	60-120	55-125
HMX	2691-41-0	60-120	55-125
MNX	NA	30-160	30-160
Nitrobenzene	98-95-3	60-120	55-125
RDX	121-82-4	60-120	55-125
Tetryl	479-45-8	60-120	55-125
TNX	NA	30-160	30-160
4,4'-TN-AZOXY	NA	30-160	30-160

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
CAS No. = Chemical Abstracts Services Registry Number.
NA = Not applicable.
QC = Quality control.
%R = Percent recovery.
RPD = Relative percent difference.

TABLE 4-6

VOLATILE ORGANIC COMPOUNDS QUALITY CONTROL LIMITS[1] FOR
MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Chemical	CAS No.	Aqueous Matrix		Solid Matrix	
		Accuracy (%R)	Precision (RPD)	Accuracy (%R)	Precision (RPD)
1,1,1,2-Tetrachloroethane	630-20-6	60-140	20	60-140	20
1,1,1-Trichloroethane	71-55-6	60-140	20	54-104	24
1,1,2,2-Tetrachloroethane	79-34-5	60-140	20	22-113	41
1,1,2-Trichloroethane	79-00-5	60-140	20	44-103	30
1,1-Dichloroethane	75-34-3	60-140	20	45-126	33
1,1-Dichloroethene	75-35-4	68-155	20	26-136	34
1,2,3-Trichloropropane	96-18-4	60-140	20	60-140	20
1,2-Dibromo-3-chloropropane	96-12-8	60-140	20	60-140	20
1,2-Dibromoethane	106-93-4	60-140	20	60-140	20
1,2-Dichloroethane	107-06-2	60-140	20	51-115	26
1,2-Dichloropropane	78-87-5	60-140	20	45-123	26
2-Butanone	78-93-3	60-140	20	20-160	50
2-Hexanone	591-78-6	60-140	20	20-160	50
3-Chloro-1-propene	107-05-1	60-140	20	60-140	20
4-Methyl-2-pentanone	108-10-1	60-140	20	20-160	50
Acetone	67-64-1	60-140	20	20-160	50
Acrolein	107-02-8	60-140	20	60-140	20
Acrylonitrile	107-13-1	60-140	20	60-140	20
Benzene	71-43-2	87-128	20	52-112	37
Bromodichloromethane	75-27-4	60-140	20	48-107	30
Bromoform	75-25-2	60-140	20	31-102	47
Bromomethane	74-83-9	60-140	20	20-146	50
Carbon disulfide	75-15-0	60-140	20	20-134	50
Carbon tetrachloride	56-23-5	60-140	20	48-110	21
Chlorobenzene	108-90-7	75-124	20	45-108	45
Chloroethane	75-00-3	60-140	20	38-140	48
Chloroform	67-66-3	60-140	20	59-101	21
Chloromethane	74-87-3	60-140	20	20-158	50
Chloroprene	126-99-8	60-140	20	60-140	20
cis-1,2-Dichloroethene	156-59-2	60-140	20	55-93	24
cis-1,3-Dichloropropene	10061-01-5	60-140	20	33-108	39
Dibromochloromethane	124-48-1	60-140	20	36-108	33
Dibromomethane	74-95-3	60-140	20	60-140	20
Dichlorodifluoromethane	75-71-8	60-140	20	60-140	20
Ethyl methacrylate	97-63-2	60-140	20	60-140	20
Ethylbenzene	100-41-4	60-140	20	40-118	41
Iodomethane	74-88-4	60-140	20	60-140	20
Methacrylonitrile	126-98-7	60-140	20	60-140	20
Methyl methacrylate	80-62-6	60-140	20	60-140	20
Methylene chloride	75-09-2	60-140	20	20-160	50
Styrene	100-42-5	60-140	20	29-114	36

TABLE 4-6

VOLATILE ORGANIC COMPOUNDS QUALITY CONTROL LIMITS[1] FOR
MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Chemical	CAS No.	Aqueous Matrix		Solid Matrix	
		Accuracy (%R)	Precision (RPD)	Accuracy (%R)	Precision (RPD)
Tetrachloroethene	127-18-4	60-140	20	32-94	34
Toluene	108-88-3	73-136	20	39-120	37
trans-1,2-Dichloroethene	156-60-5	60-140	20	42-97	23
trans-1,3-Dichloropropene	10061-02-6	60-140	20	34-109	39
trans-1,4-Dichloro-2-butene	110-57-6	60-140	20	60-140	20
Trichloroethene	79-01-6	69-119	20	36-124	50
Trichlorofluoromethane	75-69-4	60-140	20	60-140	20
Vinyl acetate	108-05-4	60-140	20	60-140	20
Vinyl chloride	75-01-4	60-140	20	29-138	50
Xylenes, Total	1330-20-7	60-140	20	38-108	31

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
CAS No. = Chemical Abstracts Services Registry Number.
QC = Quality control.
%R = Percent recovery.
RPD = Relative percent difference.

TABLE 4-7

VOLATILE ORGANIC COMPOUNDS QUALITY CONTROL LIMITS[1] FOR LABORATORY CONTROL SAMPLES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA
PAGE 1 OF 2

Chemical	CAS No.	Aqueous Matrix	Solid Matrix
		Accuracy (%R)	Accuracy (%R)
1,1,1,2-Tetrachloroethane	630-20-6	60-140	60-140
1,1,1-Trichloroethane	71-55-6	60-140	60-140
1,1,2,2-Tetrachloroethane	79-34-5	60-140	60-140
1,1,2-Trichloroethane	79-00-5	60-140	60-140
1,1-Dichloroethane	75-34-3	60-140	60-140
1,1-Dichloroethene	75-35-4	80-146	65-129
1,2,3-Trichloropropane	96-18-4	60-140	60-140
1,2-Dibromo-3-chloropropane	96-12-8	60-140	60-140
1,2-Dibromoethane	106-93-4	60-140	60-140
1,2-Dichloroethane	107-06-2	60-140	60-140
1,2-Dichloropropane	78-87-5	60-140	60-140
2-Butanone	78-93-3	60-140	60-140
2-Hexanone	591-78-6	60-140	60-140
3-Chloro-1-propene	107-05-1	60-140	60-140
4-Methyl-2-pentanone	108-10-1	60-140	60-140
Acetone	67-64-1	60-140	60-140
Acrolein	107-02-8	60-140	60-140
Acrylonitrile	107-13-1	60-140	60-140
Benzene	71-43-2	79-128	72-121
Bromodichloromethane	75-27-4	60-140	60-140
Bromoform	75-25-2	60-140	60-140
Bromomethane	74-83-9	60-140	60-140
Carbon disulfide	75-15-0	60-140	60-140
Carbon tetrachloride	56-23-5	60-140	60-140
Chlorobenzene	108-90-7	77-115	65-121
Chloroethane	75-00-3	60-140	60-140
Chloroform	67-66-3	60-140	60-140
Chloromethane	74-87-3	60-140	60-140
Chloroprene	126-99-8	60-140	60-140
cis-1,2-Dichloroethene	156-59-2	60-140	60-140
cis-1,3-Dichloropropene	10061-01-5	60-140	60-140
Dibromochloromethane	124-48-1	60-140	60-140
Dibromomethane	74-95-3	60-140	60-140
Dichlorodifluoromethane	75-71-8	60-140	60-140
Ethyl methacrylate	97-63-2	60-140	60-140
Ethylbenzene	100-41-4	60-140	72-127
Iodomethane	74-88-4	60-140	60-140
Methacrylonitrile	126-98-7	60-140	60-140
Methyl methacrylate	80-62-6	60-140	60-140
Methylene chloride	75-09-2	60-140	60-140
Styrene	100-42-5	60-140	60-140

TABLE 4-7

VOLATILE ORGANIC COMPOUNDS QUALITY CONTROL LIMITS[1] FOR LABORATORY CONTROL SAMPLES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Chemical	CAS No.	Aqueous Matrix	Solid Matrix
		Accuracy (%R)	Accuracy (%R)
Tetrachloroethene	127-18-4	60-140	60-140
Toluene	108-88-3	77-177	66-124
trans-1,2-Dichloroethene	156-60-5	60-140	60-140
trans-1,3-Dichloropropene	10061-02-6	60-140	60-140
trans-1,4-Dichloro-2-butene	110-57-6	60-140	60-140
Trichloroethene	79-01-6	76-120	61-124
Trichlorofluoromethane	75-69-4	60-140	60-140
Vinyl acetate	108-05-4	60-140	60-140
Vinyl chloride	75-01-4	60-140	60-140
Xylenes, Total	1330-20-7	60-140	60-140

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
CAS No. = Chemical Abstracts Services Registry Number.
QC = Quality control.
%R = Percent recovery.

TABLE 4-8

MISCELLANEOUS PARAMETERS QUALITY CONTROL LIMITS[1] FOR
MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Chemical	CAS No.	Aqueous Matrix		Solid Matrix	
		Accuracy (%R)	Precision (RPD)	Accuracy (%R)	Precision (RPD)
Total Organic Carbon		70-119	20	50-150	20
Perchlorate (EPA Method 314)	14797-73-0	50-140	30	50-150	25
Perchlorate (SW-846 Method 8321A)[2]	14797-73-0	35-135	50	35-135	50

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
2 Perchlorate by SW-846 Method 8321 will only take place if positive perchlorate results are obtained by EPA Method 314.

CAS No. = Chemical Abstracts Services Registry Number.
QC = Quality control.
%R = Percent recovery.
RPD = Relative percent difference.

TABLE 4-9

MISCELLANEOUS PARAMETERS QUALITY CONTROL LIMITS[1] FOR
LABORATORY CONTROL SAMPLES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Chemical	CAS No.	Aqueous Matrix	Solid Matrix
		Accuracy (%R)	Accuracy (%R)
Total Organic Carbon		90-110	50-150
Perchlorate (EPA Method 314)	14797-73-0	80-120	50-150
Perchlorate (SW-846 Method 8321A)[2]	14797-73-0	35-135	35-135

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.

2 Perchlorate by SW-846 Method 8321 will only take place if positive perchlorate results are obtained by EPA Method 314.
CAS No. = Chemical Abstracts Services Registry Number.
QC = Quality control.
%R = Percent recovery.

TABLE 4-10

QUALITY CONTROL LIMITS[1] FOR
SURROGATE COMPOUND RECOVERIES
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Analytical Method	Chemical	CAS No.	Aqueous Matrix	Solid Matrix
			Accuracy (%R)	Accuracy (%R)
SW-846 8330	3,4-Dinitrotoluene	610-39-9	40-320	20-160
SW-846 8260B	1,2-Dichloroethane-d4	17060-07-0	60-140	60-140
	4-Bromofluorobenzene	460-00-4	110-290	110-290
	Dibromofluoromethane	1868-53-7	60-140	60-140
	Toluene-d8	2037-26-5	60-140	60-140

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
CAS No. = Chemical Abstracts Services Registry Number.
QC = Quality control.
%R = Percent recovery.

TABLE 4-11

QUALITY CONTROL LIMITS[1] FOR
LABORATORY DUPLICATE SAMPLE PRECISION
SWMU 03 - ABG/OJT/LSC
QAPP ADDENDUM NO. 1
NSWC CRANE, CRANE, INDIANA

Analytical Method	Analyte	CAS No.	Aqueous Matrix	Solid Matrix
			Accuracy (%R)	Accuracy (%R)
SW-846 6010	Aluminum	7429-90-5	30	50
	Antimony	7440-36-0	30	50
	Arsenic	7440-38-2	30	50
	Barium	7440-39-3	30	50
	Beryllium	7440-41-7	30	50
	Cadmium	7440-43-9	30	50
	Calcium	7440-70-2	30	50
	Chromium	7440-47-3	30	50
	Cobalt	7440-48-4	30	50
	Copper	7440-50-8	30	50
	Iron	7439-89-6	30	50
	Lead	7439-92-1	30	50
	Lithium	7439-93-2	30	50
	Magnesium	7439-95-4	30	50
	Manganese	7439-96-5	30	50
	Mercury	7439-97-6	30	50
	Nickel	7440-02-0	30	50
	Potassium	7440-09-7	30	50
	Selenium	7782-49-2	30	50
	Silver	7440-22-4	30	50
	Sodium	7440-23-5	30	50
	Strontium	7440-24-6	30	50
	Thallium	7440-28-0	30	50
	Tin	7440-31-5	30	50
	Titanium	7440-32-6	30	50
	Vanadium	7440-62-2	30	50
	Zinc	7440-66-6	30	50

1 In-house QC limits provided by Laucks Testing Laboratories, Inc.
CAS No. = Chemical Abstracts Services Registry Number.
QC = Quality control.
%R = Percent recovery.

REFERENCES

Albertson, et al., 1998. "RCRA Facility Investigation, Part 2, Phase III Soils Study, Ammunition Burning Ground, SWMU 03/10," prepared by the US Army Corps of Engineers (USACE) Waterways Experiment Station (WES)

Barnhill, M. L. and C. P. Ambers, 1994. Geology and Hydropetrology of the Big Clifty Sandstone and Beech Creek Limestone Aquifer System at Ammunition Burning Ground: Naval Surface Warfare Center, Crane, Indiana, prepared by the Indiana Geological Survey, Bloomington, Indiana, for the U. S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi.

Baedke, Steven A., 1998. Hydrogeologic and Geochemical Assessment of the Porous Media and Karstic Flow Regimes of the Beech Creek Aquifer Ammunition Burning Grounds, Naval Surface Warfare Center, Crane Indiana, University of Indiana Department of Geological Sciences, Bloomington, Indiana, January.

CCME, 1997. Recommended Canadian Soil Quality Guidelines. Canadian Council of Ministers of the Environment. Ottawa, Ontario. March 1997.

Dunbar, J.B., 1982. Hydrogeologic Investigation of Waste Disposal Sites at the Naval Weapons Support Center, Crane, Indiana, prepared by U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi, April.

Dunbar, Joseph B., 1984. Definition of Contaminated Ground-Water Plumes at Selected Waste Disposal Sites, Naval Weapons Support Center, Crane, Indiana. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS., April 1984

Duwelius, et al., 1995. Ground-Water Levels and Directions of Flow at the Ammunition Burning Ground, Naval Surface Warfare Center, Crane Division, Crane, Indiana, September 20-21, 1993. U.S. Geological Survey, Administrative Report, Indianapolis, Indiana.

Fisher, A.T., 1996. The hydrogeologic properties and sedimentary facies relations of shallow Pennsylvanian bedrock aquifers: well tests, lithologic descriptions, and gamma-ray logs, NSWC Crane, Indiana Geological Survey and Indiana University, Open File Report 96-3, 1996.

Hunt, R.W. 1988. Geology and hydrogeology of the Ammunition Burning Ground, Crane Naval Weapons Support Center Technical Report GL-88-27. U.S. Army Engineer Waterways Experiment Station. Vicksburg, Missouri.

Jock and Krothe, 2002. Jeep Trail Dye and Ammunition Burning Grounds Test. Indiana University Geological Science Department "Hydrogeology Laboratory," June 4, 2002.

Krothe, 2002. p1-14. Ground Water Investigation at the Ammunition Burning Ground, Crane Division, Naval Surface Warfare Center, Crane, Indiana, prepared by Indiana University, Department of Geological Sciences, Bloomington, Indiana, for Crane Division, Naval Surface Warfare Center, Crane, Indiana, April.

May et al., 2003. Hydrogeologic Feasibility of Using Natural Attenuation and Phytoremediation as Remedial Alternatives for Explosives and TCE Contaminated Groundwater at the Ammunition Burning Grounds, Naval Surface Warfare Center Crane, Indiana U.S. Army Corps of Engineers Research and Development Center, November.

Murphy and Ciocco, 1990. Dye Trace of Beech Creek Aquifer, Ammunition Burning Ground, Naval Weapons Support Center Crane Division, Crane, Indiana, prepared by U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi for Command, Philadelphia, Pennsylvania, Technical Report GL-90-21, September.

Murphy, W.L., 1994. Final Report, RCRA Facility Investigation, Phase III, SWMU 03/10, Ammunition Burning Ground, prepared by U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi, Technical Report GL-94-15, May.

Murphy, W.L., and R. Wade, 1995. Draft Report, RCRA Facility Investigation, Phase II Groundwater Release Assessment, SWMU 06/09 Demolition Area and Phase III Release Characterization, SWMU 07/09 Old Rifle Range, Naval Surface Warfare Center, Crane, Indiana. U. S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS, 1995.

Murphy, W.L., 1996. Letter Report: Preliminary Assessment of Geology, Ground Water Hydrology, and Ground Water Contaminant Distribution of Jeep Trail 25 Area, Ammunition Burning Ground, Crane Naval Surface Warfare Center, Crane, Indiana, prepared by U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi, for the Department of Environmental Management, Crane Naval Surface Warfare Center, Crane, Indiana, May.

Murphy and Wade, 1998. "RCRA Facility Investigation, Phase II Release Assessment for Surface Water, SWMU 03/10, Ammunition Burning Ground," prepared by the USACE WES.

Tetra Tech NUS (TtNUS), 1999. Current Contamination Condition Risk Assessment, SWMU #03/10 (Ammunition Burning Grounds) SWMU #07/09 (Old Rifle Range) SWMU #06/09 (Demolition Range) NAVSURFWARCENDIV, Crane, Indiana. February.

TtNUS, 2001. Quality Assurance Project Plan for Ammunition Burning Grounds, Little Sulphur Creek, and Jeep Trail. Resource Conservation and Recovery Act. Phase III RCRA Facility Investigation. NSWC Crane. April.

TtNUS, 2003. Resource Conservation and Recovery Act Facility Investigation Report for SWMU 03 – Old Jeep Trail/Little Sulphur Creek. NSWC, Crane. October.

TtNUS, 2004. Health and Safety Plan for Field Invetigation at the Ammunition Burining Grounds, Jeep Trail, and Little Sulphur Creek, Naval Surface Warfare Center Crane Dividsion, Crane Indiana, March.

USACE, 1992. Draft RFI Phase III Part I Soils Report for Ammunition Burining Ground, SWMU #03/11, Naval Surface Warfare Center Crane, Indiana, U.S. Army Corps of Engineers Waterways Experiment Station, Wilimington District, Wilmington, North Carolina.

U.S. EPA, 1986. Test Methods for Evaluating Solid Waste; Physical/Chemical Methods (SW-846), 3rd edition, up to and including Update III. Office of Solid Waste and Emergency Response, Washington, DC. 1986

APPENDIX A

STANDARD OPERATING PROCEDURES FOR FIELD WORK

APPENDIX A

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CTO126-09	Inspection of Existing Monitoring Wells
CTO126-10	Monitoring Well Development
CTO126-14	Calibration and Care of Water Quality Meter
CTO126-15	Management of Investigation Derived Waste
CTO126-16	Low-Flow Well Purging and Stabilization
CTO126-17	Decontamination of Field Sampling Equipment
CTO126-18	Measurement of Water Levels in Monitoring Wells
CTO126-21	Estimating Flow in Small Streams
CTO126-22	Hydraulic Conductivity Testing
CTO126-24[1]	Sample Preservation, Packaging, and Shipping

Note: SOPs CTO126-11, 12, 13, 19, 20 and 23 not applicable during this round of field investigation.

1 - SOP added to this QAPP Addendum No. 1.

STANDARD OPERATING PROCEDURE
NUMBER CTO126-01

SAMPLE LABELING

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures to be used for labeling and tagging sample containers. Sample labels and tags are used to document the sample ID, date, time, analysis to be performed, preservative, matrix, sampler, and the analytical laboratory. A sample label and a sample tag will be attached to each sample container. The label and tag for each container will contain identical information.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Writing utensil

Disposable medical-grade gloves (e.g. latex, nitrile)

Sample Logsheets

Required sample containers: All sample containers for analysis by fix-based laboratories will be supplied and deemed certified clean by the laboratory.

Preprinted Sample Labels and Sample Tags

Chain-of-Custody records

Sealable Polyethylene bags

Heavy-Duty Cooler

Ice

3.0 PROCEDURES

3.1 The following information will be printed on the labels and tags prior to field activities.

- Project number (CTO 126)
- Project Location (NSWC Crane)
- Sample ID
- Preservative

- Analysis to be performed
- Matrix type, and
- Laboratory name.

3.2 Preprinted sample labels and tags will be prepared prior to mobilizing to the field. Check to determine if:

- One sample label and tag exists for each sample container that is to be collected for all media during the field activities.
- The information printed on each tag and label are correct.
- Extra blank labels and tags are brought to the site in case additional environmental samples or QA samples are collected that are not anticipated in the QAPP. Additional blank labels and tags should also be brought to the site in case a sample container is broken or some of the preprinted labels or tags are accidentally lost before being attached to a container.

3.3 Once at the field site, sample containers should have labels affixed before sampling activities begin.

3.4 Select the labeled containers that are appropriate for a given sample and fill in the date, time, and sampler's initials just before sampling begins. Use a black waterproof marker or pen.

3.5 Fill the appropriate containers with sample material. Securely close the container lids without overtightening.

3.6 Write the same date, time, and sampler's initials on the sample tag as written on the label.

3.7 Place the sample container in a ziplock plastic bag and place in a cooler containing ice.

3.8 Fill in appropriate information on the Sample Collection Log form and the Chain-of-Custody form.

Example sample labels and tags are attached at the end of this SOP.

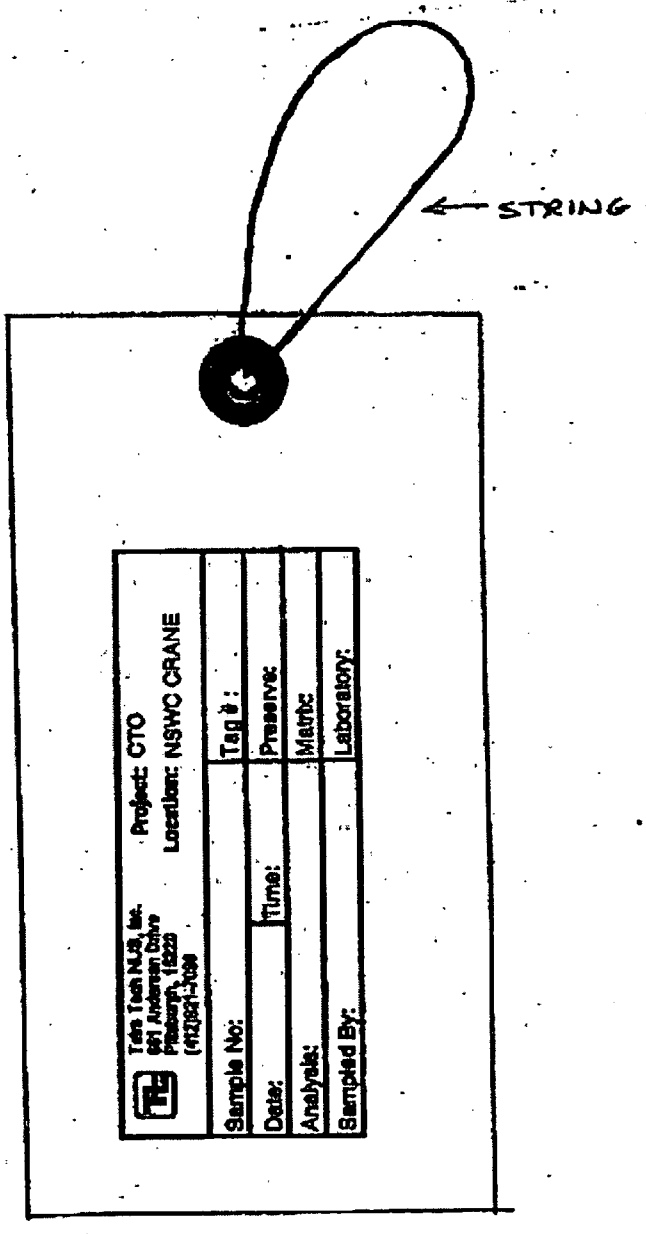
4.0 ATTACHMENTS

1. Sample Label and Tag

ATTACHMENT 1

SAMPLE LABEL AND TAG

SAMPLE LABEL AND TAG



STANDARD OPERATING PROCEDURE
NUMBER CTO126-02

SAMPLE IDENTIFICATION NOMENCLATURE

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish a consistent sample nomenclature system that will facilitate subsequent data management at the Naval Surface Warfare Center (NSWC). The sample nomenclature system has been devised such that the following objectives can be attained.

- Sorting of data by site, location or matrix
- Maintenance of consistency (field, laboratory, and database sample numbers)
- Accommodation of all project-specific requirements
- Accommodation of laboratory sample number length constraints
- Ease of identification and direct link to site and year

The NSWC Crane Environmental Protection Department must approve any deviations from this procedure.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Pen with indelible ink
Sample tags
Sample container labels

3.0 SAMPLE IDENTIFICATION NOMENCLATURE

3.1 Monitoring Samples

All monitoring samples collected at NSWC Crane will be properly labeled with a sample label affixed to the sample container and a tag tied around the neck of the sample container. Each sample will be assigned a unique sample tracking number. The sample tracking number will consist of a four or five segment alpha-numeric code that identifies the sample's associated solid waste management unit (SWMU) or associated

site, sample type, location, and, for aqueous samples where applicable, whether a sample is filtered, and/or the sample round number. For soil or sediment samples the final four tracking numbers will identify the depth at which the soil or sediment sample was collected.

The alpha-numeric coding to be used in the NSWC Crane sample system is explained in the diagram and the subsequent definitions:

NN	**AA**	**A or N** **2 to 5-Characters**	**NN and/or A** **Aqueous only**	**NNNN** **Soils and Sediment only**
SWMU or Site Number	Sample Type	Location	Round Identifier and/or Filtered	Depth Interval

Character Type:

A = Alpha
N = Numeric

SWMU or Site Number:

03 = Ammunition Burning Grounds including Jeep Trail and Little Sulphur Creek

Sample Type:

GW - Ground water Sample from a Permanent Monitoring Well
ID - Investigation Derived Waste Sample
SB - Soil Boring Sample
SD - Sediment Sample
SP - Seep Sample or Spring Sample
SS - Surface Soil Sample
SW - Surface Water Sample

Location:

The sample location code is the well number, soil sample location, sediment sample location or the stream sample location (i.e. surface water, springs, or seeps). The location code for each sample is listed on figures and tables in the site-specific Work Plan. Existing well numbers are used when unique. New wells will be designated by a SWMU or site number, followed by MW for permanent monitoring well, TW for temporary well, etc.; a "T" for Tetra Tech NUS; and numbered sequentially, by SWMU, beginning with zero one (MWT01).

Well clusters that are newly installed by TtNUS (two or more wells in close proximity) in the same investigative effort will be designated with the letter P followed by the number 2, 3, 4 etc. The number signifies the well depth in relation to other wells in that cluster. This two-digit code will follow the well identification. Using well T02 as an example, of a three well cluster, the well identification will be as follows:

T02	=	The deepest well in the cluster.
T02P2	=	Intermediate well
T02P3	=	Shallowest well in the cluster

Note: To keep the sample identification nomenclature to a minimum number of characters and to avoid redundancy, MW (monitoring well) is used for text, figures and tables and replaced with GW (groundwater) in the sample identification, example MWT01 would be GWT01.

Round Identifier and/or Filtered:

This code section will be used for aqueous samples only.

Round Identifier:

A two digit round identifier will be used to track the number of aqueous samples (GW, SW, SP) taken from a particular aqueous sample location. The first sample collected from a location will be assigned round identifier 01, the second 02, etc. This applies to both existing and proposed monitoring wells and surface water locations.

Filtered:

Water samples that are field filtered (dissolved analysis) will be identified with an "F" in the last code section. No entry in this segment signifies an unfiltered (total) sample.

Depth Interval, Soil and Sediment only:

The depth code 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, feet bgs (soil) inches bgs (sediment) of the sample. The depths will be noted in whole numbers only, further detail if needed will be recorded on the sample log sheet, boring log, log book, etc.

Depth (for soils, in feet bgs)

0002 = soil collected from 0 to 2 feet bgs

0204 = soil collected from 2 to 4 feet bgs

0810 = soil collected from 8 to 10 feet bgs

Depth (for sediments, in inches bgs)

0006= sediment collected from 0 to 6 inches bgs

0612= sediment collected from 6 to 12 inches bgs

3.1.1 Examples of Sample Nomenclature

The first ground water sample collected from existing monitoring well 01 at the Ammunition Burning Grounds (SWMU 03) for a filtered sample would be designated as 03GW0101F.

The second ground water sample collected from existing monitoring well C20P2 at the Ammunition Burial Ground for an unfiltered sample would be designated as 03GWC20P202.

The first unfiltered ground water sample collected from new monitoring well MWT01 at the Ammunition Burning Ground would be designated as 03GWT0101.

The second surface water sample collected from point 01 in Little Sulphur Creek for an unfiltered sample would be designated as 03SW0102.

A surface soil sample collected from soil boring 03 at the Burn Pit at the 0 to 2 foot interval would be designated as 03SS030002.

A subsurface soil sample from the same soil boring 3 at an interval of 4 to 5 feet bgs would be designated as 03SB030405.

A sediment sample collected in Little Sulphur Creek from 0 to 6 inches at location 14 would be designated as 035SD03006.

3.2 Field Quality Assurance/Quality Control (QA/QC) Sample Nomenclature

Field QA/QC samples are described in the approved Field Sampling Plan and QAPP. They will be 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
SB = 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 sample log sheets and will document the location of the duplicate sample (sample log sheets are not provided to the laboratory).

3.2.2 Examples of Field QA/QC Sample Nomenclature

The first duplicate of the day for a filtered ground water sample collected on June 3, 2000 would be designated as FD06030001F.

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.

STANDARD OPERATING PROCEDURE
NUMBER CTO126-03

SAMPLE CUSTODY AND DOCUMENTATION OF FIELD ACTIVITIES

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedures for sample custody and documentation of field sampling and field analyses activities.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following logbooks, forms, and labels, are required.

Site Logbook
Field Logbook
Sample label
Chain-of-Custody form
Custody seals
Equipment Calibration Log
Monitoring Well Inspection Form
Water Level Measurement Form
Low-Flow Purge Data Sheet
Ground Water Sample Log Sheet
Surface Water Sample Log Sheet

3.0 PROCEDURES

This section describes custody and documentation procedures. All entries made into the logbooks, custody documents, logs, and log sheets described in this SOP must be made in indelible ink (black is preferred). No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single strike mark, initialed, and dated.

3.1 Site Logbook

The site logbook is a hardbound, paginated, controlled-distribution record book in which all major on-site activities are documented. At a minimum, the following activities/events shall be recorded (daily) in the site logbook:

- All field personnel present
- Arrival/departure of site visitors
- Arrival/departure of equipment
- Start or completion of sampling activities
- Daily on-site activities performed each day
- Sample pickup information
- Health and safety issues
- Weather conditions

The site logbook is initiated at the start of the first on-site activity (e.g., site visit or initial reconnaissance survey). Entries are to be made for every day that on-site activities take place.

The following information must be recorded on the cover of each site logbook:

- Project name
- Project number
- Book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). At the completion of each day's entries, the site logbook must be signed and dated by the Field Operations Leader (FOL).

3.2 Field Logbooks

The Field Logbook is a separate dedicated notebook used by field personnel to document his or her activities in the field. This notebook is hardbound and paginated.

3.3 Sample Labels

Adhesive sample container labels must be completed and applied to every sample container. Information on the label includes the project name, location, sample number, date, time, preservative, analysis, matrix, sampler's initials, and the name of the laboratory performing the analysis.

3.4 Chain-of-Custody Form

The Chain-of-Custody form (COC) is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as it is transferred from person to person. Each COC is numbered. This form must accompany any samples collected for laboratory chemical analysis. A copy of a blank chain-of-custody form is attached at the end of this SOP.

The FOL must include the name of the laboratory in the "Remarks" section to ensure that the samples are forwarded to the correct location. If more than one COC is necessary for any cooler, the FOL will indicate "Page __ of __" on each COC. 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. Once the samples are received at the laboratory, the sample custodian checks the contents of the cooler(s) against the enclosed COC(s). Any problems are noted on the enclosed COC form (bottle breakage, discrepancies between the sample labels, COC form, etc.) and will be resolved through communication between the laboratory point-of-contact and the Task Order Manager (TOM). The COC form is signed and retained by the laboratory and becomes part of the sample's corresponding analytical data package.

3.5 Custody Seal

The Custody Seal is an adhesive-backed label with a number on each seal. It is part of the 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 transit to the laboratory. The Custody Seals are signed and dated by the samplers and affixed across the opening edges of each cooler (two seals per cooler) containing environmental samples. The laboratory sample custodian will examine the Custody Seal for evidence of tampering and will notify the TOM if evidence of tampering is observed.

3.6 Equipment Calibration Log

The Equipment Calibration Log is used to document calibration of measuring equipment (e.g., multi-parameter water-quality meter) used in the field. The Equipment Calibration Log documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. An Equipment Calibration Log must be maintained for each electronic measuring device requiring calibration. Entries must be made for each day the equipment is used.

3.7 Monitoring Well Inspection Form

The Monitoring Well Inspection Form is used to document the inspection of existing monitoring wells in accordance with SOP CTO126-09.

3.8 Water-Level Measurement Form

The Water Level Measurement Form is used to document the determination of water levels in monitoring wells in accordance with SOP CTO126-18.

3.9 Low-Flow Purge Data Sheet

The Low-Flow Purge Data Sheet is used to document field measurements made while purging wells to stabilization.ccordance with SOP CTO126-16.

3.10 Ground Water Sample Log Sheet

The Ground Water Sample Log Sheet is used to document the samples taken from a monitoring well at the end of low-flow well purging. This sheet is used in conjunction with SOP CTO126-05.

3.11 Surface Water Sample Log Sheet

The Surface Water Sample Log Sheet is used to document the samples collected from surface waters. This sheet is used in conjunction with SOP CTO126-19.

3.12 Soil and Sediment Sample Log Sheet

The Soil and Sediment Sample Log Sheets are used to document the sampling of soils and sediments. This sheet is used in conjunction with SOP CTO126-08 and SOP CTO126-20.

4.0 ATTACHMENTS

1. Chain-of-Custody Record

ATTACHMENT 1
CHAIN-OF-CUSTODY RECORD

TETRA TECH NUS, INC. CHAIN OF CUSTODY | NUMBER | PAGE ____ OF _____

PROJECT NO:	SITE NAME:	PROJECT MANAGER AND PHONE NUMBER	LABORATORY NAME AND CONTACT:
SAMPLERS (SIGNATURE)		FIELD OPERATIONS LEADER AND PHONE NUMBER	ADDRESS
		CARRIER/WAYBILL NUMBER	CITY, STATE

STANDARD TAT ☐
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

DATE YEAR ____	TIME	SAMPLE ID	MATRIX	GRAB (G) COMP (C)	No. OF CONTAINERS	TYPE OF ANALYSIS / CONTAINER TYPE PLASTIC (P) or GLASS (G) / PRESERVATIVE USED								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)

3/99
FORM NO. TINUS-001

STANDARD OPERATING PROCEDURE
NUMBER CTO126-04

BOREHOLE ADVANCEMENT AND SOIL CORING USING DIRECT PUSH TECHNOLOGY

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures for collecting surface and subsurface soil cores from unconsolidated overburden materials using direct push technology (DPT) for the Jeep Trail at the NSWC Crane facility. For this investigation, a Geoprobe® rig with a Macrocore Sampler will be the type of DPT used.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Cut-resistant Non-latex Impermeable Gloves
Cotton Gloves
Disposable medical-grade gloves (e.g., latex, nitrile)
Writing Utensil
Boring Log Sheets: A copy of this form is included in SOPCTO126-07
Photoionization Detector (PID) (see SOP CTO 126-06)
Geoprobe® or Equivalent DPT Equipment
Geoprobe® Macrocore Sampler or Equivalent
Geoprobe® Sampling Kit or Equivalent
Clear Acetate Liners: one new liner for each soil core
Required Decontamination Materials (see SOP CTO126-17)
Bentonite Pellets

3.0 BOREHOLE ADVANCEMENT AND SOIL SAMPLING USING A GEOPROBE®

Direct Push Technology (DPT) will be employed to collect soil cores. DPT refers to sampling tools and sensors that are driven directly into the ground without the use of conventional rotary drilling equipment. DPT typically utilizes hydraulic pressure and/or percussion hammers to advance the sampling tools. Geoprobe® is a manufacturer of a hydraulically-powered, percussion/probing machine utilizing DPT to

collect subsurface environmental samples. This type of rig with a Macrocore Sampler will be used at the ABG and Jeep Trail to collect soil cores.

3.1 Clear the area to be sampled of any surface debris (herbaceous vegetation, twigs, rocks, litter, etc.).

3.2 Place a new clear acetate liner in the detachable Macrocore core barrel and attach coring device to the Geoprobe® rig.

3.3 Drive macrocore sampler (lined with acetate) into the ground to a depth of 2 feet using hydraulic pressure. The 0 –2 foot depth soil interval is considered to be the surface soil.

3.4 Retract the sampler from the borehole and remove the acetate liner and the soil core from the Macrocore barrel.

3.5 Attach the metal trough from the Geoprobe® Sampling Kit firmly to the tail gate of a vehicle. If a vehicle with a tailgate is not available, secure the trough on another suitable surface.

3.6 Place the acetate liner containing the soil core in the trough.

3.7 While wearing cut-resistant gloves (constructed of non-latex over cotton), 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. CAUTION: Do not attempt to cut the acetate liner while holding it in your hand.

3.8 Scan the entire length of the soil core for VOCs using the PID. Record the specific depth interval and the associated PID reading on the Boring Log Sheet. Collect a soil VOC sample using Encore samplers from the soil interval that had the highest PID reading. If no above-background PID readings were detected, collect the VOC sample from an interval that is discolored or displays other visual signs of being contaminated. If no visual sign of contamination is evident, collect the soil VOC sample from the center of the core interval (i.e., one foot depth). Details for collecting a VOC sample using the Encore sampler are included in SOP CTO126-08.

3.9 Log the soil core on the Boring Log Sheet (see SOP CTO126-07).

3.10 Collect the remainder of the soil sample aliquots, as described in SOP CTO 126-08.

3.11 Repeat steps 3.2 through 3.11 for the next depth intervals.

3.12 The depth to bedrock should be recorded on the Boring Log and the estimated moisture content of the soil and the presence or absence of water in the boring should be noted.

3.13 If readings from the PID are all at background levels below field screening criteria, then excess soil core materials shall be returned to the hole and tamped. If insufficient soil is available to fill the hole to the ground surface, then bentonite pellets mixed with the soil shall be used to backfill the hole.

3.14 If screening instruments indicate that contaminants may be present in the soil materials, then all excess soil core materials will be placed in a plastic bag (or drum if larger quantities). The bag will be tagged identifying the location and depths from where the soils came from and the date. The bag will then be placed in a 55-gallon drum and stored onsite until laboratory analyses of the soil are completed and classification of the soil waste materials can be determined (see SOP CTO126-15).

3.15 If soil materials from the boring are suspected of being contaminated (see 3.14 above), the soil boring will be backfilled with bentonite pellets up to the ground surface.

3.16 Decontaminate all soil sampling equipment in accordance with SOP CTO126-17 prior to collecting the next sample.

STANDARD OPERATING PROCEDURE
NUMBER CTO126-05

MONITORING WELL SAMPLING

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedure for monitoring well sampling. Low-flow sampling techniques will be used for ground water sampling at the Jeep Trail at the NSWC Crane facility.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following field forms and equipment are required for low-flow sampling of monitoring wells:
Ground Water Sample Log Form: A copy of this form is attached at the end of this SOP

Bound Field Log Book

Chain-of-Custody Form

Bladder Pump and appropriate Teflon tubing

Peristaltic Pump and appropriate Teflon tubing

Surgical Gloves

Labeled sample containers: Sample containers are certified clean by the laboratory supplying the sample containers.

Tag for each sample container

Plastic storage bags

Shipping containers with ice

3.0 MONITORING WELL SAMPLING PROCEDURES

3.1 Ground water sampling may be initiated when the monitoring well has been purged and stabilized in accordance with SOP CTO126-16.

3.2 Record the sample start time (using military time) on the Ground Water Sample Log Sheet. Record the field measurements for pH, ORP, specific conductance, temperature, dissolved oxygen, and turbidity.

3.3 With the pump continuing to run, disconnect the flow-through cell from the pump discharge tube and immediately start filling sample bottles directly from the pump discharge. All sample containers will be supplied by the laboratory, and the laboratory will pre-preserve all sample containers, where appropriate.

3.4 Allow the pump discharge to flow gently down the inside of the container with minimal turbulence when filling sample containers. Avoid immersing the discharge tube into the sample as the sample container is being filled. Sample containers for volatile constituents (VOCs) must be completely filled so that no headspace exists in the container. The VOC vials shall be filled to the top so that a convex meniscus is formed. Gently secure the cap, turn the vial upside down, and check to see if any air has been trapped inside the vial. If so, open the cap, reform the meniscus, and attempt again to secure the lid without trapping air in the sample. All other sample containers can have air space included when the container lid is secured.

3.5 Cap each container immediately after filling.

3.6 Record the sample time on the Ground Water Sample Log Form, the sample tag, and on the sample label.

3.7 Secure the associated tag to each sample container.

3.8 Place the tagged sample container into a plastic storage bag and then into a cooler containing ice.

3.9 Enter the proper information on the Chain-of-Custody form for each sample container (see SOP CTO126-03).

3.10 Repeat steps 3.3 through 3.9 for each sample container collected.

3.11 The pump rate should not be adjusted after sampling has commenced. If it becomes necessary to adjust the pump rate, document the change on the Ground Water Sample Log Form.

3.12 All samples will be collected into pre-preserved bottles (if required) supplied by an approved laboratory. Table 4-13 of the QAPP includes information on preservation requirements. All samples will be collected in the following sequence (where applicable):

- Volatile organic compounds (VOCs)
- Other organics
- Appendix IX Metals plus Sn (totals)
- Nitrate
- Nitrite

3.13 If the last turbidity measurement prior to the commencement of sampling showed turbidity to be greater than 10 Nephelometric Turbidity Units (NTUs), then filtered aliquots of ground water will be collected and analyzed for dissolved metals. Without turning off the pump, attach a disposable, inline, 0.45-um filter cartridge at the end of the discharge tube. Fill sample containers marked for "dissolved metals" so that the laboratory knows that these aliquots are distinct sample fractions and that the results should be reported as dissolved analytes.

3.14 Repeat steps 3.5 through 3.9 for the filtered sample containers.

3.15 After completion of sample collection, remove the bladder pump from well and decontaminate following the procedures in SOP CTO126-17.

3.16 Replace the outer protective well cap and lock the well.

3.17 All equipment should be cleaned and packed into the sample vehicle, along with the sample cooler for transport. Disposable gloves and other equipment should be placed in a plastic trash bag and handled as investigation derived waste (SOP CTO126-15).

4.0 ATTACHMENTS

1. Ground Water Sample Log Sheet

ATTACHMENT 1

GROUND WATER SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Domestic Well Data
[] Monitoring Well Data
[] Other Well Type: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____
Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA:

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Time:	(Visual)	(S.U.)	(mS/cm)	(°C)	(NTU)	(mg/l)	(%)	
Method								

PURGE DATA:

Date:	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Method								
Monitor Reading (ppm):								
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:		Signature(s):
MS/MSD	Duplicate ID No.:	

STANDARD OPERATING PROCEDURE
NUMBER CTO126-06

CALIBRATION AND USE OF PHOTOIONIZATION DETECTOR

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes procedures for the maintenance, calibration, and use of a photoionization detector (PID). The Photovac 2020 Photoionization Air Monitor will be used during the Ammunition Burning Ground, Little Sulphur Creek and Jeep Trail investigation. The procedures for its use are discussed in detail in the following sections.

2.0 GLOSSARY

Electron-volt (eV) - A unit of energy equal to the energy acquired by an electron when it passes through a potential difference of 1 volt in a vacuum.

Intrinsically Safe (I.S.) - Based on wiring, configuration, design, operation, gasketing, construction, this instrument may be employed within locations where flammable gases and/or vapors may exist.

Ionization Potential (I.P.) - The energy required to remove an electron from a molecule yielding a positively charged ion and a negatively charged free electron. The instrument measures this energy level.

Photoionization Detector (PID) - Photoionization detector is employed as the general reference to air monitors of this type. PID's detection method employs ultraviolet (UV) radiation as an energy source. As air and contaminants are drawn through the ionization chamber the UV light source causes the contaminant with ionization potentials equal to or less than the UV source to break into positive and negatively charge ions. The created ions are subjected to an electrostatic field. The voltage difference is measured in proportion to the calibration reference and the concentration of the contaminant.

Ultraviolet Radiation (UV) Lamp - Ultraviolet radiation is the energy source employed by the instrument to ionize collected sample gas streams. The UV lamp source is required to be equal to or greater than the ionization potential of the substance drawn through the instrument in order to create separate ionized species.

3.0 REQUIRED EQUIPMENT

Pen

Equipment Calibration Form

Photoionization Detector

Isobutylene Calibration Gas (i.e., span gas)

Regulator

4.0 PROCEDURES

4.1 Principle of Operation

The Photovac portable photoionizer detects many organic (and a few inorganic) species. The basis for detection of this instrument is the ionization of components in gaseous streams. The incoming gas molecules are subjected to ultraviolet (UV) radiation, which is energetic enough to ionize many compounds associated with industrial activities. Molecules are transformed into charged-ion pairs, creating a current between two electrodes. Each molecule has a characteristic ionization potential, which is the energy required to remove an electron from the molecule, yielding a positively charged ion and a free electron. The instrument measures this energy level.

This instrument measures the concentration of airborne photoionizable gases and vapors and automatically displays and records these concentrations. It does not distinguish between individual substances. Readings displayed represent the total concentration of all photoionizable chemicals present in the sample. This instrument is factory-set to display concentration in units of ppm or mg/m^3. The meter display updates itself once per second.

The 2020 also performs short-term exposure limit (STEL), time-weighted average (TWA) and PEAK calculations. You can view any of these results, but only one mode may be viewed at a time.

The 2020 has 6 keys for alphanumeric entry and for accessing multiple functions. The keys are used to set up and calibrate 2020. They allow you to manipulate the concentration data in various ways.

All information entered with the keys and stored in the 2020's memory is retained when the instrument is switched off. The clock and calendar continue to operate and do not need to be set each time the 2020 is turned on.

4.1.1 Displays

The 2020 has a meter display for reporting detected concentration and a display used for status/ information to guide you through configuration options. All functions of the 2020 will be controlled or reported using one of these displays.

4.1.1.1 Meter Display

The meter display is 4-digits. It will always be used for reporting detected concentration. When the detector and pump are off, the meter display will be blank.

In order to accommodate the range of concentrations the 2020 can detect, the meter reading will be reported using one of 2 resolutions. A resolution of 0.1 will be used for concentrations below 100 ppm, and a resolution of 1 will be used for concentrations above 100 ppm.

4.1.1.2 Status Display

The status display is a 2 line by 16-character display. The top line is used to display status/information and prompts you for your inputs. The bottom line is used for soft key names. Up to 3 names can be displayed for the 3 soft keys. If a name does not appear for a soft key, then the soft key has no associated function.

4.1.2 Keys

4.1.2.1 Fixed Keys

The three round keys below the soft keys each have a fixed function. The first key is the ON/OFF key, the middle key is the EXIT key, and the last key is the ENTER key.

The ON/OFF key is used to both turn power on and off. To turn on the 2020, press the ON/OFF key. To turn the power off, press the ON/OFF key and hold it down for 2 seconds, and then release it. This is done to prevent accidental power off.

The EXIT key provides a way of returning to the default display. In the functional map, the soft keys allow you to advance and the EXIT key provides a way to go back. If you are at the initial entry of the menu, EXIT will return you to the default display.

The ENTER key has a context sensitive function. When you are operating or navigating through the function map, the ENTER key is used to exit the functions and return you to the default display. When entering data such as a name, number, date, or time, ENTER is used to confirm the entry.

4.1.2.2 Soft Keys

The three soft keys on the 2020 are located directly below the status display. Each key has varying functions for configuring the 2020, editing the data logger, and controlling the display. Because only three soft keys are available, each function is broken down into a path.

4.1.2.3 Entering Text With the Soft Keys

For all information that you must enter, the left, center, and right soft keys correspond to the up, down, and right arrow.

The up and down arrows are used to change the character highlighted by the cursor. The right arrow is used to advance the cursor to the next character on the right. When the cursor is advanced past the right most character, it wraps around to the first character again. To accept the changes, press the ENTER key. To ignore the change, press EXIT.

Formatting characters, such as the colon (:) in the time, the decimal (.) in a concentration, and the slash (/) in the date are skipped when advancing the cursor.

All inputs are an 8-character input, which is displayed on the right side of the top line of the status display. The prompt, describing the input, occupies the left half of the top line. The soft keys are defined on the bottom line of the status display.

4.2 Default Display

The meter display shows the detected concentration. The resolution of the display changes with the magnitude of the reading. A reading of 0 to 99.9 will be displayed with a resolution of 0.1 ppm. A reading greater than 99.9 will be shown with a resolution of 1 ppm or 1 mg/m^3. The meter will display concentrations up to 2000 ppm or 2(99) mg/m^3.

The status display is used to display the instrument status, date, time, units, and active soft keys.

The default display provides the following information: instrument status, current detected concentration, time, date, and measurement units. The status display toggles between showing time and units and then the date.

When the display mode is MAX, the date and time correspond to the date and time the MAX concentration was recorded. In TWA mode, the time represents the number of hours and minutes during which the TWA has been accumulating. For PEAK and STEL monitoring, the date and time correspond to the current date and time.

4.3 Monitoring

4.3.1 Instrument Status

The instrument status is shown on the left of the first line of the status display and on the Table and Graph outputs. Each status has a priority assigned to it. If more than one status is in effect, then the status with the highest priority is displayed until the condition is corrected or until the option is turned off.

4.3.2 Alarms

While operating the instrument, any one of three alarm conditions can occur. To accurately identify the source of the alarm, each type of alarm has been given a unique status.

In addition to the status, the 2020 also has an audible alarm and a visual alarm LED. To conserve power, the 2020 alternates between these two alarm indicators, rather than operating both concurrently. Different alarms are identified by the frequency at which the 2020 alternates as follows: PEAK alarm-5 times per second; STEL alarm-2.5 times per second; and TWA alarm-1.25 times per second.

The left soft key is used for acknowledging alarms, and is labeled "Ack." If no alarm exists, then the "Ack" key is not shown. To clear the alarm, press the "Ack" key. Once acknowledged, the alarm indicators are cleared. The alarm status will remain until the alarm condition clears.

The 2020 updates the peak concentration once every second. Following every update, the peak concentration is compared to the peak alarm level, and if exceeded, an alarm is triggered.

If a 15-minute average concentration exceeds the selected STEL, a STEL alarm is generated.

The TWA alarm is generated when the current average concentration over an 8-hour period, since the TWA was last cleared, has exceeded the TWA exposure limit.

During calibration, all alarms are disabled. Once the calibration is complete the alarms are re-enabled.

4.4 STEL, TWA, MAX, and PEAK Operation

The 2020's meter display can be configured to show one of four values: STEL, TWA, PEAK, and MAX.

4.4.1 Short-term Exposure Limit Mode

The STEL mode displays the concentration as a 15-minute moving average. The 2020 maintains 15 samples, each representing a one-minute averaging interval.

Once every minute, the oldest of the 15 samples is replaced with a new one-minute average. This moving average provides a 15-minute average of the last 15 minutes with a one-minute update rate. Because the average is calculated using 15 one-minute averages, the meter display will only update once every minute.

The STEL is set to zero each time the instrument is turned on. Because STEL is a 15-minute moving average, there is no need to clear, or reset the STEL.

STEL calculations are always being performed by the 2020. You can display the results of the calculations by selecting "STEL" as the Display mode.

4.4.2 Time-weighted Average (TWA) Mode

The TWA accumulator sums concentrations every second until 8 hours of data have been combined. If this value exceeds the TWA alarm setting, a TWA alarm is generated. The TWA is not calculated using a moving average. Once 8 hours of data have been summed, the accumulation stops. In order to reset the TWA accumulator, press the "Clr" key.

This sum will only be complete after 8 hours, so the meter displays the current sum divided by 8 hours. While you are in TWA mode, the time on the status display will show the number of minutes and hours of data that TWA has accumulated. When this reaches 8 hours, the 2020 stops accumulating data and the TWA is complete.

TWA calculations are always being performed by the 2020. You can display the results of the calculations by selecting TWA as the Display mode.

4.4.3 MAX Mode

The MAX mode displays the maximum signal, with the date and time that it was recorded. The 2020 continues to log data according to the selected averaging interval, but only the maximum detected concentration is displayed on the meter display.

The right soft key is used to clear the meter when displaying MAX. The "Clr" key only affects the reading that the meter is displaying. For example, if you display the MAX reading, and you press "Clr," only the MAX value is cleared. The TWA is still accumulating in the background.

4.4.4 PEAK Mode

The PEAK mode displays the current detected concentration. The reading is updated once a second. In the background, the 2020 data logger is sampling the concentration and measuring minimum, maximum, and average concentrations for the selected averaging interval. At the end of every interval, one entry is placed in the data logger until the data logger is full. For CTO 126, the instrument should be operated in this mode. Operation within the other specialized modes are the responsibility of the SSO.

4.5 Set Functions

Set functions are used to setup the 2020. There are three functions which can be set on the 2020: Pump, Clock, and Calibration.

4.5.1 Pump

The Pump function is used to control the pump. After selecting "Set Pump", the 2020 responds by displaying the new pump status.

The detector is also turned off when you turn the pump off. This prevents the detector from being damaged when there is no sample flowing through the detector.

When the pump and the detector are off, the meter display will be blank. Turn the pump and detector off when concentration measurements are not necessary, and the 2020 will only be used for reviewing data or generating reports. By operating the instrument with the pump and detector off when you do not need them, you will conserve the lives of the battery and ultraviolet (UV) lamp.

To set the pump:

1. Press the ENTER key. The top line of the status display changes to "Select?". The bottom line displays 3 soft key names: "Set," "Log," and "Disp."

2. Press the soft key below "Set."

3. The names of the soft keys change to reflect the Set options. The display now shows 3 devices which can be set: "Clock," "Pump," and "Cal." Press the "Pump" key.

4. The 2020 turns the pump off. If the pump was off, pressing "Pump" will turn the pump on.

5. A message will be displayed to show you the status of the pump. The 2020 reverts back to the previous menu after a few seconds.

6. To return to the default display, press the ENTER key.

4.5.2 Clock

The Clock function is used to set both the current date and time.

To set the clock:

1. Press the ENTER key.

2. Press the "Set" key.

3. When the names of the soft keys change, press the "Clock" key.

   The up and down arrows are used to change the character underlined by the cursor. The right arrow is used to advance the cursor to the next character on the right. When the cursor is advanced past the right-most character, it wraps around to the first character again.

   Formatting characters, such as the colon (:) in the time and the slash (/) in the date are skipped when advancing the cursor.

4. Use the "arrow keys" to enter the correct time. The time is formatted as Hour:Minute:Second.

5. Press the ENTER key to confirm the time and move to the date option.

6. When setting the date, the 2020 prompts you for the current date formatted as Year/Month/Day. Use the "arrow keys" to enter the correct date.

7. Press the ENTER key to confirm the date and return to the Set options. You can wait for the display to timeout or press ENTER to return to the default display.

4.5.3 Calibration (Cal)

"Cal" allows you to setup and calibrate the 2020. There are three options under the Cal function: "Zero," "Span," and "Mem."

A calibration memory consists of a name, a response factor, and PEAK, TWA, and STEL alarm levels.

The "Zero" and "Span" keys are covered in detail in the manufacturer's operations manual for the instrument.

To edit the calibration memory, select "Mem" and then "Chng." The 2020 prompts you with two new soft keys: "User" and "Lib."

4.5.4 Library (Lib)

Library selections simplify Cal Memory programming, and provide standard response factors for approximately 70 applications. "Lib" allows you to select an entry from a pre-programmed library. The name, response factor, and three alarm levels are all set from the library. To select a library entry to program the selected Cal Memory:

1. Select "Set," "Cal," "Mem," "Chng," and "Lib."
2. Use the "Next" and "Prev" keys to scroll through the list. See the manufacturer's manual Appendix 8.7 for a list of the library entries.

4.6 Preparing for Field Operation of the Photovac 2020

Turning The 2020 On

1. Turn the 2020 on by pressing the ON/OFF key.

2. The 2020 will display the software version number. Wait for the 2020 to proceed to the default display.

3. Allow 10 minutes for the instrument to warm up and stabilize.

4. Press the Enter Key. The default display will provide 3 soft key selection "Set," "Log," and "Display."

5. Press "Set." From this option, 3 other soft key selections will be offered: "Pump," "Clock," and "Cal."

6. Press "Cal." This will begin the calibration sequence. The first selection is to Zero the instrument.

7. Press Enter, zeroing will begin. (Note: When employing zero gas attach and activate zero gas supply at this time.)

8. The next selection offered will be Span. Press Enter at which time the concentration will be requested. The isobutylene calibration gas employed under general service will be marked on the side of the container. Use the soft keys to toggle into position and to log the concentration. Once the concentration is logged press "Enter." The direction on the status display will indicate spanning. At this time hook up the span gas with a regulator to the Photovac 2020, and open it to supply enough flow to elevate the flow rate indicator to the green indicator line (1/8" from the rest position).

9. Once spanning is complete, the alarms, which have been disabled during calibration, will activate indicating that calibration is complete.

10. Document this calibration procedure using a Document of Calibration form (included in Appendix A).

This instrument is ready for general purpose application.

Calibration is to be performed daily or prior to each use in accordance with this section.

4.7 Maintenance and Calibration Schedule

Function	Frequency
Routine Calibration	Prior to each use
Factory Inspection and Calibration	Once a year, or when malfunctioning
Wipe Down the Outer Casing of the Unit	After each use
Clean UV Light Source	Every 24 hours of operation
Sample Inlet Filter	Change on a weekly basis or as required by level of use
Battery charging	After each use
Clean ionization chamber	Monthly

4.7.1 Cleaning the UV Light Source Window

1. Turn the FUNCTION switch to the OFF position. Use the 2020 multi-tool and remove the lamp housing cover. CAUTION: The UV lamp is delicate and expensive-handle carefully.

2. Tilt the lamp housing with one hand over the opening, slide the lamp out of the housing.

3. The lamp window may now be cleaned with any of the following compounds using lens paper:
   a. 11.7 eV Lamp - Dry Aluminum Oxide Powder (3.0 micron powder)
   b. All other lamps-HPLC Grade Methanol

4. Following cleaning, reassemble by first sliding the lamp back into the lamp housing. Replace the o-ring as necessary, reinstall the lamp housing cover, and tighten it using the 2020 multi-tool. (Do not over tighten).

5. Recalibrate the instrument as per Section 4.6.

4.7.2 Cleaning the Ionization Chamber

1. Turn the FUNCTION switch to the OFF position and remove the lamp housing cover and lamp as per Section 4.7.1.

2. Using a gentle jet of compressed air, gently blow out any dust or dirt.

3. Following cleaning, reassemble by first sliding the lamp back into the lamp housing. Replace the o-ring as necessary, reinstall the lamp housing cover, and tighten it using the 2020 multi-tool. (Do not over tighten).

4. Recalibrate the instrument as per Section 4.6.

4.8 Instrument Advantages

The Photovac 2020 is easy to use in comparison to many other types of monitoring instrumentation. Its detection limit range is in the low parts-per-million range. Response rapidly reaches 90 percent scale of the indicated concentration (less than 3 seconds for benzene). This instrument's automated performance covers multiple monitoring functions simultaneously, incorporating data logging capabilities.

4.9 Limitations of the Photovac 2020 Photoionization Monitor

- Because the 2020 is a nonspecific total gas/vapor detector, it cannot be used to identify unknown chemicals; it can only quantitate them in relationship to a calibration standard (relative response ratio).

- For appropriate application of the 2020, ionization potentials of suspected contaminants must be known.

- Because the types of compounds that the 2020 can potentially detect are only a fraction of the chemicals possibly present at a hazardous waste site or incident, a background or zero reading on this instrument does not necessarily signify the absence of air contaminants.

- The 2020 instrument can only monitor certain vapors and gases in air. Many nonvolatile liquids, toxic solids, particulates, and other toxic gases and vapors cannot be detected.

- PID's are generally not specific. Their response to different compounds is relative to the calibration gas used. This is referred to as relative response ratio. Instrument readings may be higher or lower than the true concentration. This can be an especially serious problem when monitoring for total contaminant concentrations if several different compounds are being detected at once.

- The 2020 is a small, portable instrument which cannot be expected to yield results as accurately as laboratory instruments.

4.9.1 Variables Affecting Monitoring Data

Monitoring a hazardous waste site environment can pose a significant challenge in assessing airborne concentrations and the potential threats to site personnel. Several variables may influence both dispersion and the instrument's ability to detect actual concentrations. Some of the variables, which may impact these conditions, are as follows:

- Temperature - changes in temperature or pressure will influence volatization, and affect airborne concentrations. Additionally, an increase or decrease in temperature ranges may have an adverse effect on the instrument's ability to detect airborne concentrations.

- Humidity - excessive levels of humidity may interfere with the accuracy of monitoring results.

- Rainfall - through increased barometric pressure and water, may influence dispersion pathways affecting airborne emissions.

- Electromagnetic interference - high voltage sources, generators, other electrical equipment may interfere with the operation and accuracy of direct-reading monitoring instruments.

5.0 TROUBLESHOOTING

5.1 Fault Messages

When the "Fault" status is displayed, the 2020's operation is compromised.

Fault 1: Signal from zero gas is too high.

Cause: If another fault occurred while the 2020 was setting its zero point, then this fault is displayed.
Action: Ensure no faults are occurring and calibrate the 2020 again.

Cause: Contamination of sample line, sample probe, or fittings before the detector.

Action: Clean or replace the sample line, sample probe, or the inlet filter.

Cause: Span gas and zero air are switched.

Action: Ensure clean air is used to zero the 2020. If you are using gas bags, mark the calibration and zero gas bags clearly.

Cause: Ambient air is contaminated.

Action: If you are unsure about the quality of ambient air, use a supply of commercial zero grade air to zero the 2020.

Fault 2: Signal from span gas is too small.

Cause: Operator may have switched the span gas and zero air.

Action: Ensure clean air is used to zero the 2020. If you are using gas bags, mark the calibration and zero gas bags clearly.

Action: Ensure the span gas is of a reliable concentration.

Cause: UV lamp window is dirty.

Note: Do not remove the detector lamp in a hazardous location.

Action: Clean the UV lamp window.

Cause: UV lamp is failing.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: Install a new UV lamp.

Cause: Incompatible application.

Action: The concentration and sample gas are incompatible for use with the 2020.

Fault 3: UV lamp fault. UV lamp has not started.

Cause: The UV lamp has not started immediately.

Action: This fault may be seen momentarily when 2020 is first turned on. Allow 30 to 60 seconds for the UV lamp to start and the fault to clear.

Cause: The UV lamp serial number label is blocking the photocell.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If you have a UV lamp with a white serial number label, it is possible that the label is blocking the photocell. Rotate the lamp approximately 90 degrees and then try to start the 2020 again. If the fault persists, replace the lamp.

Cause: the UV lamp is not installed.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: Install a UV lamp.

Cause: The UV lamp has failed.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: Install a new UV lamp.

Cause: Electronic problem.

Action: If a new UV lamp still generates this fault, then contact the Photovac Service Department.

Fault 4: Pump current too low or too high.

Cause: If the pump sounds labored, then the pump is operating beyond normal operating parameters.

Action: Check for an obstruction in the sample line. Make sure sample line, sample probe or inlet filter are not plugged.

Note: Do not replace the inlet filter in a hazardous location.

Action: Replace the inlet filter.

Action: Ensure the sample outlet, located on the underside of the 2020, is not obstructed.

Cause: The UV lamp is too wide, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too wide for the lampholder. Contact the TtNUS Equipment Manager.

Cause: The 2020 has been exposed to a solvent that can pass through the inlet filter and liquid has been aspirated.

Action: Contact the TtNUS Equipment Manager.

Cause: The pump has failed.

Action: Contact the TtNUS Equipment Manager.

5.2 Specific Problems

Problem: Very low or no instrument response detected, yet compounds are known to be present.

Cause: The 2020 has not been calibrated properly.

Action: Ensure the calibration gas is of a reliable concentration and then calibrate the instrument as outlined in Section 4.6 of the User's Manual. After the instrument has been calibrated, sample the bag of calibration gas. A reading equivalent to the calibration gas should be displayed. If not, contact the TtNUS Equipment Manager.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Disconnect the battery charger before calibrating the 2020.

Cause: Calibration Memories have not been programmed correctly.

Action: Program all the calibration memories you require for your application. You must use the correct calibration gas and concentration for each Cal Memory.

Cause: The response factor has been set to zero.

Action: Enter the correct response factor. Refer to Appendix 8.6 for a list of response factors. If the compound is not listed in Appendix 8.6 or you are measuring gas mixtures, then enter a value of 1.0. See User's Manual provided by the manufacturer.

Cause: You are not using the correct Cal Memory.

Action: Select the correct Cal Memory for your application.

Note: It does not matter which Cal Memory is selected or which response factor is entered. The 2020's response is not specific to any one compound. The reading displayed represents the total concentration of all ionizable compounds in the sample.

Cause: Detector is leaking. A decrease in sensitivity may be due to a leak in the detector.

Note: Do not remove or replace the detection lamp in a hazardous location.

Action: Ensure the UV lamp has been installed correctly.

Action: Ensure the lamp cover has been tightened down. Do not overtighten the cover.

Action: Ensure the o-ring seal on the lamp cover is positioned correctly.

Cause: The UV lamp is too long, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too long for the lampholder. Replace the lamp and contact the TtNUS Equipment Manager.

Cause: UV lamp is too wide, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too wide for the lampholder. Contact the TtNUS Equipment Manager.

Cause: The sampling environment is extremely humid.

Action: Water vapor is not ionized by the PID, but it does scatter and absorb the light and results in a lower reading. The 2020 detector has been designed to operate under high humidity conditions. Under extreme conditions you may notice decreased response due to humidity.

Cause: The UV lamp is failing.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: High concentration of non-ionizable compounds. Chemical compounds, such as methane, with IPs greater than the 10.6 eV scatter and absorb the UV light. Sensitivity may be decreased significantly. Application with high backgrounds of such materials, may be incompatible with the 2020. Contact the Photovac Applications Group for more information.

Problem: Erroneously high readings.

Cause: Sampling environment is extremely humid.

Action: Water vapor may contain mineral salts, which carry a charge. The water vapor becomes an electrolytic solution, which becomes ionized when it enters the detector. Atmospheric water in areas around the sea or stagnant water may produce a response in the absence of contaminants. The same effect may be seen when conducting ground water investigations in areas where the water is hard because it contains a significant concentration of minerals.

Cause: The 2020 has not been calibrated properly.

Action: Ensure the calibration gas is of a reliable concentration and then calibrate the instrument as outlined in Section 4.6. After the instrument has been calibrated, sample the bag of calibration gas. A reading equivalent to the calibration gas should be displayed. If not contact the TtNUS Equipment Manager.

Cause: Cal Memories have not been programmed correctly.

Action: Program all the Cal Memories you require for your application. You must use the correct calibration gas and concentration for each Cal Memory. See Section 3.4, of the User's Manual.

Cause: You are not using the correct Cal Memory.

Action: Select the correct Cal Memory for your application. See Section 3.2.2 or 3.3.2, of the User's Manual.

Note: It does not matter which Cal Memory is selected or which response factor is entered. The 2020's response is not specific to any one compound. The reading displayed represents the total concentration of all ionizable compounds in the sample.

Cause: The Detector has been short circuited by foreign matter in the detector cell.

Note: Do not service the 2020 in a hazardous location.

Action: Do not touch the wire grid inside the detector cell. Use a gentle jet of compressed air to remove any dust in the detector cell.

Warning: Do not insert any object, other than the UV lamp, into the lampholder.

Cause: There is an undetermined problem.

Action: Contact the TtNUS Equipment Manager.

Problem: Date and time settings are not retained.

Cause: The battery pack has been removed before the 2020 was turned off.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Replace the battery pack and reset the time and date. Ensure that the 2020 has been turned off before removing the battery pack.

Cause: The 2020 has not been used for 3 months or more and the internal battery (not the external battery pack) has discharged.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Connect the 2020 to the AC adapter and turn the 2020 on. Turn the pump off. While the 2020 is running the internal battery is charging. Leave the instrument running for approximately 24 hours.

Problem: Instrument status shows "Over."

Cause: High concentrations of gases and vapors will cause a rapid change in signal level. The detector and associated electronics may become temporarily saturated.

Action: Wait a few seconds for the status to return to normal. PIDs are designed to detect relatively low concentrations of gases and vapors. Exposure to very high concentrations may result in a very high or maximum response.

Cause: The detector has become saturated.

Action: Move the 2020 to a location where it can sample clean air. Sample clean air until the reading stabilizes around 0.

Cause: Detector has been short circuited by foreign matter in the detector cell.

Note: Do not service the 2020 in a hazardous location.

Action: Do not touch the wire grid inside the detector cell. Use a gentle jet of compressed air to remove any dust or dirt in the detector cell.

Warning: Do not insert any object, other than the UV lamp, into the lampholder.

Cause: There is an undetermined problem.

Action: Contact the TtNUS Equipment Manager.

Problem: Display is blank.

Cause: Battery pack is critically low.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Replace the battery pack or connect the 2020 to the AC adapter.

Cause: The battery pack is not connected to the instrument correctly.

Action: Ensure the battery pack connector is securely attached to the connector on the 2020.

Cause: There is an undetermined problem.

Action: Reset the 2020. You must leave the instrument on while you disconnect the battery pack. This will reset the instrument. Reconnect the battery pack and close the battery hatch. Turn on the 2020, set the time and date and program all the calibration memories that you are using.

Action: Contact the TtNUS Equipment Manager.

Problem: Sample flow rate is less than 300 ml/min.

Cause: The inlet filter is plugged.

Note: Do not replace the inlet filter in a hazardous location.

Action: Replace the inlet filter.

Cause: The inlet filter has not been installed properly.

Action: Ensure that the inlet filter has been installed correctly.

Cause: The UV lamp is too long, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too long for the lampholder. Replace the lamp and contact the TtNUS Equipment Manager.

Cause: The UV lamp is too wide, causing flow to be restricted.

Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too wide for the lampholder. Contact the TtNUS Equipment Manager.

Cause: The 2020 has been exposed to a solvent that can pass through the inlet filter and liquid has been aspirated.

Action: Contact the TtNUS Equipment Manager.

Cause: Sample outlet is obstructed.

Action: Ensure the sample outlet is not obstructed in any way.

Cause: Pump has been damaged.

Action: Contact the TtNUS Equipment Manager.

Problem: Liquid has been aspirated.

Cause: The 2020 has been exposed to a solvent that can pass through the inlet filter.

Action: Contact the TtNUS Equipment Manager.

Problem: Corrosive gases and vapors have been sampled.

Cause: The 2020 has been exposed to corrosive gases and vapors.

Action: Corrosive gases and vapors can affect the electrodes within the detector as well as the lamp window. Prolonged exposure to corrosive materials may result in permanent fogging or etching

of the window. If the 2020 is exposed to corrosive material, contact the TtNUS Equipment Manager.

6.0 SHIPPING

The Photovac may be shipped as cargo or carried on as luggage providing there is no calibration gas cylinder accompanying the kit. When shipping or transporting the calibration gas, a Hazardous Airbill must be completed.

7.0 REFERENCES

Photovac 2020 Photoionization Monitor User's Manual, 1995.

8.0 ATTACHMENTS

1. Equipment Calibration Log

ATTACHMENT 1
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		

STANDARD OPERATING PROCEDURE
NUMBER CTO126-07

BOREHOLE AND SOIL SAMPLE LOGGING

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the standard procedures and technical guidance on the logging of soil cores collected at the Jeep Trail, at the NSWC Crane facility.

2.0 FIELD FORMS AND EQUIPMENT

Knife
Ruler (marked in tenths and hundredths of feet)
Boring Log: An example of this form is attached.
Photoionization Detector (PID) (see SOP 126-06)
Writing Utensil

3.0 RESPONSIBILITIES

A field geologist/engineer is responsible for supervising all boring activities and assuring that each borehole is properly and completely logged.

4.0 PROCEDURES FOR BOREHOLE AND SAMPLE LOGGING

To maintain a consistent classification of soil, it is imperative that the field geologist understands and accurately uses the field classification system described in this SOP. This identification is based on visual examination and manual tests.

4.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Figure 1 (attached to this SOP).

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 distinguishable 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 categories: 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.

4.2 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." Because 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.

4.3 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).

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 the following table.

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

Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Figure 1).

The consistency of cohesive soils is determined by hand by determining the resistance to penetration by the thumb. The thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample. The sample shall be broken in half and the thumb 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. 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 the above-listed table.

4.4 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

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.

4.5 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 gloved 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 field activity.

4.6 Classification of Soil Grain Size for Chemical Analysis

To determine the gross grain size classification (e.g., clay, silt, and sand) from the USCS classification described above, the following table shall be used.

Gross Soil Grain Size Classification	USCS Abbreviation	Description
Clay	CL	inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays,
	CH	inorganic clays of high plasticity, fat clays
	OH	organic clays of medium to high plasticity, organic silts
Silt	ML	inorganic silts and very fine sands, rock four, silty or clayey fine sands with slight plasticity
	OL	organic silts and organic silty clays of low plasticity
	MH	inorganic silts, micaceous or diatomaceous fine sand or silty soils

Gross Soil Grain Size Classification	USCS Abbreviation	Description
Sand	SW	well graded sands, gravelly sands, little or no fines
	SP	poorly graded sands, gravelly sands, little or no fines
	SM	silty sands, sand-silt mixtures
	SC	clayey sands, sand-clay mixtures

4.7 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
- Other distinguishing features
- Grain size
- Depositional environment

4.0 ATTACHMENTS

1. Figure 1 - Unified Soil Classification System
2. Boring Log

ATTACHMENT 1

FIGURE 1 - UNIFIED SOIL CLASSIFICATION SYSTEM

Unified Soil Classification System

Coarse Grained Soils (more than half of soil > No. 200 sieve)	Gravels (More than half of coarse fraction > no. 4 sieve size)	GW	Well graded gravels or gravel-sand mixtures, little or no fines
		GP	Poorly graded gravels or gravel-sand mixtures, little or no fines
		GM	Sandy gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-silt mixtures
	Sands (More than half of coarse fraction < no. 4 sieve size)	SW	Well graded sands or gravelly sands, little or no fines
		SP	Poorly graded sands or gravelly sands, little or no fines
		SM	Silty sands, sand-silt mixtures
		SC	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
Fine Grained Soils (more than half of soil < No. 200 sieve)	Silts and Clays LL = < 50	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, lean clays
		OL	Organic silts and organic silty clays of low plasticity
	Silts and Clays LL = > 50	MH	Inorganic silts, micaceous or diatomaceous fine sand or silty soils, elastic silts
		CH	Inorganic silts of high plasticity, fat clays
		OH	Organic clays of high plasticity, organic silty clays, organic silts
Highly Organic Soils		Pt	Peat and other highly organic soils

Grain Size Chart

Classification	Range of Grain Sizes	
	U.S. Standard Sieve Size	Grain Size In Millimeters
Boulders	Above 12"	Above 305
Cobbles	12" to 3"	305 to 76.2
Gravel	3" to No. 4	76.2 to 7.76
coarse	3" to 3/4"	76.2 to 4.76
fine	3/4" to No.4	19.1 to 4.76
Sand	No. 4 to No. 200	4.76 to 0.074
coarse	No.4 to No. 10	4.76 to 2.00
medium	No. 10 to No. 40	2.00 to 0.420
fine	No. 40 to No. 200	0.420 to 0.074
Silt and Clay	Below No. 200	Below 0.074

Relative Density (SPT)

SANDS AND GRAVELS	BLOWS/FOOT
VERY LOOSE	0 – 4
LOOSE	4 – 10
MEDIUM DENSE	10 – 30
DENSE	32 – 50
VERY DENSE	OVER 50

Consistency (SPT)

SILTS AND CLAYS	BLOWS/FOOT
VERY SOFT	0 – 2
SOFT	2 – 4
MEDIUM STIFF	4 – 8
STIFF	8 – 16
VERY STIFF	16 – 22
HARD	OVER 32

ATTACHMENT 2

BORING LOG

Tetra Tech NUS, Inc.

BORING LOG

Page ___ of ___

PROJECT NAME: _____ BORING No.: _____
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 reponse read.

Remarks: _____

Drilling Area Background (ppm): _____

Converted to Well: Yes _____ No _____ Well I.D. #: _____

STANDARD OPERATING PROCEDURE
NUMBER CTO126-08

SURFACE AND SUBSURFACE SOIL SAMPLING

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures to be used for surface and subsurface soil sampling using direct push technology (DPT) or split-barrel samplers during field activities at the Jeep Trail at the NSWC Crane facility. This procedure also describes the collection of samples for analysis of volatile organic compounds (VOCs) using EnCore samplers, and the use of field screening (i.e., photoionization detector [PID]) to select the most appropriate subsurface soil interval for VOC sampling.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Writing utensil with indelible ink
Disposable medical-grade gloves (i.e. latex, nitrile)
Boring log
Soil sample logsheets
Stainless-steel mixing bowls or plastic sheets
Stainless-steel or disposable trowel or soup spoon
EnCore handle and samplers
Required sample containers: All sample containers including shipping coolers for analysis by fix-based laboratories will be supplied and deemed certified clean by the laboratory.
Required decontamination materials
Chain-of-custody records
Required personnel protective equipment (PPE)
Photoionization detector (PID) (see SOP 126-06)
Wooden stakes or pin flags
Sealable polyethylene bags
Heavy-duty cooler
Ice
Razor knife

Geoprobe and sampling equipment

Sample labels and tags

3.0 COLLECTION OF SOIL SAMPLES FOR VOLATILE ORGANIC COMPOUNDS (VOCs)

When soil cores are collected using DPT such as Geoprobe, 2-foot soil intervals will be collected in clear acetate tubes, which can be extracted from the Geoprobe core barrel (see SOP CTO126-04) upon retrieval at the surface.

3.1 Slit the acetate liner lengthwise with a razor knife, remove a section of the liner, and expose the length of the soil interval (see SOP CTO126-04).

3.2 Scan the soil core interval with a PID, slowly moving the intake nozzle along the length of the core where the acetate liner has been slit open. Note on the Boring Log what the range of PID readings are detected, and the specific location(s) along the sample interval where above-background readings are encountered. If elevated volatile organics are measured via the PID, collect the VOC samples from the specific interval where the highest PID reading is measured. If no above-background PID readings are measured, then the VOC sample will be collected from a specific interval where visual signs of contamination (staining, etc.) are observed. If no above-background PID reading is measured, and no discoloration or odor in the soil core indicate potential contamination, then collect the VOC sample from near the center of a core.

3.3 The 0-2 feet core interval will be collected as a "surface soil" sample. Determine where in this core interval the highest PID reading was encountered. Soil samples collected for volatile organics will be obtained directly from soil cores using four EnCore samplers for each VOC sample. These samples are to be collected by pushing the EnCore samplers directly into the soil core where the highest PID readings were measured, ensuring that the sampler is packed tight with soil, and leaving no headspace between cap and container. All four EnCore sample containers will be collected as close to each other as possible. Make sure that all caps are securely fastened to the samplers and locked in place with both clips (see instructions that come with samplers). Write the sample ID on the strip labels that come with the samplers and place a label on each of the four samplers.

3.4 Place the four EnCore samplers in the ziplock pouches that come with the samplers and fill in appropriate information, including sample ID, date, time, and other information on the label. Place the four pouches in a plastic bag and place the tag on the bag, identifying the sample ID and other necessary information (see SOP CTO126-01).

3.5 Once the samples are properly labeled, bagged, and tagged, place the sample into the cooler containing ice and a trip blank. It should be kept at 4°C and shipped to the analytical laboratory for preservation or extraction within 48 hours.

3.6 Fill in the required information on the Soil Sample Log Sheet (attached at the end of this SOP) and fill in the required information on the Chain-of-Custody (COC) form.

3.7 Additional subsurface soil samples may be collected from each boring. For these subsurface soil samples, the collected cores will be scanned with the PID before a specific depth is selected for VOC sampling. Choose the specific location within the collected cores that had the highest PID reading and proceed to collect four EnCore samples, as described above in 3.2 through 3.6. If readings are not elevated, samples will be collected from the center of each cored interval using the default sample depths identified in the QAPP. Place the samples in the cooler containing ice, once they have been properly labeled, bagged, and tagged.

4.0 COLLECTION OF OTHER SOIL SAMPLE ALIQUOTS

Note: A surface soil sample is collected from the 0-2 feet depth (i.e., one core length). Additional subsurface soil samples each consist of two 2-foot core segments.

4.1 After the VOC sample has been collected for the soil interval of interest (see 3.0 above), the remainder of the soil interval shall be composited and used to fill the remainder of the sample containers. Any surface debris (e.g., herbaceous vegetation, twigs, rocks, litter, etc.) should first be removed from the top of the surface soil core. For other core intervals, the top 2 inches of each core should be discarded because it often contains material scraped from the side of the borehole and not fresh material from the bottom of the borehole.

4.2 Slide the remaining core material out of the acetate liner and into a clean, decontaminated stainless steel mixing bowl or on a plastic sheet. Mix the soil thoroughly with a stainless steel or disposable spoon or trowel and remove gravel, large pebbles, and other coarse materials. Fill the required sample containers in the following order:

- Containers for organic analyses
- Container for metals
- Container for Nitrate
- Container for Nitrite

The containers (number, size, and type) required for each type of laboratory analysis are listed in Table 4-12 of the QAPP.

4.3 Complete all required information on the sample labels (see SOP CTO126-01).

4.4 Fill in all required information on the sample tag and secure the tag to the sample container.

4.5 Place the sample container in a ziplock plastic bag and seal shut. Place the bag in a cooler containing ice and cool to 4 $\pm$ 2°C.

4.6 Record the required information on the Soil Sample Log Sheet and the COC form.

5.0 PACKAGING AND SHIPPING OF SAMPLES

Samples will be packaged and shipped according to SOP CTO126-04.

6.0 ATTACHMENTS

1. Soil and Sediment Sample Log Sheet

ATTACHMENT 1

SOIL AND 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 Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
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):

STANDARD OPERATING PROCEDURE
NUMBER CTO126-09

INSPECTION OF EXISTING MONITORING WELLS

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes procedures for the inspection and repair of existing monitoring wells at the Jeep Trail, at the NSWC Crane facility.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following equipment and field forms are required for inspection of existing monitoring wells.

Monitoring well inspection form: A copy of the monitoring well inspection form is attached.
Writing utensil with indelible ink
Bound field log book
Well keys
Disposable medical-grade gloves (e.g., latex, nitrile)
Photoionization detector (PID)
Electronic water-level indicator
Steel rod (about 1-inch diameter with eye bolt at one end)
100 feet of nylon rope
Internal pipe cutter
File, v notch

3.0 INSPECTION PROCEDURES

3.1 Record the well identification information (ID), date, and time on the Monitoring Well Inspection Form.

3.2 Record the condition of the well ID tag. Is the tag in place and legible? If not, note the discrepancies on the Monitoring Well Inspection Form.

3.3 Record the condition of the protective casing, caps, and lock. Has the casing, cap, and/or lock been tampered with or damaged? Has the well been damaged in any way or does it show signs of deterioration?

3.4 Record the condition of the concrete or gravel pads, if a pad is present. Check the condition of the pad (or the area around the well if no pad exists) and note any abnormalities. Are concrete pads cracking or heaving? If a gravel pad is present, is there any erosion or plant growth in the pad area?

3.5 Record the condition of the cement seal surrounding the protective casing. Has the seal cracked or pulled away from the protective casing? Record any visible signs of deterioration in the area of the seal.

3.6 Record the presence of depressions and/or standing water around the casing or pad.

3.7 Unlock the well cap and open the protective cover, if one exists.

3.8 Inspect and record the condition of the PVC riser pipe and the surveyed reference point. The surveyed reference point is a V-notch on the top of the PVC riser pipe.

3.9 Measure the height of the protective casing and riser pipe above the ground surface. Record these readings on the inspection form to the nearest 0.01-foot.

3.10 Check Table 3-6 of the QAPP to verify the total original depth of the monitoring well being inspected.

3.11 Open the well cap and use the PID to screen the air within the well opening to determine whether above-background levels of VOCs are present within the well. Refer to the HASP for procedures to follow for the presence of VOCs in a well.

3.12 Lower the electronic water-level indicator probe down the well casing. If an obstruction is encountered, record the depth of the obstruction, and whether the obstruction is partial or complete.

3.13 If no obstruction is encountered, continue lowering the water-level indicator down the well casing until ground water is encountered. Measure the depth to water to the nearest 0.01 feet (see SOP CTO131-18), and record the depth on the Inspection Log.

3.14 Continue lowering the indicator probe down the casing until a solid bottom is reached or an obstruction is encountered. Record the depth to bottom of well (from top of casing) on the Inspection Log.

3.15 If an obstruction is encountered in the casing before the well bottom is reached, record the depth of obstruction on the Inspection Log, and whether the obstruction is partial or complete.

3.16 Remove the water-level indicator from the well.

3.17 If an obstruction was encountered during steps 3.12 or 3.14, lower a heavy steel rod slowly down the well casing until the obstruction is encountered. Attempt to loosen the obstruction by raising and dropping the steel rod, letting it hit the obstruction with gradually increasing force. Record whether the obstruction could be loosened.

3.18 If step 3.17 is performed, remove the steel rod from the well and remeasure the depth to the obstruction. If the obstruction has been knocked loose and settles to the bottom, then the well may still be used as a piezometer, but will not be used for ground water sampling.

3.19 Close the well cap and lock, if lock is present.

3.20 Decontaminate the water-level indicator and steel rod, if used, per SOP CTO126-17.

3.21 Make recommendations on the Inspection Log, if necessary, for repair of the monitoring well. Replace lock, if needed, as soon as possible.

3.22 Perform repair of well as soon as possible.

4.0 Field Repairs to Monitoring Wells

Field repairs to monitoring wells, for the most part, will be limited to the repair of the PVC riser (inter case). If a monitoring well is damaged beyond the repair capabilities of the field crew, the NSWC Crane Environmental Department will be notified and a decision will be made to repair or replace the well using a drilling contractor.

4.1 Remove a short section of the top of the PVC riser, that is broken, using an inside pipe cutter. Prior to cutting the riser, a clean rag will be inserted into the riser to just below the cut, this will prevent cuttings from entering the well. Insert the cutter just below the damaged area and remove only the damaged section of riser. Carefully remove the rag, measure and record the length of riser removed, mark the top of the riser for water level measurement (filing a V notch is the preferred method).

4.2 If the riser damage indicates that a riser must be added, a section of PVC may be attached to the existing riser. After removing the damaged riser (see 4.1 above), cut a new section of riser to the needed length and attach a slip coupler to one end. In most cases, the coupler will fit securely to the pipe without the need for mechanical fasteners (pop-rivets/screws). If needed, fasteners may be used, but in no case will glue be used to attach the coupler. Attach the new coupler and PVC pipe to the existing riser, mark the top for measurement purposes and document the length of pipe added. All new materials (pipe and couplers) will be decontaminated prior to installation.

5.0 ATTACHMENTS

1. Monitoring Well Inspection Sheet

ATTACHMENT 1

MONITORING WELL INSPECTION SHEET

MONITORING WELL INSPECTION SHEET

Well ID: _____

Time: _____ **Date:** _____ **Inspector's Name:**

Inspection Item	Types of Problems	Status		Observation
		S	U	
Well Tag	Is it in-place, legible			
Well security	Condition protective case, cap, lock			
Well pad	Concrete or gravel & condition			
Well seal	Condition of...			
Area immediately around well pad	Record any evidence of/or standing water in area of well			
Dedicated sampling equipment	Condition of...			
PVC Riser	Condition of riser & survey reference point			

Comments:

Signature(s)_____

Note: S= Satisfactory, U= Unsatisfactory
Check one, If unsatisfactory explain

NSB-NLON
Field Form
Revision: 1
January: 1999

STANDARD OPERATING PROCEDURE
NUMBER CTO126-10

MONITORING WELL DEVELOPMENT

1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper development of new and existing monitoring wells. The methods described herein are specific for monitoring wells located at the Jeep Trail at the NSWC Crane facility. Guidelines by South Division, Naval Facilities Engineering Command, (SOUTHDIV NAVFAC, 1997) and the State of Indiana regulatory requirements in Article 16 Water Well Drillers of Chapter 310 of the Indiana Annotated Codes (310 IAC 16) should be consulted.

2.0 RESPONSIBILITIES

The drilling contractor will provide adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of performing the development of monitoring wells. The drilling contractor personnel must have all of the health and safety training required to perform the work, as specified in the Health and Safety Plan.

3.0 REQUIRED EQUIPMENT/ITEMS

The following list includes equipment and items required for monitoring well installation:

Health and safety equipment as required by the HASP and the Site Safety Officer.

Well development 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).

4.0 WELL DEVELOPMENT METHODS

The development of new wells shall not occur until at least 48 hours after the well has been installed and grouted. This time is required so that the grout in the annulus can set and harden. The purpose of well development is to stabilize and increase the permeability of the sand pack and 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, if any, is removed from the well.

Sequential measurements of pH, specific conductance, turbidity, and temperature taken during development yield information (stabilized values) that sufficient development is reached. Development should proceed until criteria are met as stated in Navy Guidelines.

A surge plunger (also called a surge block) that is approximately the same diameter as the well casing will be used 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. Site-specific conditions will dictate which type will be used. 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.

Surging causes water to move in and out of the screens. This movement of water pulls fine materials into the well, preventing bridging of sand particles in the gravel pack. These fine materials will then be removed from the well using one of several methods available, such as submersible pumps (i.e. whale pumps), bailers, or even peristaltic pumps. Whale pumps can be used to surge and sweep the well screen as it pumps. Another alternative method for development would be to utilize a waterra (i.e. check valve method). This method allows for surging and purging of the well by moving tubing in an up and down motion. On the downward stroke, the ball in the foot valve lifts and the tubing fills with water; and on the upward stroke the ball is set and surged ground water is forced out of the tubing and into a purge bucket.

Development should proceed until the following criteria are met:

- The well water is clear to the unaided eye AND-

- A minimum removal of five times the standing water volume in the well (to include the well screen and casing plus saturated borehole annulus, assuming 30% annular porosity) OR

- When pH measurements remain constant within 0.1 Standard Units and specific conductance and temperature vary no more than plus or minus 3% for at least three consecutive readings. Turbidity should also show stabilization and ideally be below 10 Nephelometric Turbidity Units (NTUs).

or

- If the well has been purged dry at least three times while waiting 15 to 20 minutes to allow the well to recharge between pumping intervals. Recharge rates will be documented while the well is allowed to recover.

If for any reason the above criteria cannot be met, the site geologist should document the event in writing and consult with the TOM regarding an alternate plan of action.

Well development must be completed at least 24 hours before well sampling. The intent of this hiatus is to provide time for the newly installed well and backfill materials to sufficiently equilibrate to their new environment and for the new environment to re-stabilize after the disturbance of drilling. All well development water should be handled in accordance with SOP CTO126-15.

5.0 ATTACHMENTS

1. Monitoring Well Development Record

ATTACHMENT 1

MONITORING WELL DEVELOPMENT RECORD

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Page ___ of ___

Well: _____
Site: _____
Date Installed: _____
Date Developed: _____
Dev. Method: _____
Pump Type: _____

Depth to Bottom (ft.): _____
Static Water Level Before (ft.): _____
Static Water Level After (ft.): _____
Screen Length (ft.): _____
One Well Volume (gal/L): _____
Casing ID (in.): _____

Responsible Personnel: _____
Drilling Company: _____
Project Name: _____
Project Number: _____
PID Readings: Bore Hole_____ppm
PID Readings: Breathing Zone_____ppm

Time	Cumulative Water Volume (Gal.)	Flow Rate (mL/min.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units _____)	Turbidity (NTU)	Remarks (odor, color, etc.)

STANDARD OPERATING PROCEDURE
NUMBER CTO126-14

CALIBRATION AND CARE OF WATER QUALITY METER

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedures for the calibration and maintenance of field instruments used to measure water quality, and for the proper documentation of calibration and maintenance. The YSI 6-Series Environmental Monitoring System will be used to measure pH, temperature, oxidation-reduction potential (ORP), specific conductance (SC), dissolved oxygen (DO), and turbidity in water. The YSI meter has a multiprobe sensor, which can be used in conjunction with a flow-through cell attached to a pump discharge tube to measure water quality parameters in a ground water discharge, or can be immersed in a surface water body such as a stream, pond, or drainage ditch.

2.0 FIELD FORMS AND EQUIPMENT LIST

The following log books, forms, equipment and supplies are required.

Site log book
Equipment calibration log sheet
YSI Model 610-D and Sonde: multi-parameter water quality meter with flow through cell
Equipment manual
Calibration kit
Deionized water, paper towels, spray bottle etc.
Disposable medical-grade gloves (e.g., latex, nitrile)

3.0 PROCEDURES

This section describes the calibration procedure for the YSI Model 610-D. The meter is supplied with an instruction manual. Sections of this manual are reproduced in this SOP. The manual will be on-site and used as the calibration guidance document for the meter's calibration (page 29, Section 2.6 of the manual

starts the calibration procedure). This procedure will list requirements for frequency of calibration and checks to be performed on the meter.

The YSI Model 610-D and Sonde is a multi-parameter, water quality meter that may be used to measure open water bodies (streams, ponds, springs, etc.) with the probe guard installed. With the flow through cell attached, the meter has the ability to measure water quality parameters in ground water via a pump discharge line. By performing the measurements in the discharge line coming directly from the well, the parameters are measured prior to the ground water coming in contact with the atmosphere. The parameters measured by the YSI for this field effort are:

- Dissolved Oxygen (DO)
- Specific Conductance (SC)
- Temperature
- pH
- Oxidation-Reduction Potential (ORP)
- Turbidity

3.1 Documentation

The Equipment Calibration Log is used to document calibration of measuring equipment used in the field. The Equipment Calibration Log documents that the manufacturer's instructions were followed for calibration of the equipment, including the frequency of calibration, type of standards used, and checks performed on calibration during the course of using the equipment. An Equipment Calibration Log must be maintained for each measuring device that requires calibration. Entries must be made for each day the equipment is used. A blank Equipment Calibration Log form is attached at the end of this SOP.

3.2 Calibration

All the parameters listed in Section 3.0 must be calibrated prior to the start of each field effort. After this initial calibration, the YSI will be checked each day that it is used. If the check shows any out-of-spec readings, the specific probe will be recalibrated. Meter specifications can be found in the equipment manual, starting on page 248. Calibration and calibration checks will be documented in the Field Logbook and on the Equipment Calibration Log. The name, lot number, and expiration date for all calibration buffers and standards used will be recorded on the Equipment Calibration Log. The meter's model, serial number, and name of rental company will also be recorded on the equipment calibration form.

3.3 Tips for Good Calibration

- The DO calibration is a water-saturated air calibration. Make certain to loosen the calibration cup seal to allow pressure to equilibrate before calibrating.

- Make certain that sensors are completely submersed in solution and readings are stable when calibration values are entered.

- Use a small amount of calibration solution (previously used solution may be used, then discarded for this purpose) to pre-rinse the sonde.

- Fill a bucket with ambient temperature water to rinse the sonde between calibration solutions.

- Make sure to rinse and dry the probe between calibration solutions. This will reduce carry-over contamination and increase the accuracy of the calibration.

4.0 MAINTENANCE

The YSI Meter will be rented for the duration of each brief field effort. Therefore, little field maintenance will be required. For any maintenance other than the routine cleaning, calibrating, or battery charging, the instrument should be returned to the vendor and a replacement sent immediately to the job site.

4.1 Meter Storage

For this field effort, the meter storage will be short term, i.e. over-night or between work shifts (4-day break). During these breaks the meter shall be placed on charge. One-half inch of tap or distilled water shall be placed in the meter calibration cup and the cup threaded onto the sonde. The key for short-term storage of probes is to use a minimal amount of water so that the calibration cup will remain at 100% humidity. The water level must be low enough so that none of the probes are actually immersed. Proper storage of the sonde between usage will extend its life and will also ensure that the unit is ready for use as quickly as possible for the next application.

Multi-parameter short term storage key points:

- Use enough water to provide humidity, but not enough to cover the probe surfaces.
- Make sure the storage vessel is sealed to minimize evaporation.

- Check periodically to make certain that water is still present.

4.2 Probe Cleaning

- Rinse the probe thoroughly with potable water.
- Wash the probe in a mild solution of Liquinox and water and wipe with paper towels and/or cotton swabs.
- Rinse and soak the probe in deionized water.
- If stronger cleaning is required, consult Section 2.10 on page 89 of the equipment manual.

Note: Reagents that are used to calibrate and check the YSI may be hazardous. Review the Health and Safety Plan, Appendix A of the equipment manual, and MSDS's, all of which are on file in the field trailer.

5.0 ATTACHMENTS

1. Equipment Calibration Log

ATTACHMENT 1
EQUIPMENT CALIBRATION LOG

Tetra Tech NUS, Inc.

DOCUMENTATION OF FIELD CALIBRATION

PROJECT NAME : _____ INSTRUMENT NAME/MODEL: _____

SITE NAME: _____ MANUFACTURER: _____

PROJECT No.: _____ SERIAL NUMBER: _____

Date of Calibration	Person Performing Calibration	INITIAL READINGS						FINAL READINGS						Calibration Standard (Lot No.)	Remarks and Comments
		PH	COND	TURB	DO	TEMP	SAL	PH	COND	TURB	DO	TEMP	SAL		

STANDARD OPERATING PROCEDURE
NUMBER CTO126-15

MANAGEMENT OF INVESTIGATION DERIVED WASTE

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes how investigation derived waste (IDW) will be collected, segregated, classified, and managed during the field investigations at the Ammunition Burning Ground (ABG), Little Sulphur Creek and Jeep Trail, at the NSWC Crane facility. The following types of IDW will be generated during this investigation:

- Excess soil and rock materials remaining from subsurface drilling activities
- Well development water and purge water related to monitoring well installation and sampling
- Decontamination solutions
- Personal protective equipment and clothing (PPE)
- Miscellaneous trash and incidental items

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Health and safety equipment (with PPE)
Decontamination equipment
Field logbook and indelible ink pen
Plastic sheeting and/or tarps
55-gallon drums with sealable lids
IDW labels for drums
Waste water container tanks
Plastic garbage bags

3.0 PROCEDURES

Management of IDW includes: the collection, segregation, temporary storage, classification, final disposal, and documentation of the waste handling activities.

3.1 Liquid Wastes

Liquid wastes that will be generated during the site activities include well development water, well purge water (collected during low-flow sampling), and decontamination solutions from drilling and sampling equipment. As they are collected, these wastewaters will be placed in a 300-gallon (or smaller) portable tank attached to a truck. Whenever the portable tank approaches full, it will be transported to a central location at NSWC Crane adjacent to a Crane-designated sanitary sewer manhole. The water in the portable tank will be discharged to the sewer by gravity draining.

An accurate record will be kept by the FOL of all wastewaters that have been placed in the large holding tank. At a minimum, this information will include:

- the location and type of each water that has been placed in the tank (e.g., purge water from well 03MW47),
- the quantity of water from each source,
- the date the waste water was generated,
- the date and time the waste water was placed in the tank,
- the person(s) present when the wastewaters were discharged to the sewer.

3.2 Drill Cuttings and Cores

As cuttings are removed from borings, they will be screened for VOCs. If these results do not show above-background levels of VOCs, the cuttings materials will be mixed with bentonite and returned to the borehole when sampling activities in the hole are completed or spread on the ground in the area of the borehole. The backfill materials will be tamped as they are placed in the hole to increase density and reduce permeability of the backfill material.

If any soil materials from a screened borehole interval shows evidence of contamination (based on the field screening results), then the soil material from the screened interval will be placed in a plastic trash bag (or directly in a drum if a larger quantity) and the bag will be tagged. Information included on the tag will consist of the hole from which the material came, the depth interval from which the material came, the date, and the name of the person filling out the tag. The bag will then be placed in a 55-gallon drum and sealed (more than one bag may be placed in a drum). The waste drums will be stored at the Jeep Trail temporarily until laboratory results have been received concerning the soil samples that were collected from the suspect borehole. If the results indicate that no contamination is present in the soil samples. then the soils will be disposed of at the Jeep Trail site. If the levels of contamination of any of the

samples from a borehole exceed TCLP limits (using the total soil concentrations), then all excess soil from the borehole will be considered as RCRA-hazardous and disposed of offsite in accordance with RCRA waste disposal regulations. Alternatively the toxicity characteristic leaching procedure may be conducted for any constituent which could exceed the TC limits based on total concentrations.

Cuttings from well borings will be handled in the same manner as soil boring cuttings.

3.3 PPE, Pump Discharge Tubing, DPT Sample Liners and Incidental Trash

All PPE wastes, pump discharge tubes, DPT sample liners and incidental trash materials (e.g., wrapping or packing materials from supply cartons, waste paper) will be decontaminated (if contaminated) double-bagged, securely tied shut, and placed in a designated waste receptacle at NSWC Crane.

STANDARD OPERATING PROCEDURE
NUMBER CTO126-16

LOW-FLOW WELL PURGING AND STABILIZATION

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedure for well purging and stabilization utilizing low-flow techniques.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following field forms and equipment are required for low-flow purging.

Low-Flow Purge Data Sheet: A copy of this form is attached at the end of this SOP.
Ground Water Sample Log Sheet: A copy of this form and instructions for its completion are included in SOP CTO126-05.
Bound Field Log Book
Writing Utensil
Photoionization detector (PID): The procedures for the operation of the PID are found in the Health and Safety Plan and SOP CTO126-06.
Well key
Electronic water level indicator: The water level indicator must have a cable of sufficient length to reach the water surface and be capable of measurements of 0.01-feet (see SOP CTO126-18).
Electronic Programmable Controller, model 400: This controller regulates air flow in a bladder pump.
Cylinder of compressed nitrogen with regulator: Compressed gas serves as the power source for the bladder pump.
Multiple parameter water quality meter: This unit measures and displays field parameters measured in the field including pH, dissolved oxygen, oxidation-reduction potential (ORP), temperature, and specific conductance (see SOP CTO126-14).
Flow-through cell adapter for water quality meter
LaMotte Turbidity Meter: Used to measure turbidity (see SOP CTO126-14).
Purge water containers
Graduated cylinder and stopwatch: Used to calculate flow rate.

Decontamination supplies: SOP CTO126-17 describes required decontamination supplies.

Disposable medical-grade gloves (e.g., latex, nitrile)

Peristaltic Pump

Bladder Pump

Teflon tubing (new tubing used for each well)

3.0 PROCEDURES FOR WELL PURGING AND STABILIZATION

Steps 3.1 through 3.9 pertain to the use of a bladder pump. However, a peristaltic pump can be used as a substitute for a bladder pump if the water level in the well does not drop below 25 feet below ground surface during low-flow purging. A peristaltic pump should be operated per the manufacturer's operating manual and ground water should be pumped at the same rates as discussed in Steps 3.1 through 3.9.

3.1 Prior to mobilizing to the site, clean, check for proper operation, and calibrate as per manufacturer requirements above equipment as necessary.

3.2 Follow the steps outlined in SOP CTO126-18 to obtain a static water level measurement of the well to be purged. Record the information on the Ground Water Sample Log Sheet and the Low-Flow Purge Data Sheet. Leave the water level meter suspended in the well casing.

3.3 Calculate one well casing volume as follows:

1. Obtain the total depth of the well from Table 3-6 of this QAPP.

2. Using the static water level determined in Step 3.2 of this SOP and the total depth of the well, calculate the well casing volume using the following formula:

$$V = (0.163)(T)(r^2)$$

where:

V	=	Static casing volume of well (in gallons).
T	=	Vertical height of water column (linear feet of water).
0.163	=	A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.
r	=	Inside radius of the well casing (in inches).

Note: For wells of 1-inch radius (2-inch diameter) $\dot{V}$ = 0.163 gallons per foot of water column.

3.4 If the water level in the well is above the top of the screen, lower the bladder pump into the well such that the pump intake is set at the same elevation as the midpoint of the screen. If the water level is below the top of the screen, set the pump intake at the midpoint of the water column in the well. Under no circumstances should the pump or pump intake (for peristaltic pump) make contact with sediment in the bottom of the well.

3.5 Connect the pump controller to the well pump air supply (at the well cap) by following the instructions in the pump control manual. The pump controller must be turned off when being connected.

3.6 Connect the nitrogen cylinder to the pump controller. The nitrogen cylinder valve must be closed and the regulator line pressure set at zero pounds per square inch (psi) when being connected.

3.7 Following the instructions found in the water quality meter manual, connect the flow-through cell to the pump discharge line (at the well cap).

3.8 Place the discharge tubing from the flow-through cell to direct the purge water discharge into the graduated cylinder or purge-water container.

3.9 Following the instructions in the pump controller manual, start pumping water from the well.

3.10 Start with the initial pump rate set at approximately 0.1 liters/minute. Use the graduated cylinder and stopwatch to measure the pumping rate. Adjust pumping rates as necessary to prevent drawdown from exceeding 0.3 feet during purging. If no drawdown is noted, the pump rate may be increased (to a max of 0.4 liters/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 ground water is drawn down below the top of the well screen, purging will cease and the well will be allowed to recover before purging continues. Slow recovering wells will be identified and purged at the beginning of the workday. If possible, samples will be collected from these wells within the same 8-hour workday and no later than 24 hours after the start of purging.

The time to sample any given well will vary greatly due to the many variables associated with low flow purging and sampling; i.e.,

- Stabilization of parameters
- Possible draw down
- Analytical changes from quarter to quarter
- Varying QA sample requirements from quarter to quarter
- Variable pump rates

Normally, the time from the start of purging to the end of sampling will be between 1 and 4 hours.

3.11 Measure the well water level using the water level meter every five minutes. Record the well water level on the Low-Flow Purge Data Form (attached at the end of this SOP.

3.12 Record on the Low-Flow Purge Data Form every five to ten minutes the water quality parameters (pH, specific conductance, temperature, turbidity, oxidation-reduction potential, and dissolved oxygen) 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 water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Low-Flow Purge Data Form.

3.13 Measure the flow rate using a graduated cylinder. Remeasure the flow rate any time the pump rate is adjusted.

3.14 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.

3.15 Stabilization is achieved and sampling can begin when a minimum of one casing volume has been removed and three consecutive readings, taken at 5 to 10 minute intervals, are within the following limits:

- pH ± 0.1 standard units
- Specific conduct ± 5%
- Temperature ± 5%
- Turbidity less than 10 NTUs

- Dissolved oxygen ± 10%

If the above conditions have still not been met after the well has been purged for four hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters from the Low-Flow Purge Data From onto the Ground Water Sample Log Form.

If there is a need to leave a well during purging, there are two options:

- One, if the sampler must move for 30 minutes or less but still has a clear line of sight to the well, the sampler may leave the pump running and watch the well until the sampler is able to return to the well.

- Two, if for whatever reason, the sampler must stop purging for an extended period of time or a clear line of sight cannot be maintained, the pump and cell will be shut-down. All equipment and supplies will be loaded into the sample vehicle, and the well will be secured before departing.

In both cases, the time purging was stopped and restarted will be noted on the Low-Flow Purge Data Form.

3.16 Rinse the flow-through cell, the water quality meter probes, and the turbidity cell with analyte-free water and pack the cell and meters for transport.

4.0 ATTACHMENTS

1. Low-Flow Purge Data Sheet

ATTACHMENT 1

LOW-FLOW PURGE DATA SHEET

Tetra Tech NUS, Inc.

LOW FLOW PURGE DATA SHEET

PROJECT : _____
PROJECT NUMBER: _____
PROJECT SITE NAME: _____

WELL ID.: _____
DATE: _____
WEATHER: _____

Time (Hrs.)	Water Level (Ft. below TOC)	Volume (gal/L)	Flowrate (mL/min)	pH (S.U.)	Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celsius)	ORP (mV)	Comments

Water Quality Meter (S/N) _____
Control Box Type (S/N) _____
Turbidity Meter (S/N) _____

Pump Intake Depth _____

SIGNATURE(S): _____

PAGE___OF___

STANDARD OPERATING PROCEDURE
NUMBER CTO126-17

DECONTAMINATION OF FIELD SAMPLING EQUIPMENT

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedures to be followed when decontaminating non-dedicated field sampling equipment during the field investigations at the Ammunition Burning Ground (ABG), Little Sulfur Creek and Jeep Trail, at the NSWC Crane facility.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Waterproof pens
Non-latex rubber or plastic gloves
Cotton gloves
Field log book
Potable water
Deionized water
LiquiNox detergent
Brushes, spray bottles, paper towels, etc.
55-gallon drum or other container to collect and transport decontamination fluids

3.0 DECONTAMINATION PROCEDURES

3.1 Don non-latex and/or cotton gloves and decontaminate sampling equipment (in accordance with the following steps) prior to field sampling and between samples.

3.2 Rinse the equipment with potable water. Rinsing may be conducted by spraying with water from a spray bottle or by dipping. Collect the potable water rinsate into a container.

3.3 Wash the equipment with a solution of LiquiNox detergent. Prepare the LiquiNox wash solution in accordance with the instructions on the LiquiNox container. Collect the LiquiNox wash solution into a container. Use brushes or sprays as appropriate for the equipment. If oily residue has

accumulated on the sampling equipment, remove the residue with a isopropanol wash and repeat the Liquinox wash.

3.4 Rinse the equipment with potable water. Rinsing may be conducted by spraying with water from a spray bottle or by dipping. Collect the potable water rinsate into a container.

3.5 Rinse the equipment with deionized water. Rinsing may be conducted by spraying with water from a spray bottle or by dipping. Collect the deionized water rinsate into a container.

3.6 Remove excess water by air drying, shaking, or by wiping with paper towels as necessary.

3.7 Document decontamination by recording it in the Field Logbook.

3.8 Containerized decontamination solutions will be managed in accordance with the procedures described in SOP CTO126-15 and Section 4.11 of the QAPP.

STANDARD OPERATING PROCEDURE
NUMBER CTO126-18

MEASUREMENT OF WATER LEVELS IN MONITORING WELLS

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes procedures for determining water levels in monitoring wells.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following equipment and field forms are required for determining water levels in monitoring wells.

Ground Water Level Measurement Form: A copy of the Ground Water Level Measurement Form is attached.
Bound Field Log Book
Photoionization detector (PID): Operation and calibration of the PID is discussed in SOP CTO126-06.
Well key
Writing utensil
Electronic Water-Level Indicator: The water level indicator must have a cable of sufficient length to reach the water surface and be capable of measurements of 0.01 feet.
Decontamination supplies: SOP CTO126-17 describes decontamination procedures including decontamination supplies.

3.0 WATER-LEVEL MEASUREMENT PROCEDURES

3.1 Check the operation of the electronic water level indicator or interface meter.

3.2 Record the well identification (ID), date, and time (using military time) on the Ground Water-Level Measurement Form.

3.3 Unlock the well and remove the well cap.

3.4 Place the well cap on a clean piece of plastic.

3.5 Check the well for the presence of organic vapors in the 2-inch PVC riser pipe as follows:

1. Calibration of the PID shall be done in accordance with the calibration procedures described in SOP CTO126-06. Calibration of the PID shall be done at the field office prior to entering the field.

2 Insert the PID sample inlet straw approximately three inches into the riser pipe.

3 Record the PID reading on the Ground Water Level Measurement Form. If the reading is less than concentrations specified in the site-specific HASP, proceed to step 3.6. If the reading is greater than the concentration specified in the HASP, measure the concentration in the breathing zone. If the concentration in the breathing zone is less than the concentration specified in the HASP, proceed to Step 3.6. If the reading is greater than the specified concentration, allow the riser pipe to ventilate for ten minutes and repeat the measurement of breathing zone concentrations until the concentrations fall below the level specified in the HASP before proceeding to step 3.6.

3.6 Ensure that the water level indicator probe has been decontaminated before use in accordance with the procedures outlined in SOP CTO126-17.

3.7 Slowly lower the probe into the well riser pipe until an audible and/or visible signal is produced, indicating contact with the water surface.

3.8 Read the ground water level measurement from the top of the inner casing at the surveyed reference point to the nearest 0.01-foot.

3.9 Record the water level measurement on the Ground Water Level Measurement Form.

3.10 Wind the meter cable measuring tape back onto the spool.

3.11 Replace the well cap and lock.

3.12 Decontaminate the meter's probe and cable following the procedures outlined in SOP CTO126-17.

3.13 Containerize any decontamination fluids and PPE in accordance with the procedures described in SOP CTO126-15.

4.0 ATTACHMENTS

1. Ground Water Level Measurement Sheet

ATTACHMENT 1

GROUND WATER LEVEL MEASUREMENT 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)*	Total Well Depth From TOC (feet)*	Water Level Indicator Reading (feet)*	Groundwater Elevation (feet)*	Comments

* All measurements to the nearest 0.01 foot

Page ____ of ____

STANDARD OPERATING PROCEDURE
NUMBER CTO126-21

ESTIMATING FLOW IN SMALL STREAMS

1.0 PURPOSE

This Standard Operating Procedure (SOP) provides technical guidance on the measurement of stream channel cross-section and flow in a small stream. Stream flow measurements will be obtained to evaluate the migration potential of contaminants in a stream channel. This method is applicable for free flowing streams with uniform flow and widths greater than 3 feet and depths greater than about 6 inches. Flow in the unnamed tributaries adjacent to the Ammunition Burning Ground (ABG), Little Sulphur Creek and Jeep Trail, at the NSWC Crane facility, are expected to be low when surface water samples are collected. Stream flow rates will be measured at the same time when water level measurements are collected.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Measuring rod or yardstick
Measuring tape
Waders or rubber boots
Colored flagging tape
2x2 inch wooden stakes
Bound Field Log Book
Waterproof pen
Orange or apple
Surface Water Sample Log Sheet
Indelible marker
Stopwatch

3.0 PROCEDURES

3.1 Establish a transect across the stream, along a straight reach where the stream is relatively narrow and velocity across the stream is relatively uniform. Orient the transect perpendicular to the flow.

3.2 Mark both ends of the transect with colored plastic flagging tape. Tie the flagging to a tree branch or other elevated (about eye level) object. Drive wooden stakes into the ground at both ends of transect and tack a short piece of brightly colored flagging to the stakes. Use a black marker to identify the transect number, which will be the same as the surface water sample location.

3.3 Measure the total distance across the stream with a measuring tape and record the stream width (in feet) in the field logbook.

3.4 Measure the depth of water in the stream at three or four points across the stream. Record these measurements and calculate an average depth. Record the average depth (in feet) in the field logbook.

3.5 Measure a distance of 20 feet upstream of the transect. Tie a piece of flagging on a tree branch or other visable location above the stream.

3.6 Go another 20 feet upstream and place the orange or apple in the center of the stream or where the water current is fastest.

3.7 Using a watch with a timer or a stopwatch, measure the length of time it takes the orange (or apple) to travel from the first marker flag to the transect location (distance of 20 feet). Record the time.

3.8 Repeat step 3.7 two more times. Record the readings and calculate an average time.

3.9 Calculate approximate flow rate in the stream channel by multiplying the stream width (from step 3.3) times the average depth (from step 3.4) times the average velocity (from step 3.8). Record the estimated flow rate (in ft^3/s) in the field logbook and on the Surface Water Sample Collection Log Sheet.

STANDARD OPERATING PROCEDURE
NUMBER CTO126-22

HYDRAULIC CONDUCTIVITY TESTING

1.0 PURPOSE

This Standard Operating Procedure (SOP) provides technical guidance for the performance and evaluation of a in-situ hydraulic conductivity testing (slug testing) in monitoring wells at the Jeep Trail, at the NSWC Crane facility.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Solid Slug
Pressure transducers and data recorder, including instruction manual
Manual water level indicator
Hydraulic Conductivity Testing Data Sheet
Watch
Decontamination equipment and supplies
Field Log Book
Measuring tape

3.0 PROCEDURES

Slug tests are short-term tests designed to provide approximate hydraulic conductivity values for the portion of a formation immediately surrounding the screened/open interval of a well or boring. These tests are much less accurate than pumping tests, as a much more localized area is involved. Therefore, a number of slug tests are typically performed and averaged to determine a representative hydraulic conductivity value for the formation tested. Performance of slug tests may be preferable to pumping tests in situations where handling of large volumes of contaminated water is a concern or when time/budget constraints preclude the more expensive and time-consuming setup and performance of a pumping test.

The procedure is summarized below:

3.1 Determine the total depth of the well using a weighted tape or other measuring device. A pressure transducer attached to a data logger shall be placed in the well approximately one foot from the bottom of the well. The transducer will be positioned so that it is about 5 to 10 feet lower than the slug.

3.2 Record the well number, the transducer probe identification number being used, the PSI rating for each probe, the depth below top of casing where each probe is positioned, the static water level in the well, and any other information relative to the setup and performance of the slug test. Data and information should be recorded in a bound field notebook and on the Pumping Test Data Sheet.

3.3 A falling-head test can be performed where the slug is lowered into the well and the rate of water-level fall with respect to time is recorded until equilibrium is reached. A rising-head test can be performed where a slug is lowered into the well and the water is allowed to equilibrate, then the slug is removed and the rate of water-level rise is measured with respect to time. Falling head slug tests should only be performed in wells with fully submerged screens, while rising head slug tests can be performed in wells with either partially or fully submerged screens/open intervals.

3.4 Remove or insert the slug and immediately start the data logger. Record the starting time for the data logger on the form sheet.

3.5 Manually measure the depth to water with a water depth indicator to estimate the rate of recovery while the data logger is in the sleep mode. Enter the reading onto the form sheet, along with the corresponding transducer reading from the same time.

3.6 Observe the water-level readings once the data logger can be read. Record the times and the readings on the form sheet.

3.7 Rate of recovery measurements shall be obtained from time zero (maximum change in water level) until water level recovery exceeds 90 percent of the initial change in water level. In low permeability formations, the test may be cut-off short of 90 percent recovery due to time constraints. Time intervals between water level readings will vary according to the rate of recovery of the well. For a moderately fast recovering well, water level readings at 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.75, 1.0, 1.25, 1.5, 2.0, 2.5, 3.0, 4.0, . . . minutes may be required. With practice, readings at down to 0.05-minute (3 seconds) time intervals can be obtained with reasonable accuracy, using a pressure transducer and hand held readout. For wells which recover very fast,

the pressure transducer and data logger can be set on a logarithmic recording interval. Time intervals between measurements can be extended for slow recovering wells. A typical schedule for measurements for a slow recovering well would be 0, 0.25, 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0, 8.0, 10.0, 15.0, 20.0, 30.0, . . . minutes from the beginning the test. Measurements shall be taken from the top of the well casing.

3.8 Stop the test once equilibrium is reached and repeat as necessary to ensure reproducibility.

3.9 Remove the pressure transducer, the slug, and the cables from the well and thoroughly decontaminate, per SOP CTO126-17.

3.10 Check all field notes, copy, and place into one file for each test. Download the data recorder as soon as possible and check data. Make an electronic file and paper file of all data and place with the file for evaluation later. Confirm that the data is usable for the intended analysis prior to leaving the field. Time/recovery should be field-plotted on semilog graph paper to determine the data quality. The data set should plot along a sloped, straight line. If excessive data scatter is observed, the test should be rerun until acceptable results are obtained.

4.0 PERSONNEL

A qualified geologist or hydrogeologist, having experience with these test procedures and equipment, will be needed for each sampling team to carry out the Hydraulic Conductivity tests.

5.0 ATTACHMENTS

1. Hydraulic Conductivity Testing Data Sheet

ATTACHMENT 1

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET

Tetra Tech NUS, Inc.

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET

PROJECT NAME: ..... WELL/BORING NO.: .....

PROJECT NO.: ..... GEOLOGIST: .....

WELL DIAMETER: ..... SCREEN LENGTH/DEPTH: ..... TEST NO.: .....

STATIC WATER LEVEL (Depth/Elevation): ..... DATE: .....

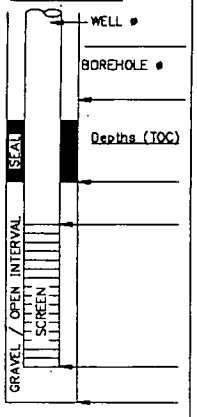
TEST TYPE (Rising/Falling/Constant Head): ..... CHECKED: .....

METHOD OF INDUCING WATER LEVEL CHANGE: ..... PAGE ..... OF .....

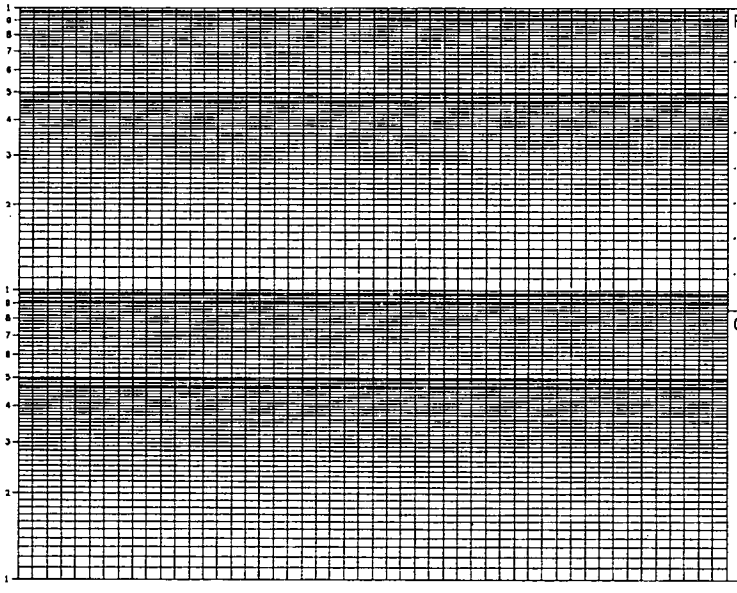
REFERENCE PT. FOR WL MEAS. (Top of Casing, Transducer, etc.): .....

ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)	ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)

WELL SCHEMATIC



▽ Indicate SWL Depth on Drawing



REMARKS:

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CALCS, SKETCH MAPS, ETC.:

ACAD:FORM_HYDCONTST.dwg 07/06/99 INL

STANDARD OPERATING PROCEDURE
NUMBER CTO126-24

SAMPLE PRESERVATION, PACKAGING, AND SHIPPING

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures for sample preservation, packaging, and shipping to be used in handling ground water, surface water (including seeps), soils, and sediments collected at the NSWC Crane.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Shipping labels

Custody seals

Chain-of-custody (COC) form(s)

Sample containers with preservatives: All sample containers for analysis by fixed-base laboratories will be supplied, with preservatives added (if required) and deemed certified clean by the laboratory.

Sample shipping containers (coolers): All sample shipping containers are supplied by the laboratory.

Packaging material: Bubble wrap, ZipLoc® bags, strapping tape, etc.

3.0 PROCEDURES FOR SAMPLE PRESERVATION, PACKAGING, AND SHIPPING

3.1 The laboratory provides sample containers with preservative already included (as required) for the analytical parameter for which the sample is to be analyzed. All samples will be held, stored, and shipped at 4°C. This will be accomplished through refrigeration (used to hold samples prior to shipment) and/or ice.

3.2 The sampler shall maintain custody of the samples until the samples are relinquished to another custodian or to the common carrier.

3.3 Check that each sample container is properly labeled, the container lid is securely fastened, and the container is sealed in a ZipLoc® bag.

3.4 If the container is glass, place the sample container into a bubble-out shipping bag and seal the bag using the self-sealing, pressure sensitive tape supplied with the bag.

3.5 Inspect the insulated shipping cooler. Check for any cracks, holes, broken handles, etc. If the cooler has a drain plug, make certain it is sealed shut, both inside and outside of the cooler. If the cooler is questionable for shipping, the cooler must be discarded.

3.6 Put ice into ZipLoc® bags and place a layer of the sealed bags on the bottom of the cooler. Place the sample containers into the shipping cooler on top of the ice in an upright position (containers will be upright, with the exception of the 40-ml vials). Place ZipLoc® bags of ice flat against the sides of the cooler. Continue filling the cooler with samples until the cooler is nearly full and the movement of the sample containers is limited.

3.7 Place a temperature blank in the cooler. Make sure that all samples identified for VOC analysis and their associated trip blank are packed in the same cooler (i.e., VOC samples and trip blank that were stored together during sampling activities can not be separated into different coolers for shipping purposes).

3.8 Add a final layer of ice sealed in ZipLoc® bags to the top of the samples just before the cooler is closed and sealed.

3.9 Place the original (top) signed copy of the COC form inside a large ZipLoc® bag. Tape the bag to the inside of the lid of the shipping cooler that contains the samples for VOC analysis.

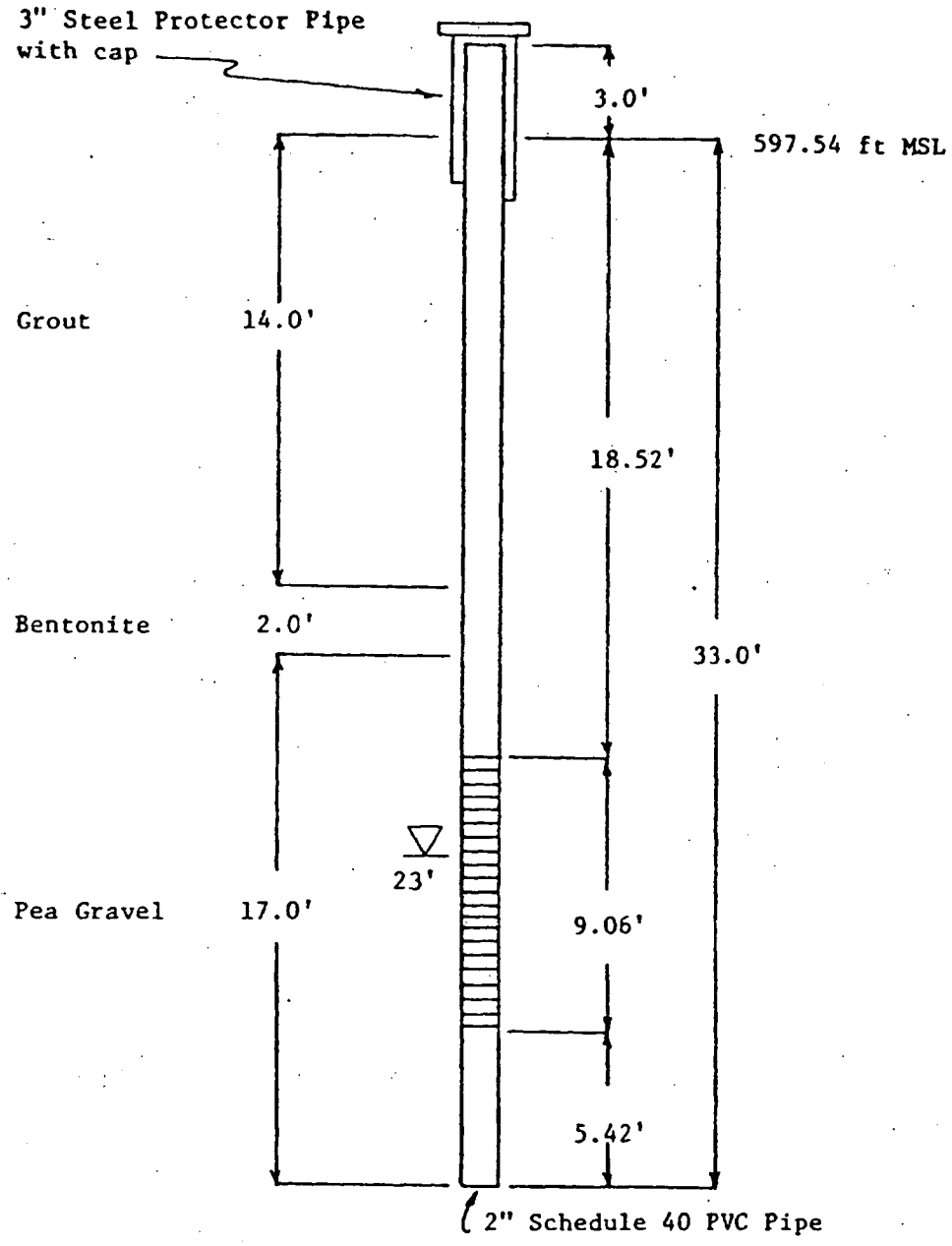
3.10 Close the cooler and seal the cooler with approximately four wraps of strapping tape at each end of the cooler. Prior to wrapping the last wrap of strapping tape, apply a signed, numbered, and dated custody seal to each side of the cooler (one per side). Cover the custody seal with the last wrap of tape. This will provide a tamper evident custody seal system for the sample shipment.

3.11 Affix a shipping label to the top of the cooler containing samples for VOC analysis, ensuring all of the shipping information is filled in properly. Overnight (e.g., FedEx Priority Overnight) courier services will be used for all sample shipments.

3.12 All samples will be shipped to the laboratory no more than 72 hours after collection. Under no circumstances will sample hold times be exceeded.

APPENDIX B

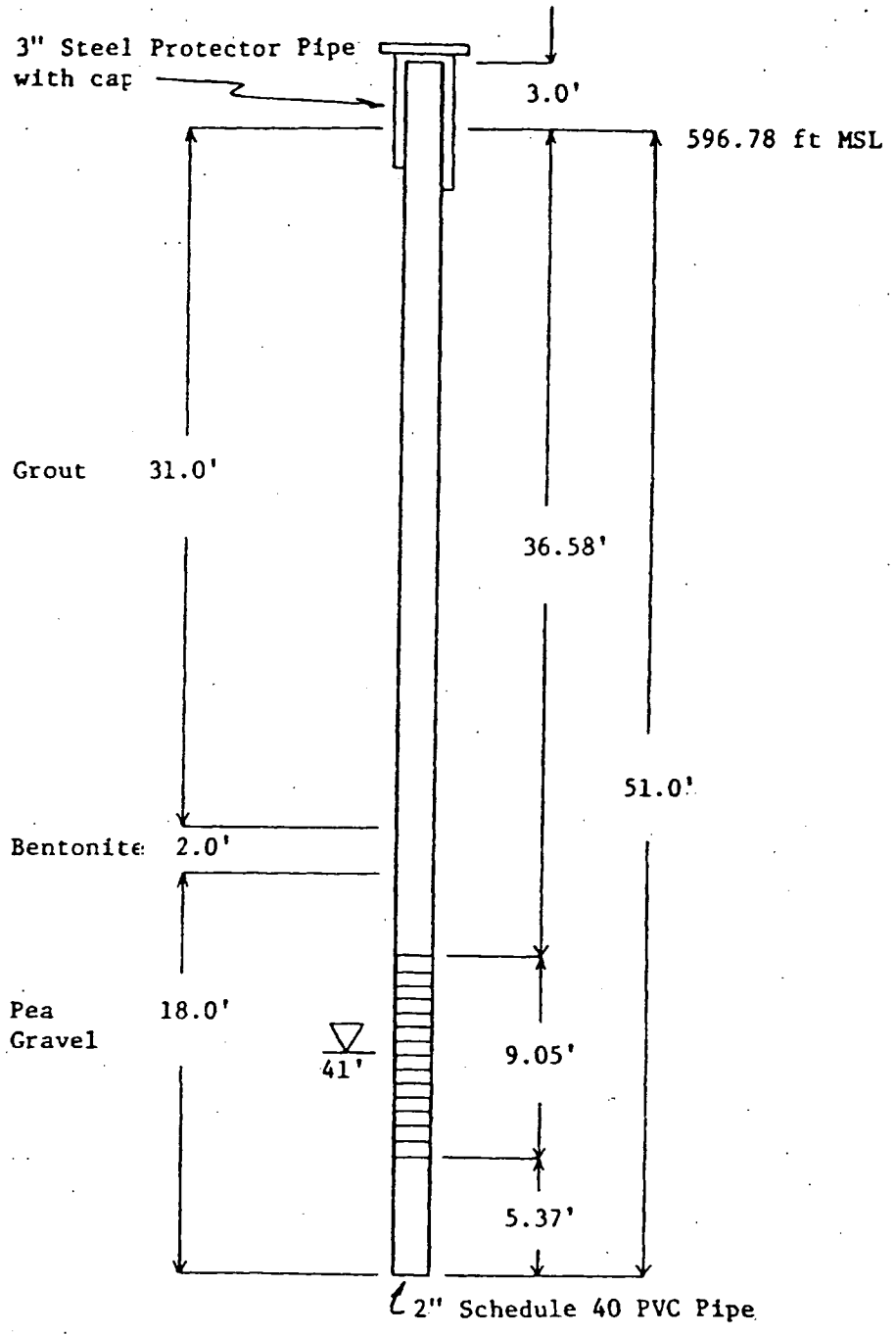
BORING LOGS AND MONITORING WELL CONSTRUCTION LOGS



Water depth at time of drilling

Well Screen

NWSC, Crane, Indiana
Ammunition Burning Grounds
Well Completion
Boring Number: WES-3-27-83



Water depth at time of drilling

Well Screen

NWSC, Crane, Indiana
Ammunition Burning Grounds
Well Completion
Boring Number: WES-3-29-83

Hole No. WES-3-34C-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3-34C	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-34C-89			Date well screen was set: 8/11/89
			+2.5			
			0.0 Ground surface			
			Grout mixture			Water level just Prior to setting screen. –
			122.0			
			Bentonite Pellets			
			126.0			Set Casing to 118.8'
			Filter Pack			
			177.5			
			Well Screen			
			187.5			
			Trap			
			188.5			
			193.9 Boring Depth			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-3-35C-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 3-35C
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-35C-89			Date well screen was set: 8/19/89
			+2.5			
			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting Screen. –
			108.0			
			Bentonite Pellets			
			112.0			
						Set Casing to 105.0'
			Filter Pack			
			164.5			
			Well Screen			
			174.4			
			Trap			
			175.5			
			177.7 Boring Depth			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-3-36C-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3-36C	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-36C-89			Date well screen was set: 9/6/89
			+2.5			
			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen. –
			118.0			
			Bentonite Pellets			
			121.0			Casing set to 115.7'
			Filter sand			
			169.0			
			Well Screen			
			179.0			
			Trap			
			180.0			
			183.1 Boring Depth			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) PROJECT HOLE NO.

Hole No. WES-3-37C-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3-37C	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-37C-89			Date well screen was set: 9/21/89
			+2.5			
			0.0 Ground surface			
			Grout mixture			Water level just Prior to setting Screen. –
			55.0			
			Bentonite Pellets			
			58.0			
						Casing set to 38.3
			Filter sand			
			104.5			
			Well Screen			
			114.5			
			Trap			
			115.5			
			116.7 Boring Depth			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS
1. PROJECT		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number)	3-38C	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED / COMPLETED
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-38C-89			Date well screen was set: 9/29/89
			+2.5			
			0.0' Ground surface			
			Grout mixture			water level just Prior to setting screen –
			12.0			
			Bentonite Pellets			
			15.0			
			Filter Pack			
			43.0			
			Well Screen			
			53.0			
			Trap			
			54.0			
			55.5' Boring Depth			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (PROJECT OFFICE) | PROJECT | HOLE NO.

APPENDIX C

STANDARD OPERATING PROCEDURES FOR LABORATORY WORK

STANDARD OPERATING PROCEDURE SUBMITTALS

Laucks Testing Laboratories and Severn Trent Laboratories will conduct the fixed-based analyses described in this QAPP Addendum No. 1. Laboratory Analytical Standard Operating Procedures (SOPs) for Laucks Testing Laboratories have previously been submitted as part of other QAPPs for investigations conducted at NSWC Crane. All analytical SOPs utilized for analysis of samples collected at NSWC Crane are listed in the Appendix C Table of Contents. For each SOP, a reference is provided to the QAPP in which the SOP was provided. Analytical SOPs that have not changed are incorporated by reference. Only SOPs that have been changed or that have not been previously submitted are included in this submission. These are shown in highlights in the Appendix C Table of Contents.

LABORATORY STANDARD OPERATING PROCEDURES (SOPs)
TABLE OF CONTENTS

SOP No.	REV No.	QAPP/WP	TITLE
LAUCKS TESTING LABORATORIES			
LTL-1001	4	126[1]	Elements of SOP and Method Formats
LTL-1002	5	126[1]	Document Tracking and Control
LTL-1003	2	126[1]	Chain-of-Custody and Documentation Procedures
LTL-1004	4	126[1]	Documentation of Analyst Competence and Training
LTL-1005	5	126[1]	Analytical Balances
LTL-1006	3	126[1]	Refrigerator, Freezer, and Oven Thermometer Calibration and Maintenance
LTL-1007	3	126[1]	Use of Instrument Records and Logbooks
LTL-1008	6	126[1]	QC Corrective Action
LTL-1009	3	126[1]	Blind Spike Program
LTL-1011	4	126[1]	Procedures for the Determination and Reporting of Detection Limits, Reporting Limits, Precision and Accuracy Studies, and Control Limits
LTL-1012	2	126[1]	Solvent QC Monitoring for Trace Residue Analysis
LTL-1013	4	126[1]	Preparation, Storage, Shelf Life and Traceability Documentation of Standards and Reference Materials
LTL-1017	1	126[1]	Internal Audit Procedures
LTL-1018	1	126[1]	Overview of Review and Approval Practices for Validatable Data Packages
LTL-1019	2	166[2]	Controlling, Maintaining, and Monitoring Laboratory Logbooks
LTL-1020	2	166[2]	Integration of IC, GC, HPLC and GCMS Peaks
LTL-2001	6	166[2]	Waste Segregation and Disposal
LTL-3000	12	166[2]	Extraction Method for Base, Acid and Neutral Compounds in Water (8270C by 3520C)
LTL-3001	4	166[2]	Extraction Method for Polynuclear Aromatics in Water (8270C by 3520C)
LTL-3011	2	166[2]	Extraction Method for Chlorinated Herbicides in Soil (8151A by 3550B)
LTL-3077	5	166[2]	Extraction Method for Ordnance Compounds in Water
LTL-3100	11	126[1]	Extraction Method for Base, Acid and Neutral Compounds in Soils (8270C by 3550B)
LTL-3101	2	166[4]	Extraction Method for Base, Acid and Neutral Compounds in Soil (8270D by 3545A)
LTL-3161	9	311[5]	Extraction Method for Ordnance Compounds in Soils (8330)
LTL-3202	3	166[2]	Extraction Method for Organochlorine Pesticides and Polychlorinated Biphenyls in Water (8081A/8082 by 3510C)

LABORATORY STANDARD OPERATING PROCEDURES (SOPs)
TABLE OF CONTENTS

SOP No.	REV No.	QAPP/WP	TITLE
LTL-3302	2	126[1]	Extraction Method for Organochlorine Pesticides and Polychlorinated Biphenyls in Soil (8081A/8082 by 3550B)
LTL-3303	2	166[4]	Extraction Method for Organochlorine Pesticides and Polychlorinated Biphenyls in Soil (8081B/8082A by 3545A)
LTL-3450	1	126[1]	Extraction Method for Polynuclear Aromatics in Soil (8270C by 3550B)
LTL-3451	3	166[4]	Extraction Method for Polynuclear Aromatics in Soil (8270D by 3545A)
LTL-3510	8	166[2]	Extraction Method for Chlorinated Herbicides in Water (8151A by 3510C)
LTL-3550	5	166[2]	Extraction Method for Picric and Picramic Acids in Water (3510C)
LTL-3555	4	166[2]	Extraction Method for Piciric and Picramic Acids in Soil (3550B)
LTL-4002	6	126[1]	Electronic Sample Entry and Log-In
LTL-4103	0	126[1]	Reviewing a Sample Delivery Group (SDG) and Updating Projects in the LIMS
LTL-4201	0	126[1]	Package Deliverables for all Reporting Levels
LTL-6006	0	166[2]	Cation –Exchange Capacity of Soils (Sodium Acetate) by SW 846 Method 9081
LTL-6008	0	166[2]	The Determination of Acid Volatile Sulfides and Simultaneously Extracted Metals in Sediment
LTL-7003	2	126[1]	Inorganic Glass Cleaning Procedure
LTL-7009	3	126[1]	Microwave Assisted Acid Digestion of Aqueous Samples and Extracts Using SW846 Method 3015
LTL-7010	3	166[2]	Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by ICP Spectroscopy by SW846 Method 3010A
LTL-7012	1	126[1]	Microwave Assisted Acid Digestion of Sediments, Sludges, Soils, and Oils Using SW846 Method 3015
LTL-7015	1	126[1]	Acid Digestion of Sediments, Sludges, and Soils Using SW846 Method 3050B
LTL-7202	4	126[1]	Metals Analysis Using Inductively Coupled Plasma – Mass Spectrometry (ICP/MS) SW846 Method 6020
LTL-7501	2	166[2]	Operation of the PE FIMS 400 for the Analysis of Hg.
LTL-8000	2	126[1]	Determination of Retention Time Windows
LTL-8019	4	166[2]	Determination of Non-Halogenated Volatile Organics by SW 8015B
LTL-8084	5	166[2]	Analysis of Organochlorine Pesticides and PCBs by SW 846 Methods SW 8081A and 8082
LTL-8151	4	166[2]	Analysis of Chlorinated Herbicides by 8151A

LABORATORY STANDARD OPERATING PROCEDURES (SOPs)
TABLE OF CONTENTS

SOP No.	REV No.	QAPP/WP	TITLE
LTI-8265	4	311[5]	Determination of Volatile Organic Compounds by Method 8260B
LTL-8277	2	166[2]	Determination of Polynuclear Aromatic Hydrocarbon Compounds by Selective Ion Monitoring (SIM) Method 8270C
LTL-8279	7	166[4]	Determination of Semivolatile Organic Compounds by Method 8270C and 8270D
LTL-8302	1	126[1]	HPLC Ordnance 8330 Data Review
LTL-8303	5	166[2]	Determination of Picric and Picramic Acid
LTL-8330	14	311[5]	Determination of Nitroaromatics and Nitramines by SW-846 Method 8330A and 8332
LTL-9104	3	166[2]	Preparation and Analysis of Total and Amenable Cyanide According to EPA Methods 335.1, 335.3, and SW 846 9012A
LTL-9109	4	166[4]	Ammonia Analysis by Lachet Auto-Analyzer, EPA Method 350.1
LTL-9110	8	166[2]	Determination of Anions by Ion Chromatography by Method 300.0A or 9056
LTL-9113	2	166[2]	pH in Soil and Waste Samples Using SW846 Method 9045C
LTL-9115	3	166[2]	The Determination of Total Organic Carbon in Water Samples by EPA415.1 and SW-846 9060
LTL-9116	6	166[2]	The Determination of Total Organic Carbon in Soil/Sediment Samples Using Modified SW-846 Method 9060
LTL-9125	3	166[4]	Nitrate/Nitrite as Non-Lachet by EPA Method 353.2
LTL-9136	0	166[2]	Determination of Perchlorate by Ion Chromatography by EPA Method 314.0
LTL-9202	3	166[2]	Total Suspended Solids (Non-Filterable Residue) Using EPA Method 160.2
SEVERN TRENT LABORATORIES			
SAC-LC-0012	1	311[5]	Determination of Perchlorate by Liquid Chromatography Coupled With Electrospray Mass Spectrometry (LC/MS) Based on Method 8321
TRIANGLE LABORATORY			
2.04	6	166[2]	Nonconformance
5.01	10	166[2]	Sample Receipt, Identification, Handling, and Storage
DSP 105	16	166[2]	Extraction of PCDD/PCDF from Solids (not tissue) – 8290
DSP 161	18	166[2]	Extraction of PCDD/PCDF from Water for Methods 1613, 8290, and 551
DHR 182	9	166[2]	PCDDs and PCDFs by HRGC/HRMS – Method 8290

LABORATORY STANDARD OPERATING PROCEDURES (SOPs)
TABLE OF CONTENTS

SOP No.	REV No.	QAPP/WP	TITLE
DPA 104	12	166[2]	Data Package Assembly and Shipping
NSWC CRANE LABORATORY			
CR4052-PD-0001	1	166[2]	Quality Assurance and Control Plan
CR4052-PD-0100	3	166[2]	Document Control
CR4052-PD-0150	4	166[2]	Record Retention
CR4052-PD-0200	3	166[2]	Preventive Maintenance
CR4052-PD-0220	0	166[2]	Chemical/Supply Management
CR4052-PD-0250	1	166[2]	Calibration
CR4052-PD-0300	0	166[2]	Training Overview
CR4052-PD-0450	0	166[2]	Performance Evaluation
CR4052-PD-0500	1	166[2]	Chain of Custody: Soil and Water Samples
CR4052-PD-0600	2	166[2]	Customer Reports
CR4052-PD-0700	0	166[2]	Glassware Cleaning Procedure
CR4052-PD-2500	0	010[3]	Determination of Organic Colorants in Environmental Matrices by HPLC
MICROSEEPS LABORATORY			
SOP-ADM10	1	166[4]	Standard Operating Procedure for Glassware Washing
SOP-AM20GAx	2.1	166[4]	Analytical Method AM20GAx Standard Operating Procedure for the Analysis of Biodegradation Indicator Gases
SOP-PM01G	1.2	166[4]	Standard Operating Procedure for the Preparation of Samples for the Analysis of Biodegradatoin Indicator Gases

Shading indicates SOPs that have been revised or that have not been included in previous QAPPs.

1 "Quality Assurance Project Plan for Ammunition Burning Grounds Little Sulphur Creek and Jeep Trail Resource Conservation and Recovery Act Phase III RCRA Facility Investigation," NSWC Crane, April 2001.

2 "Quality Assurance Project Plan for Mine Fill A (SWMU 12), Mine Fill B (SWMU 13), Cast High Explosives Fill/B146 Incinerator (SWMU 16), and Pyrotechnic Test Area (SWMU 19) RCRA FRI Investigation," NSWC Crane, February 2002.

3 Risk Assessment Work Plan for Risk Assessment at SWMUs 4, 5, 9, and 10," August 2000.

4 "Quality Assurance Project Plan Addendum No. 1 for Mine Fill A (SWMU 12), Mine Fill B (SWMU 13), Cast High Explosives fill/B146 Incinerator (SWMU 16), and Pyrotechnic Test Area (SWMU 19) RCRA RFI Investigation," NSWC Crane, September 2003.

5 "Quality Assurance Plan Addendum No. 1 for Ammunition Burning Grounds, Old Jeep Trail, and Little Sulphur Creek Resource Conservation and Recovery Act, Phase III RCRA Facility Investigation, March 2004

SOP No.—standard operating procedure number.
REV No.—SOP revision number.
QAPP—quality assurance project plan.
WP—work plan.

LAUCKS TESTING LABORATORIES INC.
Seattle, Washington

SOP #:LTL-8265

Title: **Determination of Volatile Organic Compounds by Method SW 8260B**

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1. Introduction and Scope

1.1 Method Description

Method 8260 is used in the determination of volatile organic compounds in soil, sediment, aqueous, and other matrices. This SOP addresses the determination of volatile organics in different matrices, which include medium level soils as well as low level water samples. In addition, the instrument acquisition parameters have been added for the analysis of vinyl chloride by Selected Ion Monitoring (SIM) in Appendix III, and Appendix IV contains a tabular list of the non-routine Appendix IX analytes and their respective calibration ranges.

1.1.1 Because this method employs sample introduction via a purge and trap sample concentrator, it is applicable to volatile compounds that have boiling points below 200°C and that are insoluble or only slightly soluble in water. Compounds that are more soluble in water have elevated detection limits due to their decreased purging efficiency. These include, but are not limited to ketones, nitriles, acetates, acrylates and ethers.

1.1.2 This method is restricted to use by, or under the supervision of analysts experienced in the use of purge and trap systems, gas chromatography/mass spectroscopy and in the interpretation of chromatograms and mass spectral data. Each analyst performing this method must have demonstrated the ability to perform the described chromatographic analysis and data interpretation.

1.2 Method Deviations

1.2.1 Detailed below are any deviations from the published version of method SW 8260B. All deviations are followed as the standard operation procedure by Laucks Testing Labs.

1) Laucks uses 1/2 the reporting limit (low level standard) for method blank criteria instead of method detection limits as referenced in SW 846. Refer to Section 6.4 for detailed method blank criteria.

2) The retention time window used for internal standards in all analyses is +/- 0.50 minutes relative to the daily CCV standard.

1.3 Interferences

1.3.1 Problems have been associated with the following compounds analyzed by this method.

1.3.1.1 Chloromethane is the most likely compound to be lost if the purge flow is too fast.

1.3.1.2 Bromoform is one of the compounds to most likely to be purged very poorly if the purge flow is too slow. Cold spots and/or active sites in the transfer lines may adversely affect response. Response of the quantitation ion (m/z 173) is directly affected by the tuning of BFB at ions m/z 174/176. Increasing the m/z 174/176 ratio relative to m/z 95 may improve bromoform response.

1.3.1.3 Tetrachloroethane and 1,1-dichloroethane are degraded by contaminated transfer lines in the purge-and-trap system and/or active sites in trapping materials.

1.4 Sample Collection, Sample Storage, Holding Times

1.4.1 Waters

1.4.1.1 Samples are collected with zero headspace in 40 mL glass containers containing preservative (either HCl, H_2SO_4 or solid $NaHSO_4$) and sealed with Teflon-lined caps.

1.4.1.2 The water samples are preserved to a pH of ≤2, and all samples are stored at 4°C±2°.

1.4.1.3 The holding time to analysis is 14 days from date of collection. The pH values for the water samples are measured subsequent to sample analysis. The pH values, when not preserved to a pH ≤2 are noted in the instrument logbook and client report. The project manager will also be notified **as soon as** any out of control pH is discovered.

1.4.2 Soils

1.4.2.1 At the time of this writing, the 3rd update of the 3rd edition to SW 846 requires that low level soils be collected in duplicate using 5 gram and/or 1 gram aliquots which are to be weighed out in the field. The soil samples are to be collected in a 40 mL vial containing water, sodium bisulfate, and a stir bar. 0.2 grams of sodium bisulfate are added for each 1 gram of soil (see section 1.4.2.2 for issues associated with this method). Therefore, when collecting 5 grams of sample, the VOA vial should contain 1 gram of sodium bisulfate. The sodium bisulfate is added in order to ensure a sample pH of ≤2. The vials used for low level soils should have the tared weight recorded on the label and sealed with septum-lined screw caps.

1.4.2.2 An in-depth study of the different sampling methods used for Method SW 846 5035 was performed by the IT Corporation and presented to the EPA at it's annual conference in May 2001.

1.4.2.3 Problems associated with sodium bisulfate were confirmed, including styrene degradation, acetone formation, and effervescence in some samples. Dangerous pressure and high methyl acetate results were also noted with sodium bisulfate.

1.4.2.4 IT is recommending removal of the sodium bisulfate preservation option from the next CLP SOW and EPA is planning to follow this recommendation

1.4.2.5 Another option is the use of the EnCore™ sampler, the Purge-and-Trap Sampler™, and a cut plastic syringe to transfer the sample to the soil vial. If the EnCore™ sampler is used in the field, the samples may be stored for up to 48 hours. At the time of this writing, SW-846 method 5035 acknowledges that this storage device has not been thoroughly evaluated and suggests that samples collected in this device should be transferred to the soil sample vials (and preserved) as soon as possible, or analyzed within 48 hours. However, studies from Hewitt and Sorini (see reference section 7.0) have shown that freezing EnCores will result in very little loss of volatiles and should have an extended holding time of 14 days. Based on these studies, Laucks also feels freezing EnCores is an appropriate preservation method. However, if required by the client, and for USACE samples, Laucks will extrude 3 EnCore™ samples into vials (and freeze) at the time of receipt. Other client specified methods of preservation may also be used. Additional samples will be preserved (by freezing) for designated QC samples. The holding time for soils is 14 days from the date of collection.

1.4.2.6 At the time of this writing, the 3rd update of the 3rd edition to SW 846 requires that high level soils be collected using one of the following options:

1.4.2.6.1 Option 1: Samples will be collected in duplicate using 5 gram and/or 1 gram aliquots which are to be weighed out in the field. The soil samples are to be collected in a 40 mL vial containing methanol. The vials used for high level soils should have the tared weight recorded on the label and sealed with septum-lined screw caps.

1.4.2.6.2 Option 2: Samples will be collected using an EnCore type sampler or equivalent, and immediately preserved at the laboratory by adding methanol. (Based on the studies above, Laucks may also freeze the EnCores and add methanol at the time of analysis.)

1.4.2.6.3 Option 3: Samples will be collected in vials with zero headspace.

1.4.2.7 Per client request Laucks will continue to accept unpreserved soil samples for low or high level analyses. The samples must be collected in 2- or 4-oz glass containers and sealed with septum -lined caps. These samples will be introduced by method 5030A and analyzed according to this SOP.

1.4.2.8 The holding time to analysis is 14 days from date of collection.

1.5 Definition of Terms

1.5.1 This section defines terms and acronyms as they are used in this SOP. Other terms, such as MS/MSD or method blank, are not defined here since it is assumed that the user of this SOP already understands their more general meaning.

Blank Spike	A background free matrix (DIW for water, clean sand for soils/sediments) to which known amounts or target analytes and surrogates are added each time samples are analyzed. In the context of this SOP, a blank spike is the same as a QC check standard. See also QC check standard.
CCC	Calibration check compound. There are 6 analytes which must not exceed the maximum %RSD of 30% in the initial calibration and a %D of 20% in the continuing calibration standard to validate linearity. These analytes are 1,1-dichloroethane, chloroform, 1,2-dichloropropane, toluene, ethylbenzene and vinyl chloride.
CCV	Continuing calibration verification. This is a standard analyzed at some prescribed frequency during the analysis sequence to determine whether the instrument has remained in calibration.
CLP	Contract Laboratory Program. The USEPA program that contracts with laboratories to provide laboratory services. The term has come to mean a much broader set of methods and deliverables. In the context of this SOP, CLP means procedures or operations which are detailed in the CLP contract and which are extended to a broader working definition.
IBLK	Instrument blank. An instrument blank is PFW containing the method surrogates and is introduced into the instrument to monitor for carry over between sample analyses.
ICV	Initial continuing verification. A calibration standard obtained from a different manufacturer than the standards used for the initial and continuing calibrations that is analyzed after a compliant initial calibration.

IDL	Instrument detection limit. The lowest concentration of a target analyte that will yield a signal:noise ratio of at least 3x. Used as a starting point for selecting MDL study spiking levels.
MDL	Method detection limit. The lowest concentration in a sample which will yield a positive result that is greater than zero at a known level of confidence. MDLs are empirically determined by Laucks.
PFW	Purge-free water. Laboratory deionized water that is boiled for 30 minutes prior to use. The systems used to provide deionized water at Laucks all contain carbon polishing filters which are capable of providing purge-free water for use as reagent water.
QC Check Standard	Quality control check standard. Referred to in this SOP as a blank spike. A QC check standard is a requirement of SW 846 method 8000 and is used to determine whether the analytical system is in control if MS/MSD recoveries are out of control. See also blank spike.
QC Period	Quality control period. An analysis sequence initiated by the injection of BFB, followed by the standard. A QC period is terminated after 12 hours from the injection of BFB.
Reporting Limit (RL)	The reporting limit is defined by the low level standard, also referred to as the practical quantitation limit (PQL).
RF	Response factor. A measure of the response of an analyte compared to its internal standard response. Response factors are determined by standard analysis and are used in the calculation of concentrations of analytes in samples.
RRT	Relative retention time. A measure of the retention time of an analyte compared to the retention time of its internal standard.
RSD or %RSD	Relative standard deviation or percent relative standard deviation. The ratio of the standard deviation of a set of values to the mean of the set of values. A measure of the similarity of the values one to another.

RT	Retention time. The time (in minutes) at which a target analyte elutes from the GC column.
Sequence	A set of samples and standard solutions introduced into an instrument in a chronologically continuous group. See also QC period.
SPCC	System performance check compound. Specified compounds in which the minimum RFs must be met in order to demonstrate that the initial and continuing calibration standards are in control. These compounds are chloromethane, 1,1-dichloroethane, bromoform, chlorobenzene, and 1,1,2,2-tetrachloroethane.

2. Equipment List and Standards

2.1 Chromatographic System

2.1.1 Gas Chromatograph: Hewlett Packard 5890 I or II or 6890 employing a low-dead-volume interface from the sample concentrator to the GC injection port.

2.1.2 Carrier Gas: Helium 99.995% (high purity grade) or better.

2.1.3 Column: 60m x 0.25mm x 1.4 µm film thickness, or 30 m x 0.53 mm x 3.0 µm film thickness or 75 m x 0.45 x 2.55 µm film thickness, fused silica capillary column (J&W DB-624 or Restek RTx-624 or equivalent).

2.1.4 Purge and Trap: OI Analytical 4460A and 4560 sample concentrators or equivalent.

2.1.5 Autosampler: Dynatech Precision Sampling PTA-30W/S, Varian Archon or equivalent.

2.1.6 GC/MS Interface: Hewlett Packard 59913A jet separator assembly, split/splitless or equivalent.

2.1.7 Mass Spectrometer: Hewlett Packard 5970B, 5973 or equivalent.

2.1.8 Data System: HP Chemstation Revision B.01.00 or equivalent, Environmental Processing, and EnviroForms.

2.1.9 Trap: OI Corporation, Supelco, or equivalent. Examples are listed below:

1) 1 cm 3% SP-2100/Chromosorb W AW, 7.7 cm Tenax TA, 7.7 cm silica gel 15, 7.7 cm activated charcoal. Supelco Pt No.:2-1139.

2) VOCARB 3000. 10 cm Carbopack C, 6 cm Carboxen 1000, 1 cm Carboxen 1001. Supelco Pt No.: 2-1131.

3) VOCARB 4000. 8.5 cm Carbopack C, 10 cm Carbopack B, 6 cm Carboxen 1000, 1 cm Carboxen 1001. Supelco Pt. No.: 2-1143.

2.1.10 Miscellaneous: Assorted gas-tight calibrated syringes, pipettes, 40 mL vials, caps, septa, sea sand, purge and trap grade methanol, ferrules, pH strips, purge-free DIW, volumetrics, laboratory oven capable of heating glassware up to 100°C, and assorted supplies.

2.2 Standards

2.2.1 Overview of Volatile Standards Preparation

2.2.1.1 All standards are made using a high purity purge and trap grade methanol. Every lot number of methanol is analyzed prior to use to ensure that it is free of volatile organic contaminants. A record of analysis of an aliquot from each batch is stored for a minimum of one year.

2.2.1.2 The iLIMs standard logbook is employed to document all volatile standards. All standards are assigned a unique identifier to enable cross-referencing of each individual standard back to the supplier's lot number. In addition, all standards are labeled with the standard concentration, the solvent, date prepared, expiration date, analyst's initials, and the standard reference number. Refer to Laucks' SOP LTL-1013 on the traceability, documentation, and preparation of standards.

2.2.1.3 All standards must be identified and quantitated prior to use in the laboratory. This is performed by purchasing certified standard solutions from a commercial supplier that is recognized by the EPA and which are traceable to NIST. In addition, standards are monitored frequently by comparison to the initial calibration curve. Fresh standards should be prepared if the calibration standard(s) fail to meet the criteria specified in SW 846. Standards for gases need to be replaced after one week, or as recommended by the standard manufacturer, unless the acceptability of the standard can be documented. Standards for the non-gases need to be replaced after six months or as recommended by the standard manufacturer, unless the acceptability of the standard can be documented. If the standards meet the criteria for the calibration standard(s) as specified in SW 846, they are considered acceptable.

2.2.1.4 All standard solutions are stored in the VOA freezer at -10°C to -20°C. The stock and secondary dilution standards are stored in flame-sealed amber ampules (with the exception of the internal and surrogate standards). The secondary dilution standards are checked for degradation or evaporation prior to preparing calibration standards. Secondary dilution standards should be replaced after one week, unless the acceptability of the standard can be documented. Pre-mixed certified solutions are stored according to the manufacturers' documented holding time and storage temperature recommendations. Prior to daily and initial calibration standard preparation, the standard solutions are removed from the freezer and allowed to warm to room temperature.

2.2.1.5 Refer to Appendix I for a tabular listing of all standard solutions and their concentrations. The additional appendix IX and California oxygenate compounds (which are only analyzed upon request) and their standard concentrations are tabulated in Appendix IV.

2.2.2 Preparation of Internal Standards and Surrogate Standards

2.2.2.1 If starting with a neat material, a measured amount of the neat chemical is placed in a glass volumetric and diluted to volume with methanol, then stoppered. 125 mg of neat material is diluted into 25 mL of methanol. This yields an intermediate solution of 5000 µg/mL.

2.2.2.2 Aliquots of the intermediate solutions are taken from the individual internal and surrogate standards and then combined in a volumetric flask and diluted with methanol to yield a working standard which contains all compounds at a concentration of 250 µg/mL each. This is accomplished by using a gas-tight syringe to transfer each aliquot of 2.50 mL into 50 mL of methanol. A 1 µL aliquot of this solution is injected via the autosampler into the sample, resulting in an internal and surrogate standard concentration of 50 µg/L or 10 µg/L, depending on the sample aliquot (5mLs or 25mLs respectively).

Internal Standards	Surrogate Standards
Fluorobenzene	1,2-Dichloroethane-d4
Chlorobenzene-d5	Toluene-d8
1,4-Dichlorobenzene-d4	p-Bromofluorobenzene
	Dibromofluoromethane

2.2.3 Preparation of Spike Solution

2.2.3.1 At a minimum, five volatile analytes are used for the spiking of a blank spike, matrix spike and matrix spike duplicate. Upon request by the client additional analytes may be used if they are of interest at the site. A certified spiking solution which contains the five spiking analytes is purchased pre-mixed from a commercial supplier at a concentration of 2500 µg/mL each. This solution is then diluted in methanol to a concentration of 200 µg/mL.

Spike Solution	Source*	Stock Number*
1,1-Dichloroethene	Restek	30005
Benzene		
Trichloroethene		
Toluene		
Chlorobenzene		
* or equivalent		

2.2.3.2 A 12.5 µL (2.5 µL for 25mL low level waters) aliquot of this solution is spiked into 50 mL of sample or PFW (blank spike) in a volumetric flask, resulting in a spiked concentration of 50 µg/L (or 10 µg/L for 25mL low level waters) for each analyte. This solution is transferred to a 40mL VOA vial (see specific volumes below) and placed onto the autosampler for analysis along with the samples. The following chart summarizes the preparation method for each matrix. (See Appendix XIV for laboratory control limits on the spike recoveries.)

Working Concentration	Aliquot	Final Volume (MS/MSD* use sample, blank spikes use PFW)	Concentration and volume used for analysis
Soils, 5 mL Water + (5g sand)			
200 µg/mL	12.5 µL	50 mL sample or PFW	Pour 5mL of 50 µg/L solution with 5g of sand in 40mL vial
Medium Level Soils			
200 µg/mL	12.5 µL	(Add 1mL of MEOH to blank spikes) fill to 50mL sample or PFW	Fill 50 µg/L solution into 40mL vial
25 mL Water			
200 µg/mL	2.5 µL	50 mL sample or PFW	Fill 10 µg/L solution into 40mL vial

*For MS/MSD samples all volumes may be doubled to produce 2 vials from the same solution.

2.2.4 Preparation of p-Bromofluorobenzene (BFB) Solution

2.2.4.1 The preparation of BFB is similar to that of the internal standards and surrogate standards. Refer to Section 2.2.2 for details.

2.2.4.2 A solution of 25 ng/mL is prepared and stored in flame-sealed amber ampules.

2.2.5 Preparation of Initial Calibration Standards

2.2.5.1 Certified sets of stock solutions which contain all target analytes are purchased pre-mixed from a commercial supplier at a concentration of 2000 µg/mL each. If additional target analytes are requested, these analytes may be ordered separately, either in solution or as a neat material.

2.2.5.2 These solutions are then diluted in methanol to generate standards at concentrations of 200 µg/mL. This solution is stored in flame-sealed amber ampules.

2.2.5.3 Standards are stored in the VOA freezer at -10°C to -20°C. They are removed prior to making up the initial calibration standards and are allowed to warm to room temperature.

2.2.5.4 The initial calibration standards range from 1 µg/L to 50 µg/L for 25mL low level waters, 1µg/L to 200µg/L for 5mL and 10mL low level waters, 3 µg/L to 200 µg/L for soils, and 5 mL water samples for all target analytes with the exception of the ketones

and m,p-xylenes. Please refer to Appendix I for a tabular listing of all analytes and calibration concentrations. The 5 mL water calibration standards are also employed in the analysis of medium or high level soils, since the aqueous calibration standards are purged at ambient temperature. Analysis of the solid matrices in the low level format requires a purge temperature of 40° C.

2.2.5.5 The standards are prepared by taking aliquots of the solutions and diluting them into a volumetric flask containing PFW. A 40 mL aliquot is immediately poured into a VOA vial (or a 5 mL aliquot for the low level soils is placed in a soil vessel) and placed on the autosampler. Each standard concentration is prepared just prior to analysis and any remaining standard solution is disposed of once the analytical run is initiated.

Solution	Source*	Stock Number*
APIX (ketones)	Crescent	CC2239.10
APIX	Crescent	CC2464.10
524.2 Vol. Gases	Crescent	CC2006.10
8260 Volatiles	Crescent	CCS-743
Calif. Oxygenates	Restek	30465
Chloroprene	Restek	30238
Ethyl bromide	ChemService	O-640
Acrolein/Acrylonitrile	Crescent	CC2098

* or equivalent

Low Level Water (25 mL)

Working Solution	Aliquot non-ketones	Aliquot ketones	Final Volume	Concentrations non-ketones	Concentrations ketones
200 µg/mL	1.0 µL	-	200 mL	1 µg/L	
200 µg/mL	2.5 µL	2.5 µL	100 mL	5 µg/L	5 µg/L
200 µg/mL	5.0 µL	5 µL	100 mL	10 µg/L	10 µg/L
200 µg/mL	12.5 µL	12.5 µL	100 mL	25 µg/L	25 µg/L
200 µg/mL	12.5 µL	12.5 µL	50 mL	50 µg/L	50 µg/L
200 µg/mL	-	25 µL	50 mL	-	100 µg/L

Low Level Water (5 mL and 10 mL)

Working Solution	Aliquot non-ketones	Aliquot ketones	Final Volume	Concentrations non-ketones	Concentrations ketones
200 µg/mL	1.0 µL	-	200 mL	1 µg/L	-
200 µg/mL	2.5 µL	2.5 µL	100 mL	5 µg/L	5 µg/L
200 µg/mL	5.0 µL	5 µL	100 mL	10 µg/L	10 µg/L
200 µg/mL	12.5 µL	12.5 µL	50 mL	50 µg/L	50 µg/L
200 µg/mL	25 µL	25 µL	50 mL	100 µg/L	100 µg/L
200 µg/mL	50µL	50 µL	50 mL	200 µg/L	200 µg/L

Low Level Soil

Working Solution	Aliquot non-ketones	Aliquot ketones	Final Volume	Concentrations non-ketones	Concentrations ketones
200 µg/mL	1.5 µL	2.5 µL	100 mL/50 mL	3 µg/L	10 µg/L
200 µg/mL	2.5 µL	-	50 mL	10 µg/L	-
200 µg/mL	5 µL	5 µL	50 mL	20 µg/L	20 µg/L
200 µg/mL	12.5 µL	12.5 µL	50 mL	50 µg/L	50 µg/L
200 µg/mL	5.0 µL	5.0 µL	10 mL	100 µg/L	100 µg/L
200 µg/mL	10.0 µL	10.0 µL	10 mL	200 µg/L	200 µg/L

5 mL Water And Medium Level Soil

Working Solution	Aliquot non-ketones	Aliquot ketones	Final Volume	Concentrations non-ketones	Concentrations ketones
200 µg/mL	1.5 µL	2.5 µL	100 mL/50 mL	3 µg/L	10 µg/L
200 µg/mL	2.5 µL	5 µL	50 mL	10 µg/L	20 µg/L
200 µg/mL	12.5 µL	12.5 µL	50 mL	50 µg/L	50 µg/L
200 µg/mL	25 µL	25 µL	50 mL	100 µg/L	100 µg/L
200 µg/mL	50 µL	50 µL	50 mL	200 µg/L	200 µg/L

2.2.6 Preparation of a Daily Calibration Standard

2.2.6.1 The concentration of the continuing calibration standard at a level of 10 µg/L for low level 25 mL waters, 50 µg/L for low and medium level soils and 5 mL and 10 mL waters, is also the mid-point of the initial calibration curve. This standard is always prepared just prior to analysis by transferring an aliquot of each of the 200 µg/mL multi-component working solutions into a volumetric containing PFW.

3. Safety precautions & Waste disposal

3.1 Routine Safety Precautions

3.1.1 All standards and samples should be handled as if they are hazardous substances.

3.1.2 Refer to the instrument manufacturer's manual for routine instrument precautions.

3.1.3 Routine precautions include an awareness of the moving parts on the instrument you're using. These parts are often charged with power from an electrical component or with high pressure gas and have the potential to do harm if not used properly.

3.1.4 Electrical shock - All instruments present the possibility of electrical shock. The operator should take all precautions including ensuring that all instruments are operated with fully grounded power outlets, turning off the instrument and disconnecting the instrument from the electrical power supply before working on any electrical components, etc.

3.1.5 Flammable solvents such as methanol are stored in the appropriate solvent locker located outside the volatile laboratory.

3.1.6 Many analytes are known or suspected carcinogens. Analysts should take the proper precautions such as wearing gloves when working with suspect samples or high level standards or solvents. Additionally, a respirator should be worn and a fume hood utilized for extremely hazardous compounds.

3.2 Waste disposal

3.2.1 Waste solvents and expired standards are disposed of in the appropriate waste solvent container located in the prep area under the hood.

3.2.2 Solid sample matrices are disposed of in appropriate drums labeled for this specific purpose where they are routinely picked up by an approved agency for final disposal.

4. Operation procedures

4.1 Analytical Conditions

GC Parameters*	5970	5973
Injection Port Temperature	: 200°C	250°C
GC/MS Interface Temperature	: 250°C	250°C
Initial GC Temperature	: 35°C	40 °C
Initial Hold Time	: 4 min	4 min
Ramp Rate	: 4°C/min	10°C/min
Final Temperature	: 140°C	200°C
Final Time	: 4 min	8 min
Carrier Gas Flow	: 15 mL/min	
Column Head Pressure	: 9 psi	

Purge and Trap Parameters*		
Purge Time	: 11 min	11 min
Desorb Time	: 1 min	2 min
Bake Time	: 16 min	8 min
Desorb Preheat Temperature	: 20°C	180°C
Desorb Temperature	: 180°C	250 °C
Purge Flow	: 40 mL/min	40 mL/min
Purge Temperature	: Ambient (40°C for soils)	Ambient (40°C for soils)
Desorb Flow Rate	: 15 mL/min	15 mL/min

Mass Spectrometer Parameters*	
Electron Energy	: 70 volts
Mass Range	: 35 to 300 amu
Scan Time	: 1.4 sec/scan
Scan Start Time	: 0.1 min

* parameters may vary by instrument

4.2 Method Detection Limit Study

4.2.1 Prior to the analysis of any samples, it is necessary to establish method detection limits. This procedure is fully described in the Laucks SOP for the determination of method detection limits. It involves the analysis of 7 replicate samples spiked at a concentration near the anticipated method detection limit. A Student's T-test is then applied to these measured values to calculate the MDL.

4.2.2 MDL studies will continue to be performed. This procedure is fully described in LTL-1011, *Procedure for the Determination and Reporting of Detection Limits, Reporting Limits, Precision and Accuracy Studies, and Control Limits.*

4.2.3 MDLs for this method typically are in the range of 0.2-3µg/L for high level waters, 0.3-3.0µg/kg for low level soils and 0.06-1.0 µg/L for low level waters.

4.3 Method Validation

4.3.1 Prior to the analysis of any samples, it is necessary to validate the method. A method validation study is performed in a similar manner to an MDL study with the exception that a minimum of 4 replicates are required and the concentration levels are typically 10-50 times the MDL. In the absence of criteria for the initial demonstration of proficiency, the limits of 70%- 130% can be used.

4.4 Instrument Tuning

4.4.1 Prior to the analysis of any samples, blanks, or calibration standards, the instrument must demonstrate mass calibration and resolution by meeting the established tuning criteria for BFB.

4.4.2 FC-43 (PFTBA) is used as a mass calibrant. The following ratios are suggested in order to meet the tuning criteria for BFB:

Ion	% of ion 69	Isotope	Isotope Abundances
69	100%	70	0.5-1.5%
131	25-40%	132	2.0-4.0%
219	25-40%	220	2.5-5.0%
414	1-3%		

4.4.3 In addition to the tabulated abundances listed above, other criteria should be reviewed at this time.

1) Ion peak widths: The appropriate range is between 0.5 and 0.6 amu. Amu widths beyond this range can lead to loss of minor isotopes, while insufficient peak widths will result in decreased sensitivity.

2) Leak check: The abundances of ions 18, 28, and 32 (water, nitrogen and oxygen, respectively) should be less than 5 percent relative to 69. A level greater than 5 percent is indicative of a leak in the system.

4.4.4 Following the system tuning using FC-43, the GC/MS is then calibrated with BFB. A 1 or 2 µL aliquot of BFB is injected directly into the GC resulting in a concentration of 25 ng or 50 ng.

4.4.5 The ion abundances and ratios are checked against the criteria detailed below <u>or</u> alternatively, other criteria may be used (e.g., CLP, 524.2). The only exceptions are Army Corp and AFCEE, which specify that the table listed in SW 846 must be used unless project specific requirements allow for alternative criteria. If BFB meets the tuning criteria, then the system is determined to be calibrated. If BFB does not meet the tuning criteria, the GC/MS is re-tuned with FC-43 as described above.

4.4.6 SW 846 allows for the use of 5 - 50 ng of BFB. In the absence of specific recommendations on how to acquire the mass spectrum of BFB from the instrument manufacturer, SW 846 states that the following approach has been shown to be useful: the mass spectrum of BFB may be acquired in the following manner. Three scans (the peak apex scan and the scans immediately preceding and following the apex) are acquired and averaged. Background subtraction is required, and must be accomplished using a single scan no more than 20 scans prior to the elution of BFB. Do not background subtract part of the BFB peak. Alternatively, a single point scan of the apex may be used or other documented approaches suggested by the instrument manufacturer.

4.4.7 CLP requires that the three scans (the peak apex scan and the scans immediately preceding and following the apex) are acquired and averaged. Background subtraction is required, and must be accomplished using a single scan no more than 20 scans prior to the elution of BFB. Do not background subtract part of the BFB peak.

SW 846 Tuning Criteria

Mass	Abundance %
50	15 - 40% of mass 95
75	30 - 60% of mass 95
95	base peak, 100% relative abundance
96	5 - 9% of mass 95
173	< 2% of mass 174
174	> 50% of mass 95
175	5 - 9% of mass 174
176	>95%, < 101% of mass 174
177	5 - 9% of mass 176

CLP Tuning Criteria

Mass	Abundance %
50	8 - 40% of mass 95
75	30 - 66% of mass 95
95	base peak, 100% relative abundance
96	5 - 9% of mass 95
173	< 2% of mass 174
174	50-120% of mass 95
175	4 - 9% of mass 174
176	93 - 101% of mass 174
177	5 - 9% of mass 176

4.5 Initial Multi-Point Calibration

The first option is to begin with the simplest approach, the linear model through the origin using RSDs, as described in section 7.5 of 8000B. In methods where this method is not appropriate, because the calibration acceptance criteria of 15% for non-CCC compounds cannot be met, the next option of calibration (linear regression) is used. The other calibration option is use of the quadratic curve. This calibration option requires a minimum of 6 points and is used in cases where the detector doesn't meet calibration criteria over a wide range. When using a calibration model for quantitation, the curve must be continuous, continuously differentiable and monotonic over the calibration range. (Designating sequences, the successive members of which either consistently increase or decrease but do not oscillate in relative value. Each member of a monotone increasing sequence is greater than or equal to the preceding member; each member of

a monotone decreasing sequence is less than or equal to the preceding member.) The model chosen should have no more than four parameters, i.e., if the model is polynomial, it may be no more than third order, as in the equation:

$$y = ax^3 + bx^2 + cx + d$$

4.5.1 The requirements for the linear or quadratic regression model is that R^2 be greater than or equal to 0.990. The difficulty with regression models is that the intercept may be greater than the detection limit. These calibration options exhibits a greater accuracy in the mid-range, and may demonstrate more extreme responses at the low and high end of the calibration, and therefore, it is important to dilute samples and extracts so that they are in the mid-range of the calibration.

4.5.2 For linear calibrations using the RSD, analyze standard solutions using a minimum of 5 different concentration levels. The lowest concentration establishes the reporting limit, and the highest concentration defines the upper usable working range of the detector. However, there are some cases where the reporting limit may be higher than the lowest standard due to poor purging efficiency of the analyte. Criteria for evaluating these standards are detailed in Section 6.

4.5.3 After completion of a compliant initial calibration curve, an initial calibration verification (ICV) using standards from a different supplier is analyzed. The ICV must meet the client specific limits listed in Appendix XIII, but variations in standard sources may make it difficult to meet some client criteria. These analytes that do not meet client-specific criteria will be monitored for possible further action such as finding a third standard source. In some cases the analytes just have poor purging efficiencies. This second source independent calibration verification may be used as a CCV as long as it meets the limits specified in Section 6.

4.6 Continuing Calibration Verification

4.6.1 A CCV is analyzed once the BFB tuning criteria have been met and the instrument has been calibrated. Criteria for evaluating a CCV standard are detailed in Section 6.

4.7 Instrument Blank

4.7.1 The analysis of an instrument blank (IBLK) is performed prior to the injection of BFB. This analysis ensures that there are no volatile organic contaminants in either the purge and trap sample concentrator or in the autosampler.

4.7.2 Any sample that demonstrates concentrations of target analytes high enough to saturate the detector must be followed by at least one IBLK, also known as a saturation blank. This IBLK analysis is performed to prevent any possible carry-over into the subsequent sample analysis. Evaluation criteria follow the same guidelines set forth for the analysis of a method blank.

4.8 Method Blank

4.8.1 After the analysis of the CCV and prior to sample analysis, a method blank must be analyzed. The analysis of the method blank demonstrates that the instrument is free of volatile organic contaminants and ensures that the reagent water is also free of contaminants. Refer to Section 6 for method blank acceptance criteria.

4.9 Sample Analysis

4.9.1 Samples (and associated QC) may be analyzed for up to 12 hours from the injection of BFB. The samples are analyzed subsequent to the calibration standard and method blank analyses. However, no more than twenty sample analyses are performed in a 12 hour period. Once all criteria for BFB, the calibration standard, and method blank have been met, the sample analyses are performed. The aqueous and medium level soil samples are analyzed against an aqueous (non-heated purge) calibration curve. The low level soils are analyzed against a calibration curve employing a heated purge temperature of 40°C.

4.10 Analysis sequence

IBLK (optional)
BFB
CCV
Method blank
Samples and QC

4.11 Sample Preparation

4.11.1 The samples are removed from the VOA refrigerator and are allowed to warm to room temperature. Aqueous samples which are received in 40 mL vials) are placed onto the autosampler carousel or tray. Low level soil samples (see section 1.4.2 of this SOP for further details on soil sample preservation) have 5 grams of sand added to them and are then placed onto the autosampler carousel or tray. See section 4.11.5 for the preparation of medium soils. The autosampler transfers a 5 mL or 25 mL aliquot of sample (or an aliquot of PFW for the soils) into the autosampler syringe, where it injects 1 µL of the internal standard/ surrogate standard solution.

4.11.2 The pH of all water and preserved low level soil samples is measured subsequent to analysis in order to determine if they were preserved adequately without disturbing the integrity of the sample. The pH values when not preserved to a pH ≤2 are noted in the instrument logbook and the client report. The project manager will also be notified immediately upon discovery of the out of control pH value.

4.11.3 If the concentration of any target analyte exceeds the initial calibration range, the sample must be diluted and reanalyzed.

4.11.4 If aqueous samples require dilutions, they are diluted by one of two methods listed:

1) the samples are diluted with PFW in a volumetric where they are transferred to 40 mL vials and placed onto the autosampler, or

2) the undiluted samples are placed on the autosampler, where they are diluted with PFW by the autosampler. Refer to the instrumentation manuals for the complete operation of the autosampler.

4.11.5 Medium Soils

4.11.6 The soil sample is gently mixed (no supernatant liquid is removed) and a 5 gram aliquot (weighed out to the nearest 0.1 g) is transferred to a tared 15 mL vial. 10.0 mL of methanol is added to the vial. The vial is sealed, then shaken for two minutes. A 1 mL aliquot is transferred to a GC vial for storage in the dark at 4°C (±2°C). A 100 µL sample aliquot per 5 mL of PFW is placed onto the autosampler carousel or tray. The autosampler transfers a volume of 5 mL of this sample into the autosampler syringe, where it injects 1 µL of the internal standard/ surrogate solution.

4.12 Qualitative Identification

4.12.1 Two criteria must be satisfied to verify the identification of target compounds:

1) elution of the sample component within 0.50 minutes of the standard component and,

2) appropriate correspondence between the sample mass spectrum and the standard mass spectrum.

a) The three ions of greatest relative intensity, or any ions over 30% relative intensity which are present in the standard mass spectrum must be present in the sample spectrum.

b) The relative intensities of ions must be within 30% between the standard and sample spectra.

d) The emphasis of spectral review is on the three major ions. However, if a target compound cannot be verified by all the criteria listed above, but if, in the technical judgment of the analyst, the identification is correct, then the analyte will be quantitated, and reported. Compounds meeting the identification criteria must be reported with their spectra.

4.12.2 A library search may be performed for the purpose of identifying up to 10 largest non-target analytes also referred to as Tentatively Identified Compounds (TICs) if requested by the client. The criteria for confirming TICs are listed below.

1) Relative intensities of ions in the reference spectrum > 10% of the most abundant ion should be present in the sample spectrum.

2) Molecular ions in the reference spectrum should be present in the sample spectrum.

3) The relative intensities for the major ions should agree within 20%.

4) Ions in the sample spectrum but not present in the standard spectrum should be reviewed for possible background contamination or coelution.

6) If, after careful review and in the technical judgment of the analyst, no valid tentative identification can be made, the compound should be reported as follows:

A) If the library search produces a match at or above 85%, report that compound.
B) If the library search produces more than one compound at or above 85%, report the first compound.
C)If the library search produces no matches at or above 85%, report the compound as unknown. The analyst should give additional classification of the unknown compound, if possible (i.e., unknown hydrocarbon, unknown acid type, unknown chlorinated compound).

4.13 Manual Peak Integrations

4.13.1 Manual peak integrations should be used only when necessary to correct for matrix interference, tangent peaks, split peaks, overloaded peaks and rising baselines. Manual integrations are not to be used in an attempt to meet calibration, surrogate recovery, or spike recovery criteria. Refer to LTL-1020, *The Integration of IC, GC, HPLC, and GC/MS Peaks* for more detail.

4.13.2 If a manual integration is necessary, follow the following guidelines:

1) Integrate only the peak. Start where the peak lifts from the baseline and end as soon as it returns to the baseline. Do not integrate extra baseline in an attempt to increase peak area.

2) Do not "peak shave". Do not cut off legitimate parts of the peak in order to reduce peak area.

3) In cases of tangent skims, do not increase or decrease peak areas or heights by skimming extra long baselines or drawing the baseline too low.

4) Always initial and date your manual integrations.

4.14 Compound Quantification

4.14.1 Target compound concentrations are calculated using the following equations:

Aqueous samples:

$$\text{Conc } (\mu g / L) = \frac{A_x \times I_s \times Df}{A_{is} \times ARF \times V_o}$$

where:

A_x = Area of the characteristic ion (EICP) of the analyte.
A_{is} = Area of the characteristic ion (EICP) of the internal standard.
I_s = Amount of the internal standard (ng).
ARF = Average RF from the ambient temperature purge of the initial calibration.
V_o = Volume of water purged (mL).
Df = Dilution factor. Assume 1.0 for no dilution.

Low soil (on a dry-weight basis)

$$\text{Conc } (\mu g / kg) = \frac{A_x \times I_s}{A_{is} \times ARF \times W_s \times D}$$

where:

A_x = Area of the characteristic ion (EICP) of the analyte.
A_{is} = Area of the characteristic ion (EICP) of the internal standard.
I_s = Amount of the internal standard (ng).
ARF = Average response factor from the heated purge of the initial calibration.
W_s = Weight of sample added to purge vessel (g).

$$D = \frac{100 - \%Moisture}{100}$$

Medium soil (on a dry weight basis)

$$\text{Conc } (\mu g / kg) = \frac{A_x \times I_s \times V_t \times 1000 \times Df}{A_{is} \times ARF \times V_a \times W_s \times D}$$

where:

A_x = Area of the characteristic ion (EICP) of the analyte.
A_{is} = Area of the characteristic ion (EICP) of the internal standard.
I_s = Amount of the internal standard (ng).
ARF = Average RF from the ambient temperature purge of the calibration standard.
V_t = Total volume of the methanol extract in milliliters (10 mL).
V_a = Volume of the methanol extract in microliters added to the reagent water for purging.
W_s = Weight of sample added to purge vessel (g).
Df = Dilution factor. Assume 1.0 for no dilution.

5. Reports

5.1 Data Packet Organization

5.1.1 See Appendix II for a check list detailing data packet organization.

5.2 Quality Control Reports

5.2.1 All results for quality control tests are entered into the lab database. Printouts of all data entered must be included in the data packet. The routine minimum is a method blank report, a blank spike report, and an MS/MSD report.

5.3 Control Limits

5.3.1 The laboratory has a computerized database which is used to generate control limits for various analyses, matrices, and analytes. The control limits define the range in which 99% of all values produced by a system should lie. Because the control limits are updated periodically, the current control limits listed in this SOP (Appendix XIV) may change. A copy of all current control limits are located in Laucks' Control Limits Database.

5.4 Data Qualifying Flags

5.4.1 Sample report results are qualified with data qualifying flags. These flags have the following definitions:

Code	Definition
U	The analyte of interest was not detected, to the limit of detection indicated.
B	The analyte of interest was detected in the method blank associated with the sample, as well as in the sample itself. The B flag is applied without regard to the relative concentrations detected in the blank and sample.
J	The analyte of interest was detected below the practical quantitation limit. This value should be regarded as an estimate.
D	The value reported is derived from the analysis of a diluted sample or sample extract.
E	The value reported is based on a sample or sample extract in which the target analyte concentration exceeded the calibration range. The value reported should be considered an estimate.
N	Used to denote the presumptive evidence of a target analyte. This flag is used when it is not possible to confirm the presence of a compound by the strict guidelines for mass spectral interpretation, but in the technical judgment of the analyst, this compound is present.

6. Quality Control

6.1 Initial Calibration

6.1.1 Criteria

6.1.1.1 Initial calibration data are evaluated using %RSD and the relative response factors.

RFs are calculated using the equation:

$$RF = \frac{A_x}{A_{is}} \times \frac{C_{is}}{C_x}$$

where:

A_x = Response of target analyte
A_{is} = Response of internal standard
C_x = Amount of target analyte (ng/mL).
C_{is} = Amount of internal standard (ng/mL).

%RSDs are calculated using the equation:

$$\%RSD = \frac{SD_i}{RF_i} \times 100$$

where:

Sd_i = Standard deviation of the initial calibration points
RF_i = Average RF from initial calibration

6.1.2 The System Performance Check Compounds (SPCCs) are checked to determine that the minimum average relative response factors tabulated below are met, and that the maximum RSD for each Calibration Check Compound (CCC) is ≤ 30%. The RSD for all other target analytes *should* be ≤ 15%. If the RSD of any target analyte is greater than 15%, the following steps are taken: 1) Check instrument parameters and operating conditions. 2) Check to make sure that the problem is not associated with one of the six standards in which case that standard could be replaced. 3) Narrow the calibration range by dropping the lowest(changes the reporting limit) or highest calibration standard. A mid-ranged standard can not be dropped. After these steps have been taken and an analyte still exceeds 15% additional calibration options mentioned in section 4.5 may be used. Alternatively, if the mean of the RSD values for all analytes in the calibration is ≤ 15% with each individual analyte ≤ 30%, the initial calibration is considered acceptable. The Army Corps feels that by using the steps mentioned above, all of their target compounds should be less than 15%.

6.1.2.1 The mean RSD criterion applies to all analytes in the standards, regardless of whether or not they are of interest for a specific project.

6.1.2.2 The data used must be supplied with either a summary of the initial calibration data or a specific list of those compounds for which the RSD exceeded 15% and the results of the mean RSD calculation.

SPCC Compounds	Minimum RF Limit
Chloromethane	0.100
1,1-Dichloroethane	0.100
Bromoform	0.100
Chlorobenzene	0.300
1,1,2,2-Tetrachloroethane	0.300

CCC Compounds	%RSD Limit
Vinyl chloride	≤30%
1,1-Dichloroethene	≤30%
Chloroform	≤30%
1,2-Dichloropropane	≤30%
Toluene	≤30%
Ethylbenzene	≤30%

6.1.3 Corrective action

6.1.3.1 If the criteria are not met, additional standards may be analyzed or appropriate instrument maintenance and analysis of new standards should be performed.

6.1.4 Documentation

6.1.4.1 Copies of the initial calibration standards and the calculated RRFs and RSDs are stored with the raw data. If criteria are not met, reanalysis of additional standard(s) are noted in the instrument run log.

6.2 Continuing Calibration Verification

6.2.1 Criteria

6.2.1.1 At the beginning of each 12 hour QC period, a CCV standard is analyzed. The RRF for each compound is calculated and the percent difference is calculated as follows:

$$\%D = \frac{RF_i - RF_c}{RF_i} \times 100$$

where:

RF_i = Average RF from Initial Calibration
RF_c = RF from CCV standard
%D = Percent difference

For analytes with a linear regression or quadratic regression curve fit the %Drift is calculated as follows:

$$\%Drift = \frac{\text{Calculated concentration} - \text{Theoretical concentration}}{\text{Theoretical concentration}} \times 100$$

6.2.1.2 The minimum RRFs for the SPCCs must meet the criteria applied in the initial calibration detailed above. The %D for the CCCs cannot exceed the 20% CCV criteria as tabulated below.

*CCC Compounds	% D Limit
1,1-Dichloroethene	≤20%
Chloroform	≤20%
1,2-Dichloropropane	≤20%
Toluene	≤20%
Ethylbenzene	≤20%
Vinyl chloride	≤20%

6.2.1.3 *According to the US ACOE Shell, Section I.9.2.5.4: "Evaluate the concentration of each target analyte and surrogate in the CCV. Verify that the percent drift or percent difference for the CCCs and all project-specified contaminants of concern are within ± 20 percent of their expected values. Evaluate remaining target analytes to assess instrument stability and survey the need for performing instrument maintenance." It is recommended that the list of project-specified contaminants of concern be made available to the laboratory.

6.2.1.4 The internal standard area responses must be within a factor of two (-50% to +100%) from that of the mid-point standard level of the most recent initial calibration. In addition, the retention time must fall within 30 seconds from that in the mid-point standard level of the most recent calibration sequence.

6.2.1.5 In some cases a subset of analytes (project-specified contaminants of concern) may have further requirements. If such limits are indicated, the client must provide a list of these requirements before the project begins.

6.2.2 Corrective action

6.2.2.1 Check calculations, check standard solutions or perform instrument maintenance. Reanalyze the standard, if this fails, re-do initial calibration.

6.2.3 Documentation

6.2.3.1 Copies of the continuing calibration standards and the calculated RFs, %Ds and %drifts are stored with the raw data. If criteria are not met, reanalysis of additional standard(s) are noted in the instrument run log.

6.3 Instrument Blank

6.3.1 Criteria

6.3.1.1 The criteria used are the same as those used for the method blank control limits.

6.3.2 Corrective action

6.3.2.1 If the initial IBLK contains measurable levels of target analytes above one-half the reporting limit, except where noted below, the system is out of control. The source of contamination must be identified and corrected. If analysis of an additional IBLK does not demonstrate that the analytical system is free of contaminants, then instrument maintenance such as cleaning the transfer lines or replacing the trap may be required.

6.3.3 Documentation

6.3.3.1 Copies of instrument blank analyses are stored with the sample analyses raw data. Re-analysis of the method blank and/or maintenance performed is documented in the instrument run log.

6.4 Method Blanks

6.4.1 Criteria

6.4.1.1 A method blank is an aliquot of PFW (with 5g of sand for low level soils). It is used to verify contamination free reagents and apparatus. A method blank is analyzed after every CCV and prior to sample analysis. The autosampler draws either 5mL, 10mL, or 25mL (depending on the instrument) from the blank water reservoir and directly injects internal standards and surrogates. Method blank criteria are listed below.

6.4.1.2 Laucks criteria for a method blank is less than one-half the RL for each analyte.

6.4.2 Corrective action

6.4.2.1 When these criteria are exceeded, corrective action should be taken to find/reduce/eliminate the source of this contamination in the method blank. Sample corrective action may be limited to qualification for blank contamination. When the concentrations of any target analytes within the method blank are above one-half of the reporting limit, the effect this may have had on the samples will be assessed as detailed below:

1) If any analyte is found only in the method blank, but not in any batch samples, no further corrective action may be necessary. Steps shall be taken to find/reduce/eliminate the source of this contamination in the method blank. The case narrative should also discuss the situation.

2) If an analyte is found in the method blank and some, or all, of the other batch samples, additional corrective action is required to reanalyze the method blank, and any samples containing the same contaminant(s) which exceeded the corrective action limit(s). If the contamination remains, the contaminated samples of the batch would be reprepared and reanalyzed with a new method blank and batch specific QC samples.

3) Sporadic cases of contamination may be difficult to control however, daily contamination would not be acceptable.

4) Out-of-control surrogate recoveries in the method blank require reanalysis of the method blank.

5) If common lab contaminants such as acetone and methylene chloride are present, the associated sample results for these compounds are flagged appropriately.

Bromomethane may also be present in a medium soil method blank. This is due to the build-up of methanol on the trap and is very difficult to control. Analytes may be present as long as they are less than 5 percent of the regulatory limit associated with that analyte, or less than 5 percent of the sample result for the same analyte, whichever is greater, for the method blank to be acceptable. Typically, the regulatory limits for these compounds are well above normal sporadic contamination levels however, in order to make appropriate determinations in accordance with the DoD QSM and SW 846, the lab must have the specific regulatory limit for the common lab contaminants provided by the contractor or oversight agency.

6.4.3 Documentation

6.4.3.1 Copies of all method blank analyses are stored with the sample analyses raw data. In addition, the raw data for the method blank analyses are stored in the laboratory for an extended period of time. The results for the method blank analyses are reported electronically via the laboratory's LIMS database. If criteria are not met, reanalysis of additional blank(s) are noted in the instrument run log. Outliers are discussed in the case narrative.

6.5 Blank Spikes

6.5.1 Criteria

6.5.1.1 A blank spike follows the same protocol as a matrix spike analysis except that the spiking solution is added to an aliquot of PFW (with sand for soil samples) instead of an actual sample. A method blank with added analytes is a blank spike. A blank spike is the same as a QC check standard. See Appendix XIV for laboratory control limits on the spike recoveries.

6.5.1.2 The USACOE requires at a minimum that all target analytes be spiked into the LCS. According to the USACOE Shell Document I.10.2.2: "The LCS is spiked with all single-component target analytes before it is carried through the preparation, cleanup, and determinative procedures. ***A subset of the single-component target analytes containing the specific analytes of interest can be substituted for the full list of target analytes if specified in project-specific contracts or work plans.***"

6.5.1.3 It is also recommended that all target analytes of concern be spiked into the LCS for non-USACOE projects. NELAP specifies in D.1.1.b.4.: "if the test method has an extremely long list of components or components are incompatible, a representative number (at a minimum 10%) of the listed components may be used to control the test method." The DOD QSM Final Version I specifies, in clarification Box D-5: ""an

extremely long list of components" means greater than 50 components. If a percentage of the component list is used, those analytes must be representative of each chemical class covered by the test method and include any project-specific analytes of concern."

6.5.1.4 The level spiked in the blank spike will periodically be varied within the established calibration range.

6.5.2 Corrective action

6.5.2.1 The blank spike is used to determine whether a method is in control during sample preparation and analysis. Sample reanalysis would be triggered by an out of control blank spike only if the sample surrogate recoveries and MS/MSD spike recoveries indicated sample processing errors.

6.5.3 Documentation

6.5.3.1 The raw data for the blank spike analyses are stored in the laboratory for an extended period of time. The results for the blank spike analyses are reported electronically via the laboratory's LIMS database. If criteria are not met, reanalysis of additional blank spike(s) are noted in the instrument run log.

6.6 Matrix Spike

6.6.1 Criteria

6.6.1.1 A sample is chosen at random (unless specified by a client) from the samples to be analyzed, and an aliquot of spiking solution is added to this sample prior to analysis. A matrix spike analysis is performed with each analytical batch, up to a maximum of 20 samples, unless there is insufficient sample provided by the client (Laucks informs all clients that extra sample volume must be submitted for MS/MSD analyses). The matrix spike sample is used to evaluate the matrix effect of the sample upon recovery of the analytes. The recovery of spike analytes is calculated as follows:

$$Recovery = \frac{SS - S}{SpikedAmount} \times 100$$

where:

SS = concentration in spiked sample
S = native concentration in unspiked sample

6.6.2 Corrective action

6.6.2.1 Samples with spike recoveries outside control limits (see Appendix XIV) will be reviewed for possible corrective action. Corrective action may involve recalculation and/or reanalysis. This process should also include evaluation of the recovery of surrogate compounds in the MS sample and recovery of matrix spiking compounds from the blank spike analysis. In all cases a narrative explanation of the condition is required to detail the corrective actions taken.

6.6.3 Documentation

6.6.3.1 The raw data for the matrix spike analyses are stored with the sample analyses raw data. The results for the matrix spike analyses are reported electronically via the laboratory's LIMS database.

6.7 Matrix Spike Duplicate

6.7.1 Criteria

6.7.1.1 A matrix spike duplicate analysis is performed with each analytical batch, up to a maximum of 20 samples. The compound recovery criteria are identical to those for the matrix spike sample. In addition, the matrix spike duplicate is used to measure method precision. This is done by computing the relative percent difference (RPD) between the matrix spike and matrix spike duplicate recovery values. This calculation is as follows:

$$RPD = \frac{S1 - S2}{(S1 + S2) \backslash 2} \times 100$$

where:

S1 = measured concentration for MS sample
S2 = measured concentration for MSD sample

6.7.2 Corrective action

6.7.2.1 If a trend in out-of-control RPD values is observed, the method used must be examined to determine the source of variance. Once this source is identified, the method must be changed so that samples can be analyzed with a predictable reproducibility.

6.7.3 Documentation

6.7.3.1 The raw data for the matrix spike duplicate analyses are stored with the sample analyses raw data. The results for the matrix spike duplicate analyses are reported electronically via the laboratory's LIMS database. Any out-of-control results are documented in the LIMS database and/or analytical narrative.

6.8 Surrogate Recovery

6.8.1 Criteria

6.8.1.1 Surrogates are chemically similar compounds added to every sample, method blank, and QC sample prior to sample processing. They are used to monitor potential sample processing errors and matrix effects. Appendix XIV lists all surrogates and their recovery limits. Surrogate compound recoveries are calculated as follow:

$$\text{Recovery} = \frac{S_m}{S_a} \times 100$$

where:

S_m = concentration of surrogate measured in sample
S_a = concentration of surrogate added

6.8.2 Corrective Action

6.8.2.1 Check calculations for possible error. Reanalysis is required for all surrogate recoveries which exceed the established control limits.

6.8.2.2 Out-of-control surrogate recoveries in the method blank require that the method blank be reanalyzed. Sample analyses are not performed until all criteria are met in the method blank analysis. Sample and QC analyses require reanalysis for out-of-control surrogate recoveries. If the sample reanalyses also demonstrate out-of-control surrogate recoveries due to matrix interference, this corrective action is discussed in the narrative.

6.8.3 Documentation

6.8.3.1 The surrogate recoveries for all samples, blanks, and QC analyses are reported electronically via the laboratory's LIMS database. If criteria are not met, reanalysis for out-of-control surrogate recoveries are designated by an "RE" in the instrument run log.

7. References

1) Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), US EPA Office of Solid Waste and Emergency Response, - Method 8260B, 3rd edition, 2nd revision, December 1996.

2) Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), US EPA Office of Solid Waste and Emergency Response, - Method 8000B, 3rd edition, 2nd revision, December 1996.

3) Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), US EPA Office of Solid Waste and Emergency Response, - Method 5000B, 3rd edition, revision 0, December 1996.

4) Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), US EPA Office of Solid Waste and Emergency Response, - Method 5030B, 3rd edition, 2nd revision, December 1996.

5) Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), US EPA Office of Solid Waste and Emergency Response, - Method 5035, 3rd edition, revision 0, December 1996.

6)Hewitt, Alan "Frozen Storage of Soil Samples for VOC Analysis," Environmental Testing and Analysis, Sept/Oct 1999, Vol. 8, No.5.

7)Sorini, Susan, et al, "Evaluation of VOC Loss from Soil Samples:," Contaminated Soil Sediment and Water, April/May 2002.

APPENDIX I

Initial Calibration Concentrations For Low Level (25 mL) Waters (µg/L)

Compound	STD1	STD2	STD3	STD4	STD5
Dichlorodifluoromethane	1	5	10	25	50
Chloromethane	1	5	10	25	50
Vinyl Chloride	1	5	10	25	50
Bromomethane	1	5	10	25	50
Chloroethane	1	5	10	25	50
Trichlorofluoromethane	1	5	10	25	50
1,1-Dichloroethene	1	5	10	25	50
Acetone	5	10	20	50	100
Carbon disulfide	1	5	10	25	50
Methylene chloride	1	5	10	25	50
trans-1,2-Dichloroethene	1	5	10	25	50
1,1-Dichloroethane	1	5	10	25	50
Vinyl acetate	1	5	10	25	50
2,2-Dichloropropane	1	5	10	25	50
cis-1,2-Dichloroethene	1	5	10	25	50
2-Butanone	5	10	20	50	100
Bromochloromethane	1	5	10	25	50
Chloroform	1	5	10	25	50
1,1,1-Trichloroethane	1	5	10	25	50
Carbon tetrachloride	1	5	10	25	50
1,1-Dichloropropene	1	5	10	25	50
Benzene	1	5	10	25	50
1,2-Dichloroethane	1	5	10	25	50
Trichloroethene	1	5	10	25	50
1,2-Dichloropropane	1	5	10	25	50
Dibromomethane	1	5	10	25	50
Bromodichloromethane	1	5	10	25	50
cis-1,3-Dichloropropene	1	5	10	25	50
4-Methyl-2-pentanone	5	10	20	50	100
Toluene	1	5	10	25	50
trans-1,3-Dichloropropene	1	5	10	25	50
1,1,2-Trichloroethane	1	5	10	25	50
Tetrachloroethene	1	5	10	25	50
1,3-Dichloropropane	1	5	10	25	50
2-Hexanone	5	10	20	50	100

Compound	STD1	STD2	STD3	STD4	STD5
Chlorodibromomethane	1	5	10	25	50
1,2-Dibromoethane	1	5	10	25	50
Chlorobenzene	1	5	10	25	50
1,1,1,2-Tetrachloroethane	1	5	10	25	50
Ethylbenzene	1	5	10	25	50
m,p-Xylene	2	10	20	50	100
o-Xylene	1	5	10	25	50
Styrene	1	5	10	25	50
Bromoform	1	5	10	25	50
Isopropylbenzene	1	5	10	25	50
Bromobenzene	1	5	10	25	50
1,2,3-Trichloropropane	1	5	10	25	50
1,1,2,2-Tetrachloroethane	1	5	10	25	50
n-Propylbenzene	1	5	10	25	50
2-Chlorotoluene	1	5	10	25	50
4-Chlorotoluene	1	5	10	25	50
1,3,5-Trimethylbenzene	1	5	10	25	50
tert-Butylbenzene	1	5	10	25	50
1,2,4-Trimethylbenzene	1	5	10	25	50
sec-Butylbenzene	1	5	10	25	50
1,3-Dichlorobenzene	1	5	10	25	50
1,4-Dichlorobenzene	1	5	10	25	50
p-Isopropyltoluene	1	5	10	25	50
1,2-Dichlorobenzene	1	5	10	25	50
n-Butylbenzene	1	5	10	25	50
1,2-Dibromo-3-chloropropane	1	5	10	25	50
1,2,4-Trichlorobenzene	1	5	10	25	50
Naphthalene	1	5	10	25	50
Hexachlorobutadiene	1	5	10	25	50
1,2,3-Trichlorobenzene	1	5	10	25	50
Methyl tert-butyl ether	1	5	10	25	50
1,1,2-Trichloro-1,2,2-trifluoromethane	1	5	10	25	50
Methyl acetate	1	5	10	25	50
Cyclohexane	1	5	10	25	50
Methylcyclohexane	1	5	10	25	50

Initial Calibration Concentrations For Low Level (5 mL)(10mL) Waters (µg/L)

Compound	STD1	STD2	STD3	STD4	STD5	STD6
Dichlorodifluoromethane	1	5	10	50	100	200
Chloromethane	1	5	10	50	100	200
Vinyl Chloride	1	5	10	50	100	200
Bromomethane	1	5	10	50	100	200
Chloroethane	1	5	10	50	100	200
Trichlorofluoromethane	1	5	10	50	100	200
1,1-Dichloroethene	1	5	10	50	100	200
Acetone	-	5	20	50	100	200
Carbon disulfide	1	5	10	50	100	200
Methylene chloride	1	5	10	50	100	200
trans-1,2-Dichloroethene	1	5	10	50	100	200
1,1-Dichloroethane	1	5	10	50	100	200
Vinyl acetate	1	5	10	50	100	200
2,2-Dichloropropane	1	5	10	50	100	200
cis-1,2-Dichloroethene	1	5	10	50	100	200
2-Butanone	-	5	10	50	100	200
Bromochloromethane	1	5	10	50	100	200
Chloroform	1	5	10	50	100	200
1,1,1-Trichloroethane	1	5	10	50	100	200
Carbon tetrachloride	1	5	10	50	100	200
1,1-Dichloropropene	1	5	10	50	100	200
Benzene	1	5	10	50	100	200
1,2-Dichloroethane	1	5	10	50	100	200
Trichloroethene	1	5	10	50	100	200
1,2-Dichloropropane	1	5	10	50	100	200
Dibromomethane	1	5	10	50	100	200
Bromodichloromethane	1	5	10	50	100	200
cis-1,3-Dichloropropene	1	5	10	50	100	200
4-Methyl-2-pentanone	-	5	10	50	100	200
Toluene	1	5	10	50	100	200
trans-1,3-Dichloropropene	1	5	10	50	100	200
1,1,2-Trichloroethane	1	5	10	50	100	200
Tetrachloroethene	1	5	10	50	100	200
1,3-Dichloropropane	1	5	10	50	100	200
2-Hexanone	-	5	10	50	100	200
Chlorodibromomethane	1	5	10	50	100	200
1,2-Dibromoethane	1	5	10	50	100	200

Compound	STD1	STD2	STD3	STD4	STD5	STD6
Chlorobenzene	1	5	10	50	100	200
1,1,1,2-Tetrachloroethane	1	5	10	50	100	200
Ethylbenzene	1	5	10	50	100	200
m,p-Xylene	2	10	20	100	200	400
o-Xylene	1	5	10	50	100	200
Styrene	1	5	10	50	100	200
Bromoform	1	5	10	50	100	200
Isopropylbenzene	1	5	10	50	100	200
Bromobenzene	1	5	10	50	100	200
1,2,3-Trichloropropane	1	5	10	50	100	200
1,1,2,2-Tetrachloroethane	1	5	10	50	100	200
n-Propylbenzene	1	5	10	50	100	200
2-Chlorotoluene	1	5	10	50	100	200
4-Chlorotoluene	1	5	10	50	100	200
1,3,5-Trimethylbenzene	1	5	10	50	100	200
tert-Butylbenzene	1	5	10	50	100	200
1,2,4-Trimethylbenzene	1	5	10	50	100	200
sec-Butylbenzene	1	5	10	50	100	200
1,3-Dichlorobenzene	1	5	10	50	100	200
1,4-Dichlorobenzene	1	5	10	50	100	200
p-Isopropyltoluene	1	5	10	50	100	200
1,2-Dichlorobenzene	1	5	10	50	100	200
n-Butylbenzene	1	5	10	50	100	200
1,2-Dibromo-3-chloropropane	1	5	10	50	100	200
1,2,4-Trichlorobenzene	1	5	10	50	100	200
Naphthalene	1	5	10	50	100	200
Hexachlorobutadiene	1	5	10	50	100	200
1,2,3-Trichlorobenzene	1	5	10	50	100	200
Methyl tert-butyl ether	1	5	10	50	100	200
1,1,2-Trichloro-1,2,2-trifluoromethane	1	5	10	50	100	200
Methyl acetate	1	5	10	50	100	200
Cyclohexane	1	5	10	50	100	200
Methylcyclohexane	1	5	10	50	100	200

Initial Calibration Concentrations Of Routine Target Analytes For Low And Medium Level Soils & 5 mL Waters

Compound (µg/L)	STD1	STD2	STD3	STD4	STD5	STD6
Dichlorodifluoromethane	3	10	20	50	100	200
Chloromethane	3	10	20	50	100	200
Vinyl Chloride	3	10	20	50	100	200
Bromomethane	3	10	20	50	100	200
Chloroethane	3	10	20	50	100	200
Trichlorofluoromethane	3	10	20	50	100	200
1,1-Dichloroethene	3	10	20	50	100	200
Acetone	-	10	20	50	100	200
Carbon disulfide	3	10	20	50	100	200
Methylene chloride	3	10	20	50	100	200
trans-1,2-Dichloroethene	3	10	20	50	100	200
1,1-Dichloroethane	3	10	20	50	100	200
cis-1,2-Dichloroethene	3	10	20	50	100	200
2-Butanone	-	10	20	50	100	200
Chloroform	3	10	20	50	100	200
1,1,1-Trichloroethane	3	10	20	50	100	200
Carbon tetrachloride	3	10	20	50	100	200
Benzene	3	10	20	50	100	200
1,2-Dichloroethane	3	10	20	50	100	200
Trichloroethene	3	10	20	50	100	200
1,2-Dichloropropane	3	10	20	50	100	200
Bromodichloromethane	3	10	20	50	100	200
cis-1,3-Dichloropropene	3	10	20	50	100	200
4-Methyl-2-pentanone	-	10	20	50	100	200
Toluene	3	10	20	50	100	200
trans-1,3-Dichloropropene	3	10	20	50	100	200
1,1,2-Trichloroethane	3	10	20	50	100	200
Tetrachloroethene	3	10	20	50	100	200
2-Hexanone	-	10	20	50	100	200
Chlorodibromomethane	3	10	20	50	100	200
Chlorobenzene	3	10	20	50	100	200
Ethylbenzene	3	10	20	50	100	200
m,p-Xylene	6	20	40	100	200	400
o-Xylene	3	10	20	50	100	200
Styrene	3	10	20	50	100	200
Bromoform	3	10	20	50	100	200
1,1,2,2-Tetrachloroethane	3	10	20	50	100	200

Initial Calibration Concentrations Of Additional Analytes For Low And Medium Level Soils & 5 mL Waters

Compound (µg/L)	STD1	STD2	STD3	STD4	STD5	STD6
1,1,1,2-Tetrachloroethane	3	10	20	50	100	200
2,2-Dichloropropane	3	10	20	50	100	200
Bromochloromethane	3	10	20	50	100	200
1,1-Dichloropropene	3	10	20	50	100	200
1,2-Dibromoethane	3	10	20	50	100	200
Dibromomethane	3	10	20	50	100	200
1,3-Dichloropropane	3	10	20	50	100	200
Isopropylbenzene	3	10	20	50	100	200
Bromobenzene	3	10	20	50	100	200
1,2,3-Trichloropropane	3	10	20	50	100	200
n-Propylbenzene	3	10	20	50	100	200
2-Chlorotoluene	3	10	20	50	100	200
4-Chlorotoluene	3	10	20	50	100	200
1,3,5-Trimethylbenzene	3	10	20	50	100	200
tert-Butylbenzene	3	10	20	50	100	200
1,2,4-Trimethylbenzene	3	10	20	50	100	200
sec-Butylbenzene	3	10	20	50	100	200
1,3-Dichlorobenzene	3	10	20	50	100	200
1,4-Dichlorobenzene	3	10	20	50	100	200
p-Isopropyltoluene	3	10	20	50	100	200
1,2-Dichlorobenzene	3	10	20	50	100	200
n-Butylbenzene	3	10	20	50	100	200
1,2-Dibromo-3-chloropropane	3	10	20	50	100	200
1,2,4-Trichlorobenzene	3	10	20	50	100	200
Naphthalene	3	10	20	50	100	200
Hexachlorobutadiene	3	10	20	50	100	200
1,2,3-Trichlorobenzene	3	10	20	50	100	200
Iodomethane	3	10	20	50	100	200
1,1,2-Trichloro-1,2,2-trifluoromethane	3	10	20	50	100	200
Methyl acetate	3	10	20	50	100	200
Cyclohexane	3	10	20	50	100	200
Methylcyclohexane	3	10	20	50	100	200

APPENDIX II

Data Packet Sequence

1. QC Summary
   - Surrogate recoveries
   - MS/MSD summary
   - Method blank summary
   - Instrument performance check (tuning)
   - Internal standard areas and RT summary

2. Sample Data
   - Target compound results
   - TICs (if requested)
   - Chromatogram normalized to nonsolvent peak
   - Quantitation report
   - Spectra

3. Standards Data
   - Initial calibration form
   - Chromatograms
   - Quantitation reports

   - CCV form
   - Chromatograms
   - Quantitation reports

4. Raw QC
   - BFB tune spectrum, chromatogram, and tabular listing
   - Method blank results, TICs, chromatogram, quantitation report, and spectra
   - MS/MSD results, chromatogram, quantitation report, spectra and control charts

5. Bench Sheets
   - Copy of instrument logbook, copy of COC, copy of holding blank analysis

6. Narrative.

7. Electronic Disk Deliverables (EDD) when requested

8. Control charts

APPENDIX III

Determination of Vinyl Chloride by Selected Ion Monitoring (SIM)

Analytical Conditions:*

GC Parameters

Injection Port Temperature	: 200°C
GC/MS Interface Temperature	: 200°C
Initial GC Temperature	: 30°C
Initial Hold Time	: 0 min
Ramp Rate	: 6°C/min
Final Temperature	: 105°C
Final Time	: 0 min
Carrier Gas Flow	: 15 mL/min
Column Head Pressure	: 9 psi

Purge and Trap Parameters

Purge Time	: 11 min
Desorb Time	: 1 min
Bake Time	: 16 min
Desorb Preheat Temperature	: 20°C
Desorb Temperature	: 180°C
Purge Flow	: 40 mL/min
Purge Temperature	: Ambient
Desorb Flow Rate	: 15 mL/min

Mass Spectrometer Parameters

Electron Energy	: 70 volts
Acquisition Start Time	: 0.1 min

*parameters may vary per instrument

Group 1:

M/Z	Dwell Time (milliseconds)
61	200
62	400
63	200
64	200

Group 2:

M/Z	Dwell Time (milliseconds)
49	200
51	200
128	100
129	200

Group 3:

M/Z	Dwell Time (milliseconds)
65	200
67	200
102	200
104	200

Standards:

Internal Standard: Bromochloromethane
Surrogate: 1,2-Dichloroethane-d4

APPENDIX IV

Additional Appendix IX Compounds And Their Initial Concentrations For Low Level Waters

Compound* (µg/L)	STD1	STD2	STD3	STD4	STD5
Acrolein	5	10	50	100	200
Bromoethane	5	10	50	100	200
Allyl chloride	5	10	50	100	200
Acrylonitrile	5	10	50	100	200
Chloroprene	5	10	50	100	200
Methacrylonitrile	50	100	500	1000	2000
Ethyl methacrylate	5	10	50	100	200
trans-1,4-Dichloro-2-butene	5	10	50	100	200
2-Chloroethylvinyl ether[1]	5	10	50	100	200

* The calibration range defines the reporting range for these compounds. However, the reporting limits may change for individual projects, based on MDLs, mass spectral confirmation, or project-specific requirements.

1 This analyte is not recommended because it decomposes in water, and does not recover in acidified samples.

Additional California Oxygenate Compounds And Their Initial Concentrations For Low Level Waters

Compound* (µg/L)	STD1	STD2	STD3	STD4	STD5	STD6
Tert-butanol	5	25	50	250	500	1000
Isopropyl ether	1	5	10	50	100	200
Ethyl-tert butyl ether	1	5	10	50	100	200
Tert-amyl methyl ether	1	5	10	50	100	200

APPENDIX V

Method 8260 Requirements and Corrective Actions

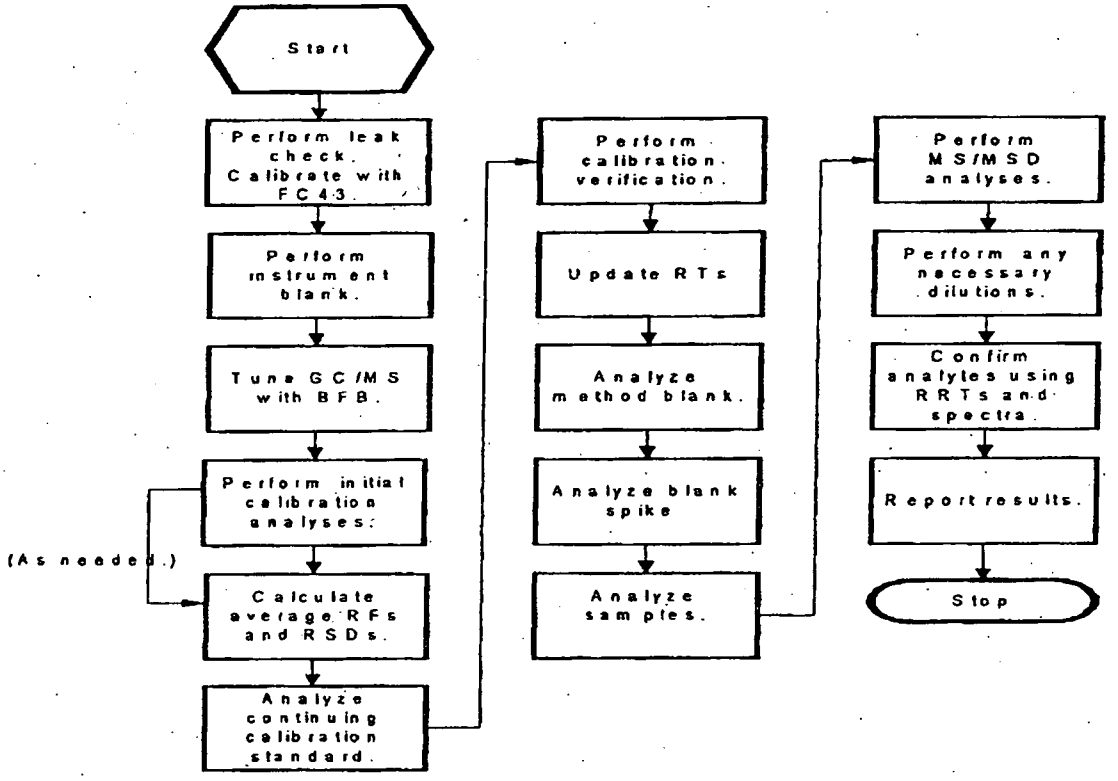
QA Element	Method Criterion	Laucks Criterion	Frequency	Corrective Action	Documentation
Holding Time	14 days from collection.	14 days from collection.	N/A	N/A	HTVR (holding time violation report).
Tuning Verification 5 - 200 ng BFB	Mass Abundance 200 15-40% of 95 75 30-60% of 95 95 100% 96 5-9% of 95 173 ≤2% of 174 174 ≥200% of 95 175 5-9% of 174 176 95-101% of 174 177 5-9% of 176 *Alternate tuning criteria may be used (e.g.,CLP,524.2).	Mass Abundance 200 15-40% of 95 75 30-60% of 95 95 100% 96 5-9% of 95 173 ≤2% of 174 174 ≥200% of 95 175 5-9% of 174 176 95-101% of 174 177 5-9% of 176 * Alternate tuning criteria may be used (except Army Corps and AFCEE).	Every 12 hours.	Re-tune instrument to meet criteria.	Copy of BFB raw data and tune criteria with file.
Initial Calibration	Minimum of 5 levels with lowest near RL. %RSD for CCCs ≤30% RF for SPCCs: chloromethane 0.10 1,1-dichloroethane 0.10 bromoform 0.10 chlorobenzene 0.30 1,1,2,2-tetrachloroethane 0.30 Non-CCCs: all analytes or average of all analytes = ≤15%.	Minimum of 5 levels %RSD for CCCs ≤30% RFs for SPCCs: chloromethane 0.10 1,1-dichloroethane 0.10 bromoform 0.10 chlorobenzene 0.30 1,1,2,2-tetrachloroethane 0.30 Non-CCCs: all analytes or average of all analytes ≤15%.	Initially.	Reanalysis of out of control standards.	Copies of all raw data, tune file, and Form VI.
Initial Calibration Verification		Typically mid-range standard. Client specific limits.	Once after initial calibration.	Re-analysis of initial calibration.	
Continuing Calibration Verification	Mid-level calibration standard every 12 hours. RF for SPCCs same as initial. RF for CCCs must be ≤20% D.	%D for CCCs ≤20%. RF for SPCCs same as initial.	Every 12 hours.	Reanalyze for analytes that exceed the control limits.	Copies of raw data and Form VII.
Internal Standards	Fluorobenzene, chlorobenzene-d5, 1,4-dichlorobenzene-d4, recommended.	Fluorobenzene, chlorobenzene-d5 and 1,4-dichlorobenzene-d4. RT must be ± 30 seconds from last calibration; area must be 200 to 100%.	Every sample.	Reanalyze all samples that do not meet these criteria.	IS areas and RTs are submitted on Form 8, and included in data package.

QA Element	Method Criterion	Laucks Criterion	Frequency	Corrective Action	Documentation
Method Blank/ Instrument Blank	One method blank per extraction batch (up to 20 samples) or when there is a change in reagents, whichever is more frequent.	≤ 1/2 Reporting limit.	One method blank per QC period, after the CCV, prior to sample analysis. Typically, an instrument blank is analyzed prior to tuning the instrument.	Evaluate, qualify.	Copies of raw data filed, and reported electronically. Daily control charts for all method blanks are recorded. Narrate any analytes ≥ 1/2 RL.
Surrogate Standards	4-bromofluorobenzene, dibromofluoromethane 1,2-dichloroethane-d4 or toluene-d8 recommended. Compare %R to laboratory established limits.	1,2-dichloroethane-d4, toluene-d8, 4-bromofluorobenzene, and dibromofluoromethane. Percent recoveries must meet established laboratory control limits. See QC database for control limits.	Every sample.	Reanalysis if surrogate recoveries exceed the established control limits.	Surrogates that exceed the control limits are documented in associated file.
Quality Control	One MS/MSD per 20 samples or each batch of samples, whichever is more frequent. Compare % recovery to laboratory established limits.	Blank spike recoveries and RPDs must meet control limits established by laboratory. MS/MSD recoveries are allowed to be out if due to matrix effect. See QC database for control limits.	One MS/MSD per 20 samples. A blank spike is analyzed every QC period.	Reanalysis of MS/MSD unless matrix effect has already been demonstrated. This can be determined by comparing with the blank spike recoveries.	Blank spike and MS/MSD recoveries are stored electronically. Raw data is stored with file. Out of control events are notated in file.
Qualitative Identification	All ions ≥ 10% intensity must be ± 20% of standard; ± 0.06 RRT units of standard RRT.	All ions > 10% intensity must be ± 20% of standard; ± 0.200 min. of standard RT.	For identifying all target analytes in each sample.		Copies of all mass spectra stored with data.
Sample Preservation and Storage	pH ≤2 with HCL for waters. pH ≤ 2 with sodium bisulfate for low level soils. Medium soils: zero headspace, methanol, or EnCore™ sampler. Store at 4 ° C.	pH ≤2 with HCL for waters. pH ≤2 with sodium bisulfate for low level soils. Medium soils: zero headspace, methanol, or EnCore™ sampler. Store at 4° C, Freezing for soils.	All water and low level soil samples.	If the water and low level soil samples are not acid-preserved, this is narrated in final report and the project manager is notified.	pH of all water samples and low level soils, where not preserved to a pH of ≤2, noted in instrument logbook.
Standard Solution Expiration	Stock standards (except gases): 6 months. Store between -10 to -20° C in Teflon-sealed liners and amber bottles with minimal headspace, protect from light. Stock gas standards: 2 months. Storage conditions same as stock standards. Calibration standards: daily.	Stock standards (except gases): 6 months. Gas stock standards: 2 months. Stored at -10° to -20° C. Calibration standards: daily. All standards sealed in flame-sealed ampules: 2 years (not to exceed parent expiration date).			All standard data recorded in standard logbook.

QA Element	Method Criterion	Laucks Criterion	Frequency	Corrective Action	Documentation
Field Sample Amount	2· 40 mL vials with zero headspace. Soils: vials, with zero headspace, or a sample aliquot in 40 mL vial. Glass container, septum-sealed screw-caps.	Waters:4 40 mL vials with zero headspace. Soils: 2 oz vials, with zero headspace, or a sample aliquot in 4 -40 mL vial. Glass container, septum-sealed screw-caps.			Bottles received by laboratory documented electronically.
Applicability	Groundwaters, soils, sediments, sludges, non-water miscible wastes and others.				

APPENDIX VI

Method 8260B Flow Chart



Refer to corrective action chart for out of control events.

APPENDIX VII

Method 8260 Target Analytes

Dichlorodifluoromethane	Chloromethane
Vinyl Chloride	Bromomethane
Chloroethane	Trichlorofluoromethane
1,1-Dichloroethene	Acetone
Carbon disulfide	Methylene chloride
trans-1,2-Dichloroethene	1,1-Dichloroethane
1,1,2,2-Tetrachloroethane	2,2-Dichloropropane
cis-1,2-Dichloroethene	2-Butanone
Bromochloromethane	Chloroform
1,1,1-Trichloroethane	Carbon tetrachloride
1,1-Dichloropropene	Benzene
1,2-Dichloroethane	Trichloroethene
1,2-Dichloropropane	Dibromomethane
Bromodichloromethane	cis-1,3-Dichloropropene
4-Methyl-2-pentanone	Toluene
trans-1,3-Dichloropropene	1,1,2-Trichloroethane
Tetrachloroethene	1,3-Dichloropropane
2-Hexanone	Chlorodibromomethane
1,2-Dibromoethane	Chlorobenzene
1,1,1,2-Tetrachloroethane	Ethylbenzene
m,p-Xylene	o-Xylene
Styrene	Bromoform
Methyl tert-butyl ether	1,1,2-Trichloro-1,2,2-trifluoromethane
Methyl acetate	Cyclohexane
Methylcyclohexane	

APPENDIX VIII

Method 8260 Optional Analytes for Low Level Water Analyses

Isopropylbenzene	Bromobenzene
1,2,3-Trichloropropane	2-Chlorotoluene
n-Propylbenzene	1,3,5-Trimethylbenzene
4-Chlorotoluene	1,2,4-Trimethylbenzene
tert-Butylbenzene	1,3-Dichlorobenzene
sec-Butylbenzene	p-Isopropyltoluene
1,4-Dichlorobenzene	n-Butylbenzene
1,2-Dichlorobenzene	1,2,4-Trichlorobenzene
1,2-Dibromo-3-chloropropane	Hexachlorobutadiene
Naphthalene	1,2,3-Trichlorobenzene
Vinyl acetate	Tert-butanol
Tert-amyl methyl ether	Isopropyl ether
Ethyl-tert butyl ether	

Appendix IX

Additional Appendix IX Compounds

Acrolein	Bromoethane
Allyl chloride	Acrylonitrile
Chloroprene	Methacrylonitrile
Methyl methacrylate	trans-1,4-Dichloro-2-butene
2-Chloroethylvinyl ether	Ethyl methacrylate
Iodomethane	

APPENDIX X

Target Analytes And Their Associated Internal Standards

Fluorobenzene	Chlorobenzene-d5	1,4-Dichlorobenzene-d4
Dichlorodifluoromethane	Toluene	Isopropylbenzene
Chloromethane	trans-1,3-Dichloropropene	Bromobenzene
Vinyl Chloride	1,1,2-Trichloroethane	1,2,3-Trichloropropane
Bromomethane	Tetrachloroethene	1,1,2,2-Tetrachloroethane
Chloroethane	1,3-Dichloropropane	n-Propylbenzene
Trichlorofluoromethane	2-Hexanone	2-Chlorotoluene
1,1-Dichloroethene	Chlorodibromomethane	4-Chlorotoluene
Acetone	1,2-Dibromoethane	1,3,5-Trimethylbenzene
Carbon disulfide	Chlorobenzene	tert-Butylbenzene
Methylene chloride	1,1,1,2-Tetrachloroethane	1,2,4-Trimethylbenzene
trans-1,2-Dichloroethene	Ethylbenzene	sec-Butylbenzene
1,1-Dichloroethane	m,p-Xylene	1,3-Dichlorobenzene
Vinyl acetate	o-Xylene	1,4-Dichlorobenzene
2,2-Dichloropropane	Styrene	p-Isopropyltoluene
cis-1,2-Dichloroethene	Bromoform	1,2-Dichlorobenzene
2-Butanone		n-Butylbenzene
Bromochloromethane		1,2-Dibromo-3-chloropropane
Chloroform		1,2,4-Trichlorobenzene
1,1,1-Trichloroethane		Naphthalene
Carbon tetrachloride		Hexachlorobutadiene
1,1-Dichloropropene		1,2,3-Trichlorobenzene
Benzene		
1,2-Dichloroethane		
Trichloroethene		
1,2-Dichloropropane		
Dibromomethane		
Bromodichloromethane		
cis-1,3-Dichloropropene		
4-Methyl-2-pentanone		
Methyl tert-butyl ether		
1,1,2-trichloro-1,2,2-trifluoromethane		
Methyl acetate		

Fluorobenzene	Chlorobenzene-d5	1,4-Dichlorobenzene-d4
Cyclohexane		
Methylcyclohexane		

Additional Appendix IX Compounds And Associated Internal Standard

Fluorobenzene (IS)	Chlorobenzene-d5
Acrolein	Ethyl methacrylate
Bromoethane	
Allyl chloride	
Acrylonitrile	
Chloroprene	
Methacrylonitrile	
Methyl methacrylate	
trans-1,4-Dichloro-2-butene	
Iodomethane	
2-Chloroethylvinyl ether	

Additional California Oxygenate Compounds And Associated Internal Standard

Fluorobenzene (IS)
Tert-butanol
Isopropyl ether
Ethyl-tert butyl ether
Tert-amyl methyl ether

APPENDIX XI

Target Analytes And Their Quantitation Ions

Compound	Primary Quant Ions*	Secondary Quant Ions*
Dichlorodifluoromethane	85	87
Chloromethane	50	52
Vinyl Chloride	62	64
Bromomethane	96	94
Chloroethane	64	66
Trichlorofluoromethane	101	103
1,1-Dichloroethene	96	61,98
Acetone	43	58
Carbon disulfide	76	78
Methylene chloride	84	49,86
trans-1,2-Dichloroethene	96	98,61
1,1-Dichloroethane	63	65
2,2-Dichloropropane	77	79
cis-1,2-Dichloroethene	96	98,61
2-Butanone	43	57,72
Bromochloromethane	128	49,130
Chloroform	83	85
1,1,1-Trichloroethane	97	99
Carbon tetrachloride	117	119
1,1-Dichloropropene	75	77,110
Benzene	78	-
1,2-Dichloroethane	62	98
Trichloroethene	130	95,132
1,2-Dichloropropane	63	65
Dibromomethane	93	95,174
Bromodichloromethane	83	85
cis-1,3-Dichloropropene	75	77
4-Methyl-2-pentanone	43	58,85
Toluene	92	91
trans-1,3-Dichloropropene	75	77
1,1,2-Trichloroethane	97	99
Tetrachloroethene	166	164

Compound	Primary Quant Ions*	Secondary Quant Ions*
1,3-Dichloropropane	76	78
2-Hexanone	43	58,100
Chlorodibromomethane	129	127
1,2-Dibromoethane	107	109
Chlorobenzene	112	114
1,1,1,2-Tetrachloroethane	131	133
Ethylbenzene	91	106
m,p-Xylene	106	91
o-Xylene	106	91
Styrene	104	78
Bromoform	173	175
Isopropylbenzene	105	120
Bromobenzene	156	158
1,2,3-Trichloropropane	75	77
1,1,2,2-Tetrachloroethane	83	85
n-Propylbenzene	120	91
2-Chlorotoluene	91	126
4-Chlorotoluene	91	126
1,3,5-Trimethylbenzene	105	120
tert-Butylbenzene	119	91,134
1,2,4-Trimethylbenzene	105	120
sec-Butylbenzene	105	134
1,3-Dichlorobenzene	111	75,148
1,4-Dichlorobenzene	146	148,111
p-Isopropyltoluene	119	134,91
1,2-Dichlorobenzene	146	148,111
n-Butylbenzene	91	92
1,2-Dibromo-3-chloropropane	157	75,155
1,2,4-Trichlorobenzene	180	182
Naphthalene	128	127,129
Hexachlorobutadiene	225	223,227
1,2,3-Trichlorobenzene	180	182
Methyl tert-butyl ether	73	57
1,1,2-trichloro-1,2,2-trifluoromethane	101	85,151
Methyl acetate	43	74

Compound	Primary Quant Ions*	Secondary Quant Ions*
Cyclohexane	56	69,84
Methylcyclohexane	83	55,98

Additional Appendix IX Compounds And Their Quantitation Ions

Compound	Primary Quant Ions*	Secondary Quant Ions*
Acrolein	56	55
Bromoethane	108	110
Allyl chloride	76	41,39,78
Acrylonitrile	53	52,51
Chloroprene	53	51,88,90
Methacrylonitrile	41	39,52,67
Ethyl methacrylate	69	41,86,99
Methyl methacrylate	41	39,69,100
trans-1,4-Dichloro-2-butene	53	75,88
Vinyl acetate	43	86
Iodomethane	142	127
Vinyl acetate	43	86
2-Chloroethylvinyl ether	63	65,106

* Primary and secondary quantitation ions assigned by Laucks may be different than those recommended in SW 846, in order to avoid interference.

Additional California Oxygenate Compounds And Their Quantitation Ions

Compound	Primary Quant Ions*	Secondary Quant Ions*
Tert-butanol	59	41
Isopropyl ether	45	87
Ethyl-tert butyl ether	59	87
Tert-amyl methyl ether	73	55,87

APPENDIX XII

Target Analytes, Their Elution Order And Standard Mixes

Compound	Standard Mix
Dichlorodifluoromethane	1
Chloromethane	1
Vinyl Chloride	1
Bromomethane	1
Chloroethane	1
Trichlorofluoromethane	1
Acrolein	2
1,1-Dichloroethene	3
1,1,2-trichloro-1,2,2-trifluoromethane	3
Acetone	4
Iodomethane	4
Bromoethane	5
Carbon disulfide	4
Allyl Chloride	6
Methyl acetate	3
Methylene chloride	3
Methyl tert-butyl ether	8,9
Tert-butanol	8
trans-1,2-Dichloroethene	3
Acrylonitrile	2
1,1-Dichloroethane	3
Isopropyl ether	8
Vinyl acetate	4
Chloroprene	7
Ethyl-tert butyl ether	8
2,2-Dichloropropane	3
cis-1,2-Dichloroethene	3
2-Butanone	4
Methacrylonitrile	6
Bromochloromethane	3
Chloroform	3
1,1,1-Trichloroethane	3

Compound	Standard Mix
Cyclohexane	3
Carbon tetrachloride	3
Tert-amyl methyl ether	8
Methyl methacrylate	6
1,1-Dichloropropene	3
1,2-Dichloroethane-d4 (surr)	10
Benzene	3
1,2-Dichloroethane	3
Trichloroethene	3
Methylcyclohexane	3
1,2-Dichloropropane	3
Dibromomethane	3
Bromodichloromethane	3
2-Chloroethylvinyl ether	4
cis-1,3-Dichloropropene	3
Ethyl methacrylate	6
4-Methyl-2-pentanone	4
Toluene-d8 (surr)	11
Toluene	3
trans-1,3-Dichloropropene	3
1,1,2-Trichloroethane	3
Tetrachloroethene	3
1,3-Dichloropropane	3
2-Hexanone	4
Chlorodibromomethane	3
1,2-Dibromoethane	3
Chlorobenzene	3
1,1,1,2-Tetrachloroethane	3
Ethylbenzene	3
m,p-Xylene	3
o-Xylene	3
Styrene	3
Bromoform	3
Isopropylbenzene	3
4-Bromofluorobenzene (surr)	12
Bromobenzene	3
1,2,3-Trichloropropane	3
1,1,2,2-Tetrachloroethane	3

Compound	Standard Mix
n-Propylbenzene	3
trans-1,4-Dichloro-2-butene	6
2-Chlorotoluene	3
4-Chlorotoluene	3
1,3,5-Trimethylbenzene	3
tert-Butylbenzene	3
1,2,4-Trimethylbenzene	3
sec-Butylbenzene	3
1,3-Dichlorobenzene	3
1,4-Dichlorobenzene	3
p-Isopropyltoluene	3
1,2-Dichlorobenzene	3
n-Butylbenzene	3
1,2-Dibromo-3-chloropropane	3
1,2,4-Trichlorobenzene	3
Naphthalene	3
Hexachlorobutadiene	3
1,2,3-Trichlorobenzene	3

Key:

1 = 524.2 Volatile Gasses Crescent CC2006.10
2 = Acrolein/Acrylonitrile Crescent CC2098
3 = 8260 Volatiles Crescent CCS-743
4 = Appendix IX Ketones Crescent CC2239-10
5 = Ethyl bromide ChemService O-640 neat
6 = Appendix IX Vols Crescent CC2464.10
7 = Chloroprene Restek 30238
8 = Calif. Oxygenates Restek 30465
9 = MTBE Restek 30402
10 = Neat Material
11 = Neat Material
12 = Neat Material

At the time of this writing, these are the current standard solutions used for the calibration standards. However, these standards may change due to Vendor supply or project-specific requirements.

APPENDIX XIII

Requirements for the Second Source* Initial Calibration Verification by Client

SW-846	AFCEE	Dept of Defense	Army Corps
None.	All analytes in the ICV must be within 25% of the expected value.	Must meet CCV requirements: No analyte can exceed a %Drift/Difference of 15%. The average %D can be used as long as no individual is greater than 25%D.	All analytes in the ICV must be within 20% of the expected value.

*A second source calibration standard is a standard that is obtained from a different manufacturer than the standard used in the initial calibration.

APPENDIX XIV

Laboratory derived control limits* for Blank Spike, MS/MSD and Surrogates

Water control limits for Blank Spike

Compound	Mean	SD	LCL	UCL	RPD
1,1-Dichloroethene	100.6	15.685	54	148	-
Trichloroethene	96.4	12.243	60	133	-
Benzene	100.9	12.802	62	139	-
Toluene	97.7	11.762	62	133	-
Chlorobenzene	97.2	10.999	64	130	-

Water control limits for MS/MSD

Compound	Mean	SD	LCL	UCL	RPD
1,1-Dichloroethene	99.5	12.617	62	137	20
Trichloroethene	96.2	11.412	62	130	20
Benzene	102.2	13.125	63	142	20
Toluene	97.7	8.755	71	124	20
Chlorobenzene	97.9	5.607	81	115	20

Soil control limits for Blank Spike

Compound	Mean	SD	LCL	UCL	RPD
1,1-Dichloroethene	100.8	8.672	70	130	-
Trichloroethene	93.3	12.600	56	131	-
Benzene	97.3	12.187	61	134	-
Toluene	94.2	11.807	59	130	-
Chlorobenzene	92.9	11.278	59	127	-

Soil control limits for MS/MSD

Compound	Mean	SD	LCL	UCL	RPD
1,1-Dichloroethene	87.3	24.128	20	160	34
Trichloroethene	79.1	21.532	20	144	50
Benzene	87.3	18.526	32	143	37
Toluene	84.5	20.572	23	146	37
Chlorobenzene	78.6	22.094	20	145	45

Surrogate recovery limits

Surrogate	LCL	UCL
Dibromofluoromethane	60	140
1,2-Dichloroethane-d4	60	140
Toluene-d8	60	140
4-Bromofluorobenzene	60	140

*These control limits were generated at the time of this writing and are subject to change.

LINEST

See Also

lates the statistics for a line by using the "least squares" method to calculate a straight line that best fits your data, and returns an array that describes the line. Because this function returns an array of values, it must be entered as an array formula.

The equation for the line is:

y = mx + b or

y = m1x1 + m2x2 + ... + b (if there are multiple ranges of x-values)

where the dependent y-value is a function of the independent x-values. The m-values are coefficients corresponding to each x-value, and b is a constant value. Note that y, x, and m can be vectors. The array that LINEST returns is {mn,mn-1,...,m1,b}. LINEST can also return additional regression statistics.

Syntax

LINEST(known_y's,known_x's,const,stats)

Known_y's is the set of y-values you already know in the relationship y = mx + b.

- If the array known_y's is in a single column, then each column of known_x's is interpreted as a separate variable.
- If the array known_y's is in a single row, then each row of known_x's is interpreted as a separate variable.

Known_x's is an optional set of x-values that you may already know in the relationship y = mx + b.

- The array known_x's can include one or more sets of variables. If only one variable is used, known_y's and known_x's can be ranges of any shape, as long as they have equal dimensions. If more than one variable is used, known_y's must be a vector (that is, a range with a height of one row or a width of one column).
- If known_x's is omitted, it is assumed to be the array {1,2,3,...} that is the same size as known_y's.

Const is a logical value specifying whether to force the constant b to equal 0.

- If const is TRUE or omitted, b is calculated normally.
- If const is FALSE, b is set equal to 0 and the m-values are adjusted to fit y = mx.

Stats is a logical value specifying whether to return additional regression statistics.

- If stats is TRUE, LINEST returns the additional regression statistics, so the returned array is {mn,mn-1,...,m1,b;sen,sen-1,...,se1,seb;r2,sey;F,df;ssreg,ssresid}.
- If stats is FALSE or omitted, LINEST returns only the m-coefficients and the constant b.

The additional regression statistics are as follows.

Statistic	Description
se1,se2,...,sen	The standard error values for the coefficients m1,m2,...,mn.
Seb	The standard error value for the constant b (seb = #N/A when const is FALSE).
r2	The coefficient of determination. Compares estimated and actual y-values, and ranges in value from 0 to 1. If it is 1, there is a perfect correlation in the sample — there is no difference between the estimated y-value and the actual y-value. At the other extreme, if the coefficient of determination is 0, the regression equation is not helpful in predicting a y-value. For information about how r2 is calculated, see "Remarks" later in this topic.
sey	The standard error for the y estimate.
F	The F statistic, or the F-observed value. Use the F statistic to determine whether the observed relationship between the dependent and independent variables occurs by chance.
df	The degrees of freedom. Use the degrees of freedom to help you find F-critical values in a statistical table. Compare the values you find in the table to the F statistic returned by LINEST to determine a confidence level for the model.
ssreg	The regression sum of squares.
ssresid	The residual sum of squares.

following illustration shows the order in which the additional regression statistics are returned.

m_n	m_{n-1}	...	m_2	m_1	b
se_n	se_{n-1}	...	se_2	se_1	se_b
r^2	se_y				
F	d_f				
ss_{reg}	ss_{resid}				

Remarks

- You can describe any straight line with the slope and the y-intercept:

  Slope (m):
  To find the slope of a line, often written as m, take two points on the line, (x1,y1) and (x2,y2); the slope is equal to (y2 - y1)/(x2 - x1).

  Y-intercept (b):
  The y-intercept of a line, often written as b, is the value of y at the point where the line crosses the y-axis.

  The equation of a straight line is y = mx + b. Once you know the values of m and b, you can calculate any point on the line by plugging the y- or x-value into that equation. You can also use the TREND function.

- When you have only one independent x-variable, you can obtain the slope and y-intercept values directly by using the following formulas:

  Slope:
  =INDEX(LINEST(known_y's,known_x's),1)

  Y-intercept:
  =INDEX(LINEST(known_y's,known_x's),2)

- The accuracy of the line calculated by LINEST depends on the degree of scatter in your data. The more linear the data, the more accurate the LINEST model. LINEST uses the method of least squares for determining the best fit for the data. When you have only one independent x-variable, the calculations for m and b are based on the following formulas:

$$m = \frac{n\left(\sum xy\right) - \left(\sum x\right)\left(\sum y\right)}{n\left(\sum\left(x^2\right)\right) - \left(\sum x\right)^2}$$

$$b = \frac{\left(\sum y\right)\left(\sum\left(x^2\right)\right) - \left(\sum x\right)\left(\sum xy\right)}{n\left(\sum\left(x^2\right)\right) - \left(\sum x\right)^2}$$

- The line- and curve-fitting functions LINEST and LOGEST can calculate the best straight line or exponential curve that fits your data. However, you have to decide which of the two results best fits your data. You can calculate TREND(known_y's,known_x's) for a straight line, or GROWTH(known_y's, known_x's) for an exponential curve. These functions, without the new_x's argument, return an array of y-values predicted along that line or curve at your actual data points. You can then compare the predicted values with the actual values. You may want to chart them both for a visual comparison.

- In regression analysis, Microsoft Excel calculates for each point the squared difference between the y-value estimated for that point and its actual y-value. The sum of these squared differences is called the residual sum of squares. Microsoft Excel then calculates the sum of the squared differences between the actual y-values and the average of the y-values, which is called the total sum of squares (regression sum of squares + residual sum of squares). The smaller the residual sum of squares is, compared with the total sum of squares, the larger the value of the coefficient of determination, r2, which is an indicator of how well the equation resulting from the regression analysis explains the relationship among the variables.

- Formulas that return arrays must be entered as array formulas.

- When entering an array constant such as known_x's as an argument, use commas to separate values in the same row and semicolons to separate rows. Separator characters may be different depending on your locale setting in **Regional Settings** or **Regional Options** in **Control Panel**.

- Note that the y-values predicted by the regression equation may not be valid if they are outside the range of the y-values you used to determine the equation.

Example 1 Slope and Y-Intercept

The example may be easier to understand if you copy it to a blank worksheet.

▶ How?

	A	B
1	**Known y**	**Known x**
	1	0
3	9	4

4	5	2
	7	3
	Formula	**Formula**
	=LINEST(A2:A5,B2:B5,,FALSE)	

Note The formula in the example must be entered as an array formula. After copying the example to a blank worksheet, select the range A7:B7 starting with the formula cell. Press F2, and then press CTRL+SHIFT+ENTER. If the formula is not entered as an array formula, the single result is 2.

When entered as an array, the slope (2) and the y-intercept (1) are returned.

Example 2 Simple Linear Regression

The example may be easier to understand if you copy it to a blank worksheet.

▶ How?

	A	B
1	**Month**	**Sales**
2	1	3100
3	2	4500
4	3	4400
5	4	5400
6	5	7500
7	6	8100
	Formula	**Description (Result)**
	=SUM(LINEST(B2:B7, A2:A7)*{9,1})	Estimate sales for the ninth month (11000)

In general, SUM({m,b}*{x,1}) equals mx + b, the estimated y-value for a given x-value. You can also use the TREND function.

Example 3 Multiple Linear Regression

Suppose a commercial developer is considering purchasing a group of small office buildings in an established business district.

The developer can use multiple linear regression analysis to estimate the value of an office building in a given area based on the following variables.

Variable	Refers to the
y	Assessed value of the office building
x1	Floor space in square feet
x2	Number of offices
x3	Number of entrances
x4	Age of the office building in years

This example assumes that a straight-line relationship exists between each independent variable (x1, x2, x3, and x4) and the dependent variable (y), the value of office buildings in the area.

The developer randomly chooses a sample of 11 office buildings from a possible 1,500 office buildings and obtains the following data. "Half an entrance" means an entrance for deliveries only.

The example may be easier to understand if you copy it to a blank worksheet.

ıw?

	A	B	C	D	E
	Floor space (x1)	Offices (x2)	Entrances (x3)	Age (x4)	Assessed value (y)
2	2310	2	2	20	142,000
3	2333	2	2	12	144,000
4	2356	3	1.5	33	151,000
5	2379	3	2	43	150,000
6	2402	2	3	53	139,000
7	2425	4	2	23	169,000
8	2448	2	1.5	99	126,000
9	2471	2	2	34	142,900
10	2494	3	3	23	163,000
11	2517	4	4	55	169,000
12	2540	2	3	22	149,000

Formula

=LINEST(E2:E12,A2:D12,TRUE,TRUE)

Note The formula in the example must be entered as an array formula. After copying the example to a blank worksheet, select the range A14:E18 starting with the formula cell. Press F2, and then press CTRL+SHIFT+ENTER. If the formula is not entered as an array formula, the single result is -2[illegible]2371645.

[illegible]n entered as an array, the following regression statistics are returned. Use this key to identify the statistic you want.

m_n	m_{n-1}	...	m_2	m_1	b
se_n	se_{n-1}	...	se_2	se_1	se_b
r_2	se_y				
F	d_f				
ss_{reg}	ss_{resid}				

The multiple regression equation, y = m1*x1 + m2*x2 + m3*x3 + m4*x4 + b, can now be obtained using the values from row 14:

y = 27.64*x1 + 12,530*x2 + 2,553*x3+ 234.24*x4 + 52,318

The developer can now estimate the assessed value of an office building in the same area that has 2,500 square feet, three offices, and two entrances and is 25 years old, by using the following equation:

y = 27.64*2500 + 12530*3 + 2553*2 - 234.24*25 + 52318 = $158,261

Or you can copy the following table to cell A21 of the example workbook.

Floor space (x1)	Offices (x2)	Entrances (x3)	Age (x4)	Assessed value (y)
2500	3	2	25	=D14*A22 + C14*B22 + B14*C22 + A14*D22 + E14

You can also use the TREND function to calculate this value.

Example 4 Using The F And R2 Statistics

In the previous example, the coefficient of determination, or r2, is 0.99675 (see cell A17 in the output for LINEST), which would indicate a strong relationship between the independent variables and the sale price. You can use the F statistic to determine whether these results, with such a high r2 value, occurred by chance.

[illegible]me for the moment that in fact there is no relationship among the variables, but that you have drawn a rare sample of 11 office buildings that causes [illegible]tatistical analysis to demonstrate a strong relationship. The term "Alpha" is used for the probability of erroneously concluding that there is a relationship.

There is a relationship among the variables if the F-observed statistic is greater than the F-critical value. The F-critical value can be obtained by referring to a table of F-critical values in many statistics textbooks. To read the table, assume a single-tailed test, use an Alpha value of 0.05, and for the degrees of freedom (abbreviated in most tables as v1 and v2), use v1 = k = 4 and v2 = n - (k + 1) = 11 - (4 + 1) = 6, where k is the number of variables in the regression analysis and n is the number of data points. The F-critical value is 4.53.

The F-observed value is 459.753674 (cell A18), which is substantially greater than the F-critical value of 4.53. Therefore, the regression equation is useful in predicting the assessed value of office buildings in this area.

Example 5 Calculating The T-Statistics

Another hypothesis test will determine whether each slope coefficient is useful in estimating the assessed value of an office building in example 3. For example, to test the age coefficient for statistical significance, divide -234.24 (age slope coefficient) by 13.268 (the estimated standard error of age coefficients in cell A15). The following is the t-observed value:

t = m4 ÷ se4 = -234.24 ÷ 13.268 = -17.7

If you consult a table in a statistics manual, you will find that t-critical, single tail, with 6 degrees of freedom and Alpha = 0.05 is 1.94. Because the absolute value of t, 17.7, is greater than 1.94, age is an important variable when estimating the assessed value of an office building. Each of the other independent variables can be tested for statistical significance in a similar manner. The following are the t-observed values for each of the independent variables.

Variable	t-observed value
Floor space	5.1
Number of offices	31.3
Number of entrances	4.8
Age	17.7

These values all have an absolute value greater than 1.94; therefore, all the variables used in the regression equation are useful in predicting the assessed value of office buildings in this area.

LAUCKS TESTING LABORATORIES INC.

Seattle, Washington

SOP #:LTL-8330

Determination of Nitroaromatics and Nitramines by SW-846 Method 8330A & 8332

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INTRODUCTION AND SCOPE

1.1 Method Description

1.1.1 This method is used for the trace analysis of ordnance compounds in water, soil, and sediment samples by high performance liquid chromatography. The concentrated water sample extracts are diluted 1:1 (v/v) with reagent grade water prior to analysis. The sample extracts are analyzed at either 254 nm or 210 nm using a UV detector. All positive measurements observed on the primary column are confirmed by a second analysis. Please refer to Appendix V for the specific columns used in the analyses.

1.1.2 This method is used to determine part per billion levels of the ordnance analytes listed below:

Compound	Acronym
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	HMX
Hexahydro-1,3,5-trinitro-1,3,5-triazine	RDX
1,3,5-Trinitrobenzene	1,3,5-TNB
1,3-Dinitrobenzene	1,3-DNB
Methyl-2,4,6-trinitrophenylnitramine	Tetryl
Nitrobenzene	NB
2,4,6-Trinitrotoluene	2,4,6-TNT
4-Amino-2,6-dinitrotoluene	4-Am-DNT
2-Amino-4,6-dinitrotoluene	2-Am-DNT
2,4-Dinitrotoluene	2,4-DNT
2,6-Dinitrotoluene	2,6-DNT
2-Nitrotoluene	2-NT
3-Nitrotoluene	3-NT
4-Nitrotoluene	4-NT

6 Additional Compounds
(Separate Analysis at 254 nm)

Compound	Acronym
2,4-Diamino-6-nitrotoluene	2,4-DA-6-NT
2,6-Diamino-4-nitrotoluene	2,6-DA-4-NT
3,5-Dinitroaniline	3,5-DNA
1-Nitroso-3,5-dinitro-1,3,5-hexahydrotriazine	MNX
1,3,5-Trinitroso-1,3,5-hexahydrotriazine	TNX
2,2',6,6'-Tetranitro-4,4'-azoxytoluene	4,4'-TN-AZOXY

PETN/NG Compounds
(Separate Analysis at 210 nm)

Compound	Acronym
Nitroglycerin	NG
Pentaerythritoltetranitrate	PETN

1.1.3 Aqueous samples of higher concentration can be directly analyzed by diluting 1:1 (v/v) with methanol or acetonitrile, filtering, separating on a C18 reverse phase column, and determined at either 254 nm or 210 nm, and confirmed on a CN column.

1.1.4 This method is restricted to use by, or under the supervision of, analysts experienced in the use of high-pressure liquid chromatography and in the interpretation of chromatograms. Each analyst performing this method must have demonstrated the ability to perform the described chromatographic analysis and/or data interpretation.

1.2 Method Deviations & Comments

1.2.1 The following items represent deviations from the published version of method SW 8330 and SW 8332 that are followed as standard operating procedure in the performance of this method at Laucks.

1. Single injections of calibration standards are analyzed rather than triplicate injections in a random order. It has been determined at Laucks that single injections of these standards yield acceptable calibration and linearity data as evidenced by the calculated percent RSDs used to evaluate the initial calibration data.

2. Method SW 8330 and SW 8332 specifies that all analyses are to be performed using a mobile phase that consists of a 50:50 mixture of methanol/water under isocratic conditions.

3. According to Method 8330 and 8332, all working standards are to be prepared daily in a methanol/calcium chloride solution. The practice at Laucks for 8330/8332 and the 6 additional compounds is to prepare working standards using acetonitrile and diluting 50/50 with water just prior to analysis. NG/PETN are prepared in a 50/50 mixture of acetonitrile and water. These working solutions have been demonstrated to be stable for at least 6 months. The stability of target analyte responses in the working solutions in use (especially that of tetryl) is used to determine whether new solutions should be prepared.

4. Tetryl decomposes rapidly in methanol/water solutions, as well as with heat. Laucks has experienced erratic recovery of tetryl from spiked sample extracts.

5. Although the compounds NG and PETN are not listed in SW 846 Method 8330, Laucks has found that adequate recovery of these compounds can be achieved using this method by modifying the wavelength from 254 nm to 210 nm.

1.2.2 In order to attain lab-wide consistency among staff members for decision-making processes with regard to laboratory anomalies, several common items have been addressed in this SOP. Any occurrences that are not covered in this SOP should be discussed with the supervisor, prior to implementing a solution.

1.2.3 One example is the determination of potential carry-over in sample analyses. Any samples analyzed after a high level sample (which is defined by yielding one or more target analytes above the calibration range) should be thoroughly examined for potential carry-over of the same target analyte(s). Corrective action in the form of reanalysis for possible carry-over should be performed and documented in the narrative, if required.

1.2.4 Another example is the review of all sample chromatograms for analytes that may not show up on the sample quantitation report due to data system error or retention time shift. All peaks should be examined and evaluated based on the retention times and sample concentration in order to prevent reporting false negatives.

1.3 Interferences

1.3.1 When there is a significant discrepancy between analytical columns, the analyst needs to take special care to review data for possible matrix interference on one or both columns. While the majority of results are reported from the primary column (C18), there may be times when reporting results from the confirmation may be more appropriate. This anomaly should also be noted in the case narrative.

1.4 Sample Collection, Sample Storage, Holding Times

1.4.1 Samples are collected in amber glass containers with Teflon-lined caps. All samples and sample extracts are stored at 4°C ±2°C. According to guidelines listed in SW-846 for the extraction of semivolatile compounds, water samples must be extracted within 7 days of collection, and soil samples must be extracted within 14 days of collection.. All extracts must be analyzed within 40 days of sample preparation.

1.4.2 Although not a routine sampling practice, a soil holding time study performed by the U.S. Army Cold Regions Research and Engineering Laboratory recommends a maximum holding time of eight weeks when samples are frozen.

1.4.3 A similar study performed for water samples recommends a maximum holding time of 50 days for relatively sterile samples that are refrigerated. Surface waters, or samples likely to have significant microbial activity, may suffer significant losses of nitroaromatic compounds (particularly trinitrobenzene and trinitrotoluene) within 1-2 days, even under refrigeration. If microbial activity is suspected, water samples should be extracted as soon after collection as is practical.

1.5 Definition of Terms

1.5.1 This section defines terms and acronyms as they are used in this SOP. Other terms, such as MS/MSD or method blank, are not defined here since it is assumed that the user of this SOP already understands their more general meaning.

Method Blank Spike	A background free matrix (DIW for water, clean sand for soils/sediments) to which known amounts of target analytes and surrogates are added each time sample extracts are prepared. In the context of this SOP, a blank spike is the same as a QC check standard. See also QC check standard.
CCV	Continuing calibration verification. This is the same acronym used in the CLP program. This is a standard injected at some prescribed frequency during the analysis sequence to determine whether the instrument has remained in calibration.
CF	Calibration factor. The ratio of peak response to nanograms injected. This term is defined in the same way in both the CLP contract and SW-846.
DIW	Deionized water. Lab reagent water. Organic-free water
IBLK	An instrument blank is solvent containing the method surrogates. It may be used to monitor the instrument conditions.
ICCV	Initial continuing calibration verification. A standard that is injected at the start of each QC period that is compared to the initial multi-point calibration to determine whether the instrument is still in calibration.

ICV	Initial calibration verification standard. This standard is analyzed after the initial calibration using a second source.
IDL	Instrument detection limit. The lowest concentration of a target analyte that will yield a signal:noise ratio of at least 3:1. Used as a starting point for selecting MDL study spiking levels.
MDL	Method detection limit. The lowest concentration in a sample which will yield a positive result that is greater than zero at a known level of confidence. MDLs are empirically determined at Laucks.
QC Check Standard	Quality control check standard. Referred to in this SOP as a blank spike. A QC check standard is a requirement of SW-846 method 8000 and is used to determine whether the analytical system is in control if MS/MSD recoveries are out of control. See also blank spike.
QC Period	Quality control period. An analysis sequence initiated by the injection of one or more standards, followed by sample extracts, and terminated with a standard injection. A QC period can be open-ended chronologically, but calibration verification must be documented using the procedures in this SOP.
Reporting Limit	Also known as PQL, or Practical Quantitation Limit, is determined by the low-level standard concentration.
RSD or %RSD	Relative standard deviation or percent relative standard deviation. The ratio of the standard deviation of a set of values to the mean of the set of values. A measure of the similarity of the values one to another.
RT	Retention time. The time (in minutes) at which a target analyte elutes from the LC column.
RT Window	Retention time window. The ± value that is applied to the ICV to establish the time range used to make tentative compound identifications.

Sequence . A set of sample extracts and standard solutions injected into an instrument in a chronologically continuous group. See also QC period.

2. Equipment List and Standards

2.1 Chromatographic System

Primary Column:	8330 compounds: C18 (octadecyl) reverse phase HPLC column, 25 cm x 4.6 mm, 5 µm particle size, (Restek 9164575-700 or equivalent). 8332 compounds: C18 (octadecyl) reverse phase HPLC column, 15 cm x 4.6 mm, 5 µm particle size, (Varian R0089200D5 or equivalent)
Secondary Column:	CN (cyano) reverse phase HPLC column, 25 cm x 4.6 mm, 5 µm particle size or Phenomenex Synergy 4µm Polar-RP 80A, 250 mm x 4.6 mm (Supelco 46207-05, Phenomenex 00G-4336-E0 or equivalent).
Mobile Phase:	C18 column: methanol (EM Science high purity solvent or equivalent) and water (EM Science HPLC Grade or equivalent). CN column: acetonitrile (EM Science high purity solvent or equivalent), methanol, and 0.01 % phosphoric acid.
UV Detector:	254 nm (210 nm for NG and PETN).
Hewlett Packard System:	HP 1313A Autosampler. HP G1311A Quaternary Pump. HP G1322A In-line degasser. HP G1316A Thermostat column compartment. HP 1314A Variable wavelength detector. Acquisition Software: EZChrom version 6.6. ChemStation software version A.09.03

2.1.1 Column Temperature Control:

2.1.2 Column temperature is controlled through the use of a column heater, which is maintained at a temperature of 25°C.

2.2 Standards

2.2.1 Target Analyte Stock Solution

2.2.1.1 The stock solution used contains the 14 standard compounds in the mix at a concentration of 1000 µg/mL and is generally purchased from AccuStandard Inc. (25 Science Park, New Haven CT 06511). Equivalent solutions from this or other vendors are also acceptable.

2.2.1.2 The NG and PETN stock solutions are purchased individually from AccuStandard, Inc. (25 Science Park, New Haven, CT 06511). The NG solution comes in 1 mL ampules at 4000 µg/mL in ethanol. The PETN solution comes in 1 mL ampules at 1000 µg/mL in methanol. Equivalent solutions from this or other vendors are also acceptable.

2.2.1.3 The 3,5-Dinitroaniline, 2,4-diamino-6-nitrotoluene, 2,6-diamino-4-nitrotoluene and 2,2',6,6'-tetranitro-4,4'-azoxytoluene standards stock solutions are obtained from AccuStandard, Inc. (25 Science Park, New Haven, CT 06511). The 1-nitroso-3,5-dinitro-1,3,5-hexahydrotriazine and 1,3,5-Trinitroso-1,3,5-hexahydrotriazine standards are made from standard analytical reference materials obtained from Stanford Research.

2.2.1.4 Calibration standard surrogate solutions are detailed in Appendix I.

2.2.2 Surrogate Stock Solution

2.2.2.1 The surrogate stock solution is received in a methanol solution at a concentration of 1000 µg/mL. The surrogate can also be prepared by weighing 100 mg of 3,4-dinitrotoluene into a 100 mL volumetric flask and diluting to volume with methanol to yield a concentration of 1000 µg/mL. (3,4-Dinitrotoluene replaced the surrogate 1,2-dinitrotoluene in June 2002, in order to eliminate co-elution.)

2.2.3 IBLK Working Solution

2.2.3.1 The working instrument blank solution contains only the surrogate compound.

2.2.4 Calibration Standards

Analyte Mix	Concentration	Vendor	Stock #
8330 Calibration Mix 1	1000µg/mL	Restek	31450
8330 Calibration Mix 2	1000µg/mL	Restek	31451
8330 Internal Standard Mix	1000µg/mL	Restek	31452

8330 Calibration Mix 1	8330 Calibration Mix 2
1,3,5-Trinitrobenzene	2,6-Dinitrotoluene
2,4,6-Trinitrotoluene	2-Amino-4,6-dinitrotoluene
2,4-Dinitrotoluene	2-Nitrotoluene
HMX	3-Nitrotoluene
m-Dinitrobenzene	4-Amino-2,6-dinitrotoluene
Nitrobenzene	4-Nitrotoluene
RDX	Tetryl

2.2.4.1 To prepare the 8330 stock solution, take a 200µl aliquot of each of the above listed solutions and put into a 10ml volumetric and dilute to volume with acetonitrile. Invert and transfer to an amber vial. The final concentration is 20 ppm. This solution is good for 6 months from the preparation date.

2.2.4.2 Prepare an intermediate stock solution; take 250µl of the stock solution at 20 ppm and dilute it to 1ml with 1:1 Acetonitrile and water. This solution is at a concentration of 5µg/mL. This solution is made up at the time it is needed. It is not stored.

Standard Name	Amount of Intermediate 8330 Stock Solution in µl	Amount of 1:1 Acetonitrile /Water in µl
Working 0.05	2	198
Working 0.1	4	196
Working 0.5	20	180
Working 1.0	40	160
Working 5.0	An aliquot of the intermediate solution	0

2.2.4.3 A continuing calibration standard is prepared fresh daily at the same level as the working 1.0 standard (1000ppb). This is usually made in a 2ml volumetric by taking 100 µl of 8330 stock solution at 20µg/mL into 2ml of 1:1 acetonitrile and water.

2.2.4.4 To prepare the standard for the attenuation compounds, take a 20µl aliquot of each of the solutions listed below and put into a 1 ml volumetric, dilute to volume with acetonitrile. Invert and transfer to an amber vial. This solution is good for 6 months from the preparation date.

Standard	Concentration	Vendor	Catalog #
8330 Int. Std Mix	1000 µg/mL	Restek	31452
2,4-DA-6-NT	1000 µg/mL	AccuStandard	M-8330-ADD-12-10X

Standard	Concentration	Vendor	Catalog #
2,6-DA-4-NT	1000 µg/mL	AccuStandard	M-8330-ADD-13-10X
3,5-DNA	1000 µg/mL	AccuStandard	M-8330-ADD-14-10X
MNX	1000 µg/mL	SRI	Custom order
TNX	1000 µg/mL	SRI	Custom order
4,4'-TN-AZOXY	1000 µg/mL	AccuStandard	M-8330-ADD-15-10X

2.2.5 Preparation of PETN/NG Stock Solution

2.2.5.1 To prepare the PETN/NG stock solution, take a 200µl aliquot of nitroglycerin and 100ul each of PETN and the Internal Standard mix and put into a 10ml volumetric and dilute to volume with acetonitrile. Invert and transfer to an amber vial. This solution is good for 1 year from the preparation date.

2.2.5.2 Prepare an intermediate stock solution; take 250µl of the stock solution and dilute it to 1ml with 1:1 Acetonitrile and water. This solution is at a concentration of 5µg/mL. This solution is made up at the time it is needed. It is not stored.

Standard	Concentration	Vendor	Catolog #
Nitroglycerin	1000 µg/mL	Accustandard	M-8330-ADD-1-10x
PETN	1000 µg/mL	AccuStandard	M-8330-ADD-2-10x
8330 Internal Standard Mix	1000 µg/mL	Restek	31452

	Amount of Intermediate PETN/NG Stock Solution in µl	Amount of 1:1 Acetonitrile /Water in µl
Working 0.25/0.125	10	190
Working 0.5/0.25	20	180
Working 1.0/0.5	40	160
Working 2.5/1.25	100	100
Working 5.0/2.5	An aliquot of the intermediate solution	0

2.2.5.3 A continuing calibration standard is prepared fresh daily at the same level as the Working 1.0/0.5 standard (1000ppb/500ppb). This is usually made in a 2ml volumetric - 100ul of PETN/NG stock solution at 20µg/mL into 2ml of 1:1 acetonitrile and water.

2.2.5.4 Note: Store all standard and surrogate solutions in amber glass vials with screw caps and Teflon-lined septa. Minimize headspace in these vials and store them in a refrigerator kept at 4°C ±2°C. Allow standards to come to room temperature prior to use.

2.2.5.5 Stock solutions may be used for up to one year, and working solutions are good for six months or the expiration date of the parent standard, whichever is sooner.

2.2.5.6 All standards are assigned a unique identifier to enable cross-referencing of each individual standard back to the supplier's lot number. In addition, all standards are labeled with the standard concentration, the solvent, date prepared, expiration date, analyst's initials, and the standard reference number. Refer to Laucks' SOP on the traceability, documentation and preparation of standards.

3. Safety precautions

3.1 Routine Safety Precautions

3.1.1 All standards and sample extracts should be handled as if they are hazardous substances.

3.1.2 All compounds analyzed by this method are used either in the manufacture of explosives or are the degradation products of these compounds. When making stock solutions for calibration, treat each explosive compound with caution.

3.1.3 Refer to the instrument manufacturer's manual for routine instrument precautions.

3.1.4 Routine precautions include an awareness of the moving parts on the instrument you're using. These parts are often charged with power from an electrical component or with high-pressure gas and have the potential to do harm if not used properly.

3.1.5 Electrical shock - All instruments present the possibility of electrical shock. The operator should take all precautions including ensuring that all instruments are operated with fully grounded power outlets, turning off the instrument and disconnecting the instrument from the electrical power supply before working on any electrical components, etc.

3.1.6 Almost all of the analytes under consideration are known or suspected carcinogens. Analysts should wash their hands after using any standard, solvent or sample extract. Additionally, a respirator should be worn or a fume hood utilized for extremely hazardous compounds or very dirty extracts.

3.2 Waste disposal

3.2.1 Out of date standards and sample extracts are disposed of in the designated organic waste container located in the organic preparation area.

3.2.2 HPLC liquid waste is disposed of by pouring into the designated organic waste container located in the solvent storage area.

4. Operation procedures

4.1 Analytical Conditions

4.1.1 Current C18 Column Conditions for the 14 Compounds:

Pump A Solvent:	Methanol
Pump B Solvent:	Water
Flow:	0.75 mL/minute:
Gradient:	Linear
Run Time:	35 minutes
Acquisition Time:	35 minutes
Injection Volume:	50 µL inj.

4.1.2 Synergy Column Conditions for the 14 Compounds

Pump B Solvent:	Water
Pump C Solvent:	Acetonitrile
Flow:	0.75 mL/minute
Gradient:	Linear
Run Time:	25 minutes
Acquisition Time:	25 minutes
Initial %B	50
Initial %C	50

4.1.3 Current Column Conditions for NG/PETN:

C18		CN	
Pump A Solvent:	Methanol	Pump A Solvent:	Methanol
Pump B Solvent:	0.01% H_3PO_4	Pump B Solvent	Water
Flow:	0.6 mL/minute:	Flow: 0.7 mL/min	1.2 mL/minute
Gradient:	Linear	Gradient:	Linear (1:1)
Run Time:	25 minutes	Run Time:	5 minutes
Acquisition Time:	25 minutes	Acq. Time:	5 minutes
Injection Volume:	50 µL inj.	Time:	50 µL

4.1.4 Current Column Conditions for the 6 Additional Compounds:

CN		Synergy Column	
Pump B Solvent:	Methanol	Pump B Solvent:	Water
Pump C Solvent:	Acetonitrile	Pump C Solvent:	Acetonitrile
Pump D Solvent:	0.01%H3PO4	Flow:	0.75 mL/minute
Flow:	1.0 mL/minute	Gradient:	Linear
Time: 0 minutes	15% B, 12% C, 73% D	Run Time:	25 minutes
Time: 19 minutes	15% B, 12% C, 73% D	Acquisition Time:	25 minutes
Time: 20 minutes	30% B, 30% C, 40% D	Initial %B	50
Time: 35 minutes	30% B, 30% C, 40% D	Initial %C	50
Time: 36 minutes	15% B, 12% C, 73% D		
Run Time:	45 minutes		
Acq. Time:	35 minutes		
Injection Volume:	50 µL inj.		

5. Calibration and Quality Control

5.1 Method Detection Limit Study

5.1.1 Prior to the analysis of any samples, it is necessary to establish method detection limits. This procedure is fully described in the Laucks SOP on determination of detection limits. Briefly, it involves the analysis of 7 replicate samples spiked at a concentration near the anticipated method detection limit. A Student's T-test is then applied to these measured values to calculate the MDL. MDL studies are performed on both columns. Current MDL values are found in the iLIMS MDL database and associated raw data are stored in department files. Refer to Appendix VIII for MDLs.

5.2 Method Validation

5.2.1 Prior to the analysis of any samples, it is necessary to validate the method. A method validation study is performed in a similar manner to an MDL study with the exception that a minimum of 4 replicates is required and the concentration levels are typically higher.

5.3 Retention Time Windows

5.3.1 It is necessary to establish retention time windows for the method by analyzing standards for all target analytes over at least a 72-hour period. At least 3 standards must be injected during the 72-hour period, at about equal time intervals. These standards should be interspersed with real sample extracts in order to mimic actual instrument operating conditions. Tabulate the retention times for all standard compounds and compute the sample (n-1) standard deviations of all the retention times.

5.3.2 The retention time window half-width is set at 3 times the above-calculated standard deviation. This operation must be repeated for each new column, whenever major equipment changes are made, or whenever the chromatographic method is modified.

5.3.3 In some cases, the retention time window may be modified in order to take into account any pattern shifting. This shift is acknowledged by observation of the surrogate peak behavior and the surrounding CCV standards. If retention time shift has occurred and the possibility of misidentifying peaks exists, the sample is reanalyzed.

5.3.4 See the Laucks SOP on determination of retention time windows for more specifics on their determination and use.

5.4 Initial Calibration

5.4.1 Analyze the working standard solutions (which include the surrogate) using at least 5 different concentration levels. Inject the standard solutions from the lowest concentration to the highest. The lowest concentration defines the reporting limit. The highest concentration should define the upper useable working range of the detector.

5.4.2 SW 846 allows the use of both linear and non-linear models for the calibration data. The option for non-linear calibration may be necessary to achieve low detection limits or to address specific instrumental techniques. If the %RSD from the initial calibration is less than or equal to 20% when averaged across all compounds, the calibration is considered valid according to SW 846. However, for DOD clients, the use of alternative calibration methods should be employed in order to eliminate the need for using the average. At the time of this writing, the laboratory can meet SW 846 and DOD calibration requirements using the %RSD criterion of less than or equal

to 20% without averaging across all compounds. The alternative calibration methods are discussed below.

5.4.3 The choice of a specific calibration model should be made in one of two ways. The first is to begin with the simplest approach, the linear model through the origin, and progressing through the other options until the calibration acceptance criteria are met, or until the analyte is best represented by a calibration model. The second approach is to use *a priori* knowledge of the detector response to choose the calibration model. Such knowledge may come from previous experience, knowledge of physics of the detector, or specific manufacturer's recommendations.

5.4.4 External standard initial calibration data are evaluated by determining the %RSD of the calibration factors. CFs are calculated using the equation:

$$CF = \frac{\text{response}}{\text{ng injected}}$$

%RSDs are calculated using the equation:

$$\%RSD = \frac{SD}{CF} \times 100$$

where:

SD = External calibration standard deviation
CF = Average CF

5.4.5 Corrective action

5.4.5.1 If the criteria are not met, the instrument must be re-calibrated or if appropriate, an alternative calibration model employed.

5.5 Non-linear Calibration

5.5.1 In situations where the analyst knows that the instrument response does not follow a linear model over a sufficiently wide working range, or when the other approaches described here have not met the acceptance criteria, a non-linear calibration model may be employed.

5.5.2 The statistical considerations in developing a non-linear calibration model require more data than the more traditional linear approaches. A quadratic (second order) requires a minimum of six standards, and a third order polynomial requires seven standards. Do not force the line

through the origin, i.e., do not set the intercept as 0, and do not include the origin (0,0) as a calibration point. The r^2 value must be ≥ 0.990.

5.5.3 Whichever option is employed, the surrogate concentration must fall within the calibration range.

5.5.4 Corrective action

5.5.4.1 If the criteria are not met, the instrument must be re-calibrated.

5.6 Second Source Standards (ICV)

5.6.1 A standard prepared from a source separate from the primary source must be analyzed with each initial calibration. The %D for each analyte must be within 15%.

5.6.2 Corrective action

5.6.2.1 If this criterion is not met, an investigation should be made into the discrepancies between vendors. Appropriate action should be taken such as possibly obtaining a third source standard.

5.7 Initial Continuing Calibration Verification (ICCV)

5.7.1 At the beginning of each analysis sequence, an initial continuing calibration verification standard is analyzed. This standard is comprised of either a mid-point calibration standard (STD 2) or STD 3 or STD 4. (The use of varied concentrations is required for DOD clients.)

5.7.2 Since the retention time windows, which were established by the retention time study are relative and not absolute, the windows are anchored by the ICCV. This allows the retention times from the ICCV to become the mid-point of the retention time windows.

5.7.3 Criteria

5.7.3.1 Using the average CF calculation technique, compute the CFs for each compound. The calibration factors for the ICCV standard are compared to the mean CFs for the initial multi-point calibration. The percent difference for these calibration factors is calculated as follows:

$$\%\,Difference = \frac{CF_a - CF_i}{CF_a} \times 100$$

where:
CF_a = .Average CF from the initial multi-point calibration
CF_i = Calibration Factor of the calibration verification standard.

5.7.3.2 The %D cannot exceed 15% for any target analytes or surrogates.

5.7.4 Corrective action

5.7.4.1 If the ICCV criteria are not met, no sample extracts can be analyzed. Determine the cause of the ICCV failure and correct. Reanalyze the ICCV and if it is still out of control, a new calibration curve must be analyzed.

5.8 Continuing Calibration Verification

5.8.1 Criteria

5.8.1.1 A CCV standard is analyzed every 10 injections, and after the last sample of the sequence. The CF for each compound is calculated and the percent difference is calculated as shown above.

5.8.1.2 The %D cannot exceed 15% for any target analytes or surrogates.

5.8.1.3 The retention times for all target analytes must fall within the RT windows established by the ICCV.

5.8.2 Corrective action

5.8.2.1 Determine the cause of failure and correct. All samples bracketed by an out of control CCV must be reanalyzed unless the CCV demonstrates an increase in response and no analytes are detected above the reporting limit in the associated samples.

5.9 Sample Analysis

5.9.1 Analysis sequence

See Appendix II for a detailed analysis injection sequence.

5.9.2 Sample Preparation

5.9.2.1 Prior to injection on the instrument water sample extracts are diluted 1:1 with water. Any extract that exceeds the instrument calibration range is diluted with 1:1 acetonitrile and water with a dilution factor necessary to quantitate the analytes within the calibration range. The lot number of acetonitrile used in the dilution will be noted on the bench sheet.

5.9.3 Compound Identification

5.9.3.1 Compounds are tentatively identified if a peak elutes in the retention time window characteristic of that compound on the primary column. To confirm the presence of that compound in the sample extract, the peak must also elute in its retention time window on a second column. Retention time windows are established as previously described and are updated each QC period. Due to constraints of the software, the RT of co-eluting compounds is determined by assigning the RT to the highest point within a given window. In order to avoid potential problems with RT windows, and in order to accurately identify these co-eluting target analytes, the retention time windows may be administratively set for the co-eluting compounds.

5.9.3.2 The experienced analyst's judgment weighs heavily in evaluating chromatograms for compound identification. For instance, the retention times of surrogate compounds may be outside their expected windows due to sample matrix effects. The analyst may decide to re-adjust target analytes' retention time windows on an ad hoc basis based on such an observed shift. This can occur only on a sample-specific basis and is used when the analyst examining the data suspects that a retention time shift has occurred. If this is done, it must be fully documented in the case narrative. If the concentration of any target analyte exceeds the calibration range, the sample extract must be diluted and reanalyzed.

5.9.4 Compound Quantification

5.9.4.1 Target compound concentrations are calculated using the following equations:

5.9.4.2 Aqueous samples

The external standard equation, as expressed in SW-846 is

$$Concentration(\mu g / L) = \frac{A_x \times A \times V_t \times D}{A_s \times V_i \times V_s}$$

where:

A_x = Response for the analyte in the extract, in area or height units.
A = Amount of standard injected (in nanograms).
A_s = Response for the external standard, same units as A_x.
V_i = Volume of extract injected, µL.
D = Dilution factor of extract. The final result of an algebraic multiplication of the ratio of all dilution final volumes to initial volumes. For example, if an extract is diluted 10 µL to 1000 µL and subsequently diluted an additional 10 µL to 1000 µL, the expression is: (1000/10) * (1000/10) = 100 * 100 = 10,000. If no dilution was made, D = 1.
V_t = Final volume of total extract, µL.
V_s = Initial sample size, mL.

5.9.4.3 In routine use at Laucks, the equation reduces as follows.

5.9.4.4 First, CF is used directly in the equation. Since $Cf = A_s/A$, this substitution is made. Next, since Laucks routinely measures all final extract volumes in mL, a conversion factor for µL to mL must be made in the numerator of the expression - i.e., $V_t = 1000 * mL$. Finally, the sample preparation process is represented as the algebraic ratio of initial sample size to final extract volume.

5.9.4.5 The equation then becomes

$$Concentration(\mu g / L) = \frac{1000 \times Ax \times D}{CF \times Vi \times (Vs / Vt)}$$

5.9.4.6 This expression is completely equivalent to the SW-846 equation, yielding the same result. To report concentrations in alternate units, apply an appropriate factor:

mg/L = µg/L * 0.001

5.9.4.7 Non-aqueous samples

5.9.4.8 The calculation for non-aqueous samples is very similar to that for aqueous samples. The only difference is the inclusion of a total solids term to calculate the dry weight equivalent of the initial sample size. (Under normal conditions 8330 soil samples are air-dried prior to extraction and this term is 1.)

$$Concentration(\mu g / kg) = \frac{1000 \times A_x \times D}{CF \times V_i \times (W / V_t) \times T_s}$$

where:

W_s = Sample size extracted in grams.
T_s = Total Solids in decimal format (i.e. 0.76 not 76).

6. Reports

6.1 Data Packet Organization

See Appendix III for a checklist detailing data packet organization.

6.2 Quality Control Reports

6.2.1 All results for quality control tests are entered into the lab database. Printouts of all data entered must be included in the data packet. The routine minimum is a method blank report, a method blank spike report, and an MS/MSD report.

6.2.2 Data Qualifying Flags

6.2.3 Sample report results are qualified with data qualifying flags. These flags have the following definitions:

U:	The analyte of interest was not detected, to the limit of detection indicated.
B:	The analyte of interest was detected in the method blank associated with the sample, as well as in the sample itself. The B flag is applied without regard to the relative concentrations detected in the blank and sample.
J:	The analyte of interest was detected below the practical quantitation limit. This value should be regarded as an estimate.
D:	The value reported is derived from the analysis of a diluted sample or sample extract.
P:	When a dual column technique is employed, this flag indicates that calculated results from the two columns differ by more than 25 percent.
E:	The value reported is based on a sample or sample extract in which the target analyte concentration exceeded the calibration range. The value reported should be considered an estimate.
X:	The sample has been analyzed at several dilutions. The value reported has been determined to be the most appropriate quantitative value.
Z:	The value reported is from the C18 column and there is coelution with another target analyte on the CN or CN/C8 columns in series.

7. Quality Control

7.1 Method Blank

7.1.1 Criteria

7.1.1.1 Method blanks are used to verify contamination free reagents and apparatus. They are prepared with every set of samples extracted at the same time or at least one blank for every 20 samples, whichever is more frequent. Analytes of interest should not be detected at levels greater than half the current reporting limit or less than 5% the regulatory limit, or less than 5% of the sample result for the same analyte. If any analytes are detected above half the reporting limit, corrective action must be taken.

7.1.2 Corrective action

7.1.2.1 Steps shall be taken to find/reduce/eliminate the source of the contamination. Sample corrective action may be limited to qualification for blank contamination. When the concentrations of any target analytes in the method blank are above 1/2 the reporting limit for the majority of target analytes or above the reporting limit for target analytes known to be common laboratory contaminants, the effect this may have had on the samples will be assessed. If any analyte is found only in the method blank, but not in any samples associated with the method blank, no further corrective action may be necessary. The case narrative should discuss the situation. If an analyte is found in the method blank and some, or all, of the other batch samples, additional corrective action is required to reanalyze the method blank and any samples containing the same contaminant. If the contamination remains, the contaminated samples of the batch would be re-extracted and reanalyzed with a new method blank and batch specific QC samples. Sporadic cases of contamination may be difficult to control; however, daily contamination would not be acceptable.

7.2 Blank Spike or QC Check Sample (LCS)

7.2.1 Criteria

7.2.1.1 A blank spike follows the same protocol as the matrix spike analysis except that the spiking solution is added to a method blank solution instead of an actual sample. Refer to Appendix VIII for control limits. Because control limits are updated often as required by the method, all current control limits are located in the LIMS database.

7.2.2 Corrective action

7.2.2.1 The blank spike is used to determine whether a method is in control during sample preparation and analysis. Sample re-extraction and reanalysis would be triggered by any analytes

falling outside of control limits in the blank spike sample unless all sample surrogate recoveries and MS/MSD spike recoveries are in control.

7.3 Matrix Spike

7.3.1 Criteria

7.3.1.1 A sample is chosen at random (unless designated by project-specific requirements) from the samples to be analyzed, and an aliquot of spiking solution is added to this sample prior to extraction. It is required that a matrix spike analysis be performed with each extraction batch. However, the minimum frequency for MS analysis is 1 each per 20 samples per matrix. This frequency may be changed on a project specific basis. This matrix spike sample is used to evaluate the matrix effect of the samples upon recovery of the analytes. This spiking solution is supplied from a source other than the calibration standards. The use of a second source for the spiking standards is employed in order to verify the calibration standards. Refer to Appendix VIII for control limits. Because control limits are updated often as required by the method, all current control limits are located in the LIMS database.The recovery of spike analytes is calculated as follows:

$$\%Recovery = \frac{SSR - SR}{SA} \times 100$$

where:
SSR = Concentration in spiked sample.
SR = Native concentration in unspiked sample.
SA = Concentration of spike added.

7.3.2 Corrective action

7.3.2.1 MS samples with spike recoveries outside control limits will be reviewed for possible corrective action. Corrective action may involve recalculation, re-extraction and/or reanalysis. This process should also look at the recovery of surrogate compounds in the MS sample and at the recovery of matrix spiking compounds from the extraction batch blank spike analysis. In all cases, a narrative explanation of the condition is required to detail the corrective actions taken.

7.4 Matrix Spike Duplicate

7.4.1 Criteria

7.4.1.1 The compound recovery criteria are identical to those for the matrix spike sample. In addition, the matrix spike duplicate is used to measure method precision. This is done by computing the relative percent difference (RPD) between the matrix spike and matrix spike

duplicate recovery values. Refer to Appendix VIII for control limits. Because control limits are updated often as required by the method, all current control limits are located in the LIMS database.

7.4.1.2 This calculation is as follows:

$$RPD = \frac{S1 - S2}{(S1 + S2)/2} \times 100$$

where:
S1 = Measured concentration for MS sample.
S2 = Measured concentration for MSD sample.

7.4.2 Corrective action

7.4.2.1 If a trend in out of control RPD values is observed, the methods used must be examined to determine the source of variance. Once this source is identified, the method must be changed so that samples can be analyzed with predictable reproducibility.

7.5 Surrogate Recovery

7.5.1 Criteria

7.5.1.1 Surrogates are chemically similar compounds added to every sample, method blank, and QC sample prior to sample extraction. They are used to monitor potential sample processing errors and matrix effects. Surrogate compound recoveries are calculated as follows:

$$\%Recovery = \frac{S_m}{S_a} \times 100$$

where:
S_m = Concentration of surrogate measured in sample.
S_a = Concentration of surrogate added.

7.5.1.2 Refer to Appendix VIII for control limits. Because control limits are updated often as required by the method, all current control limits are located in the LIMS database.

7.5.2 Corrective Action

7.5.2.1 Reanalyze the sample. Low surrogate recoveries are better indicators of poor method performance than high surrogate recoveries since non-GC/MS methods cannot separate co-eluting interferences. In instances where high surrogate recoveries are attributable to matrix effects, no

corrective action is taken. However, if elevated surrogate recoveries are attributable to preparation error, re-extraction and reanalysis is performed.

7.5.2.2 Check calculations for possible error. Re-extract the sample if surrogate recovery is less than the lower control limit. If a poor injection is suspected, reanalyze the sample.

7.5.2.3 Low surrogate recoveries in the method blank may require that all the samples in the associated batch be re-extracted and reanalyzed. In any case, it is imperative to identify the problem associated with low recovery so that it can be corrected. It is a requirement that all out of control surrogate recoveries and the corrective action taken be discussed in the narrative.

8. References

Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 3rd Edition, Method 8000B, "Gas Chromatography," Revision 1, July 1992, U.S.E.P.A.

Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 4th Update, Method 8330A, "Nitroaromatics and Nitramines by High Performance Liquid Chromatography (HPLC)," Revision 1, January 1998, U.S.E.P.A.

40 CFR Part 136, "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act; Final Rule and Interim Final Rule and Proposed Rule," October 26, 1984, U.S.E.P.A.

Special Report 93-11, "Experimental Assessment of Analytical Holding Times for Nitroaromatic and Nitroamine Explosives in Soil," Clarence L. Grant et al, June 1993, U.S. Army Cold Regions Research and Engineering Laboratory.

Special Report 93-24, "Evaluation of Pre-extraction Analytical Holding Times for Nitroaromatic and Nitroamine Explosives in Water," Clarence L. Grant et al, August 1993, U.S. Army Cold Regions Research and Engineering Laboratory.

APPENDIX I

Calibration Standard Solution Concentrations, µg/mL

Compound	STD1	STD2	STD3	STD4	STD5
HMX	0.05	0.1	0.5	1.0	5.0
RDX	0.05	0.1	0.5	1.0	5.0
1,3,5-TNB	0.05	0.1	0.5	1.0	5.0
1,3-DNB	0.05	0.1	0.5	1.0	5.0
Tetryl	0.05	0.1	0.5	1.0	5.0
NB	0.05	0.1	0.5	1.0	5.0
2,4,6-TNT	0.05	0.1	0.5	1.0	5.0
4-Am-DNT	0.05	0.1	0.5	1.0	5.0
2-Am-DNT	0.05	0.1	0.5	1.0	5.0
2,4-DNT	0.05	0.1	0.5	1.0	5.0
2,6-DNT	0.05	0.1	0.5	1.0	5.0
2-NT	0.05	0.1	0.5	1.0	5.0
3-NT	0.05	0.1	0.5	1.0	5.0
4-NT	0.05	0.1	0.5	1.0	5.0
Surrogate					
3,4-Dinitrotoluene	0.05	0.1	0.5	1.0	5.0

Calibration Standard Solution Concentrations, µg/mL

Compound	STD1	STD2	STD3	STD4	STD5
TNX	0.05	0.1	0.5	1.0	5.0
2,6-DA-4-NT	0.05	0.1	0.5	1.0	5.0
2,4-DA-4-NT	0.05	0.1	0.5	1.0	5.0
MNX	0.05	0.1	0.5	1.0	5.0
3,5-DNA	0.05	0.1	0.5	1.0	5.0
4,4'-TN-AZOXY	0.05	0.1	0.5	1.0	5.0
Surrogate					
3,4-Dinitrotoluene	0.05	0.1	0.5	1.0	5.0

Calibration Standard Solution Concentrations, µg/mL

Compound	STD1	STD2	STD3	STD4	STD5
NG	0.25	0.5	1.0	2.5	5.0
PETN	0.125	0.25	0.5	1.25	2.5
Surrogate					
3,4-Dinitrotoluene	0.25	0.5	2.5	5.0	10.0

Surrogate Stock Solution

Compound	Concentration
3,4-Dinitrotoluene	1000 µg/mL

APPENDIX II

Analysis Sequence

Injection	Sample
1	Standard #1
2	Standard #2
3	Standard #3
4	Standard #4
5	Standard #5
6	ICCV
	injections (total of 10 injections between CCVs
17	CCV Standard
	injections (total of 10 injections between CCVs)
28	CCV Standard
	injections (total of 10 injections between CCVs)
last	CCV Standard

APPENDIX III

Data Packet Order List

I. QC SUMMARY

Surrogate Recovery Summary Report
Blank Spike Report
MS/MSD Report
Method Blank Summary

II. SAMPLE DATA:

Organic Analysis Data Sheet
Sample Confirmation Worksheet
Chromatogram, primary column
Quantitation Report, primary column
Chromatogram, secondary column
Quantitation Report, secondary column

III. STANDARD DATA:

Linearity Report
ICAL Data
ICAL Response, ICAL std concentrations
ICCV reports
CCV reports
Other Standards Used to Support Sample Data and Instrument Blanks

V. Raw QC Data:

Method Blank
Chromatograms
Quantitation Report

Blank Spike
Chromatograms,
Quantitation Report

Matrix Spike
Chromatograms

Quantitation Report

Matrix Spike Duplicate
Chromatograms
Quantitation Report

V. Bench Sheets

SDG Report
Extraction Bench Sheets
Injection Sequence (logbook copy)
Miscellaneous Work Sheets. (HTVRs)
Standards Logs

VI. Reject Data:

Data not used to support reported sample results.
Non-routine standards used to support sample data should be placed at the last of the Standard Data section.

APPENDIX IV

Method 8330 Requirements and Corrective Actions					
QA Element	**Method Criterion**	**Laucks Criterion**	**Frequency**	**Corrective Action**	**Documentation**
Initial Calibration	Minimum of 5 levels. %RSD ≤ 20%	Minimum of 5 levels. Must demonstrate an RSD (or average RSD) of ≤20%.	As necessary due to major instrument maintenance or difficulties meeting the CCV requirements.	Reanalyze out of control standard. If still out, determine cause of curve failure and correct. Re-analyze curve and any samples analyzed with curve.	Target forms and raw data.
Second Source Standard		+/- 15% of the initial calibration response factor (or average).	After each initial calibration	Investigate third source if 2 existing sources do not match.	Stored with data.
Initial Continuing Calibration Verification	+/- 15% of the initial calibration response factor.	+/- 15% of the initial calibration response factor (or average).	Every 24 hr. or at the beginning of an analytical sequence, which ever is more frequent, or as necessary.	Determine cause of ICCV failure and correct. Reanalyze ICCV and if out of control a new calibration curve must be analyzed.	Target form and raw data.
Continuing Calibration Verification	+/- 15% of the initial calibration response factor. Analyze singly every 10 injections and after the final sample.	+/- 15% of the initial calibration response factor (or average).	Every 10 injections and at the end of an analytical sequence.	Determine cause of failure and correct. Reanalyze calibration curve. All samples bracketed by an out of control CCV must be reanalyzed unless the CCV demonstrates an increase in response and no analytes are detected above the reporting limit.	Target form and raw data.
Method Blank	All analytes must be ≤ MDL	All analytes must be less than half the Reporting Limit, or ≤5% regulatory limit, or ≤5% of the sample result, whichever is greater.	One method blank per 20 samples or each extraction batch, whichever is more frequent.	Reanalyze blank. If still out of control, re-extract the entire batch of samples unless the detected analyte(s) are not present in the associated samples.	Method Blank Summary and raw data. Narrative comment when necessary.
Surrogate Recovery	Minimum of 1 surrogate. Recoveries must fall within the labs established windows.	See latest version of Laucks Testing Labs control limits database. All surrogate recoveries must fall within the generated limits.	All samples, method blanks, and QC samples.	Re-extract if surrogate recovery is ≤ the lower control limit. If a poor injection is suspected, reanalyze the sample.	Target Surrogate Summary form or special test results. Narrative comment, when necessary.

Method 8330 Requirements and Corrective Actions					
QA Element	**Method Criterion**	**Laucks Criterion**	**Frequency**	**Corrective Action**	**Documentation**
MS/MSD	One per 20 samples or extraction batch which ever is more frequent. Must be per matrix.	See latest version of Laucks control limits located in the QC database.	1 MS/MSD pair per 20 samples or every extraction batch which ever is more frequent.	Per SW 846, if analyte recoveries are out of control in the MS/MSD but are in control in the associated blank spike, no further action is required.	MS/MSD report and raw data. Narrative comment when necessary.
Blank Spike	N/A	See latest version of Laucks Testing Labs control limits in the QC database. All recoveries must fall within the generated limits.	1 per 20 samples or every extraction batch which ever is more frequent.	Re-extract if analyte recoveries are outside of control limits.	Blank Spike report and raw data. Narrative comment when necessary.

APPENDIX V

Elution Order of Target Analytes

Compound	Order of Elution on Primary (C18) Column	Order of Elution on Confirmation (EtPh) Column
HMX	1	1
RDX	2	2
1,3,5-TNB	3	12
1,3-DNB	4	8
Tetryl	5	13
NB	6	3
2,4,6-TNT	8	14
4-Am-DNT	9	4
2-Am-DNT	10	7
2,4-DNT	12	11
2,6-DNT	11	10
2-NT	13	5
3-NT	15	7
4-NT	14	6
Surrogate		
3,4-Dinitrotoluene	7	9

Compound	Order of Elution on Primary (CN) Column	Order of Elution on Confirmation (EtPh) Column
TNX	1	2
2,6-DA-4-NT	2	1
2,4-DA-6-NT	5	1
MNX	3	3
3,5-DNA	4	4
4,4'-TN-AZOXY	7	5
Surrogate		
3,4-Dinitrotoluene	6	6

Compound	Order of Elution on Primary (C18) Column	Order of Elution on Confirmation (CN) Column
NG	1	2
PETN	3	3
Surrogate		
3,4-Dinitrotoluene	2	1

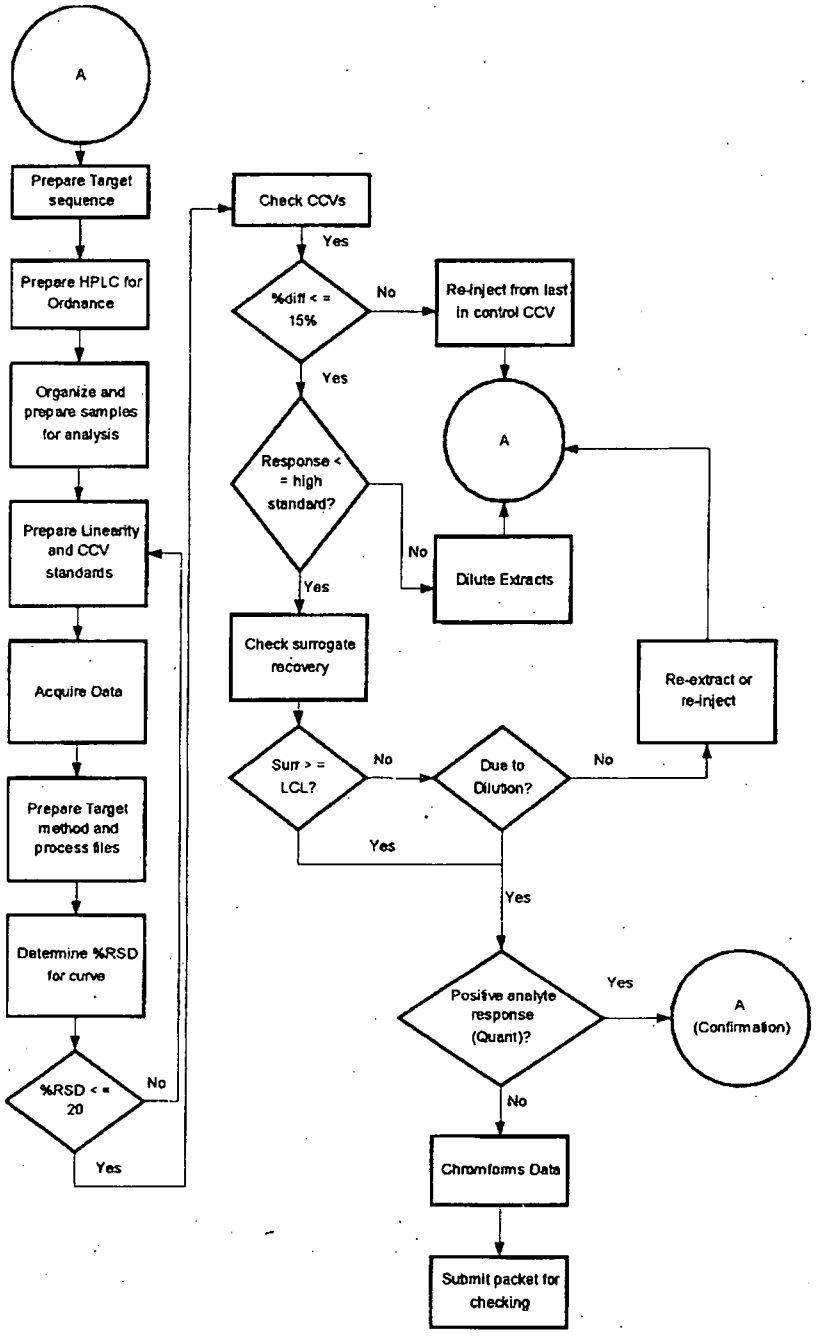
APPENDIX VI

PQLs

Compound	PQL Salting out (µg/L)	PQL SPE Prep (µg/L)	PQL (mg/Kg)
HMX	0.65	0.5	0.5
RDX	0.65	0.5	0.5
1,3,5-TNB	0.65	0.5	0.5
1,3-DNB	0.65	0.5	0.5
Tetryl	0.65	0.5	0.5
NB	0.65	0.5	0.5
2,4,6-TNT	0.65	0.5	0.5
4-Am-DNT	0.65	0.5	0.5
2-Am-DNT	0.65	0.5	0.5
2,4-DNT	0.65	0.5	0.5
2,6-DNT	0.65	0.5	0.5
2-NT	0.65	0.5	0.5
3-NT	0.65	0.5	0.5
4-NT	0.65	0.5	0.5
2,4-Diamino-6-nitrotoluene	0.65	0.5	0.5
2,6-Diamino-4-nitrotoluene	0.65	0.5	0.5
3,5-Dinitroaniline	0.65	0.5	0.5
4,4'-TN-Azoxy	0.65	0.5	0.5
MNX	0.65	0.5	0.5
TNX	0.65	0.5	0.5

APPENDIX VII

Method 8330 Flow Chart



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APPENDIX VIII

Control Limits*

8330 Water SPE Prep

Target Analyte	PQL	MDL	Blank	MS/MSD			BS/BSD		
				LCL	UCL	RPD	LCL	UCL	RPD
HMX	0.5	0.12	0.25	20	160	50	45	143	50
DNX	0.5	0.24	0.25	20	160	50	20	160	50
RDX	0.5	0.11	0.25	20	160	50	59	143	50
1,3,5-Trinitrobenzene	0.5	0.069	0.25	20	160	50	54	133	50
m-Dinitrobenzene	0.5	0.053	0.25	20	160	50	54	133	50
Nitrobenzene	0.5	0.061	0.25	20	160	50	51	131	50
Tetryl	0.5	0.079	0.25	20	160	50	48	126	50
2,4,6-Trinitrotoluene	0.5	0.091	0.25	20	160	50	49	136	50
4-Amino-2,6-dinitrotoluene	0.5	0.064	0.25	20	160	50	56	132	50
2-Amino-4,6-dinitrotoluene	0.5	0.11	0.25	20	160	50	56	131	50
2,6-Dinitrotoluene	0.5	0.059	0.25	20	160	50	46	128	50
2,4-Dinitrotoluene	0.5	0.022	0.25	20	160	50	45	124	50
2-Nitrotoluene	0.5	0.071	0.25	20	160	50	37	121	50
4-Nitrotoluene	0.5	0.061	0.25	20	160	50	36	123	50
3-Nitrotoluene	0.5	0.11	0.25	20	160	50	35	119	50
2,4-Diamino-6-nitrotoluene	0.5	0.202	0.25	20	160	50	20	160	50
2,6-Diamino-4-nitrotoluene	0.5	0.195	0.25	20	160	50	20	160	50
3,5-Dinitroaniline	0.5	0.190	0.25	20	160	50	20	160	50
4,4'-TN-Azoxy	0.5	0.558	0.25	20	160	50	20	160	50
MNX	0.5	0.106	0.25	20	160	50	20	160	50
TNX	0.5	0.168	0.25	20	160	50	20	160	50

Surrogate	Typical Limits			
	LCL	UCL		
3,4-Dinitrotoluene	20	160		

8330 Soil, Air dried

Target Analyte	PQL	MDL	Blank	MS/MSD			BS/BSD		
				LCL	UCL	RPD	LCL	UCL	RPD
HMX	0.5	0.16	0.25	20	160	50	74	139	
1,3-Dinitrobenzene	0.5	0.24	0.25	51	155	50	76	138	
RDX	0.5	0.12	0.25	28	163	25	72	139	
1,3,5-Trinitrobenzene	0.5	0.041	0.25	39	167	50	75	133	
Nitrobenzene	0.5	0.039	0.25	33	177	50	69	147	
Tetryl	0.5	0.081	0.25	43	154	20	23	149	
2,4,6-Trinitrotoluene	0.5	0.061	0.25	48	160	20	78	134	
4-Amino-2,6-dinitrotoluene	0.5	0.048	0.25	51	152	20	81	135	
2-Amino-4,6-dinitrotoluene	0.5	0.015	0.25	50	157	20	75	135	
2,6-Dinitrotoluene	0.5	0.083	0.25	35	168	25	75	134	
2,4-Dinitrotoluene	0.5	0.04	0.25	49	152	20	73	132	
2-Nitrotoluene	0.5	0.048	0.25	35	170	24	69	136	
4-Nitrotoluene	0.5	0.052	0.25	50	152	20	74	135	
3-Nitrotoluene	0.5	0.042	0.25	31	164	50	70	135	
2,4-Diamino-6-nitrotoluene	0.5	0.0679	0.25	20	160	50	20	160	
2,6-Diamino-4-nitrotoluene	0.5	.0.679	0.25	20	160	50	20	160	
3,5-Dinitroaniline	0.5	.0.257	0.25	20	160	50	20	160	
4,4'-TN-Azoxy	0.5	0.0498	0.25	20	160	50	20	160	
MNX	0.5	.0.291	0.25	20	160	50	20	160	
DNX	0.5	0.0296	0.25	20	160	50	20	160	
TNX	0.5	0.0291	0.25	20	160	50	20	160	

Surrogate	Typical Limits			
	LCL	UCL		
3,4-Dinitrotoluene	20	160		

8330 Water salting-out prep

Target Analyte	PQL	MDL	Blank	MS/MSD			BS/BSD		
				LCL	UCL	RPD	LCL	UCL	RPD
HMX	0.65	0.076	0.325	59	124	28	63	120	
RDX	0.65	0.12	0.325	56	132	39	57	120	
1,3,5-Trinitrobenzene	0.65	0.075	0.325	61	132	20	66	115	
m-Dinitrobenzene	0.65	0.033	0.325	68	114	20	65	115	
Nitrobenzene	0.65	0.037	0.325	69	120	25	58	121	
Tetryl	0.65	0.058	0.325	35	149	25	55	119	
2,4,6-Trinitrotoluene	0.65	0.093	0.325	57	138	32	72	119	
4-Amino-2,6-dinitrotoluene	0.65	0.13	0.325	63	125	20	67	113	
2-Amino-4,6-dinitrotoluene	0.65	0.066	0.325	68	117	20	68	117	
2,6-Dinitrotoluene	0.65	0.068	0.325	60	137	20	70	116	
2,4-Dinitrotoluene	0.65	0.067	0.325	67	116	20	68	114	
2-Nitrotoluene	0.65	0.077	0.325	66	126	20	59	120	
4-Nitrotoluene	0.65	0.088	0.325	64	124	20	64	119	
3-Nitrotoluene	0.65	0.081	0.325	63	125	20	60	119	
MNX	0.65	0.055	0.325	20	160	50	20	160	
TNX	0.65	0.17	0.325	20	160	50	20	160	
2,4-Diamino-6-nitrotoluene	0.65	0.2	0.25	20	160	50	20	160	
2,6-Diamino-4-nitrotoluene	0.65	0.2	0.25	20	160	50	20	160	
3,5-Dinitroaniline	0.65	0.19	0.25	20	160	50	20	160	
4,4'-TN-Azoxy	0.65	0.56	0.25	20	160	50	20	160	
DNX	0.65	0.084	0.25	20	160	50	20	160	

Surrogate	Typical Limits			
	LCL	UCL		
3,4-Dinitrotoluene	20	160		

*At the time of this writing.

APPENDIX IX

Agency Requirements

Agency Requirements for Method 8330					
	DoD	AFCEE	USACE		SW 846
QC Check	Acceptance Criteria	Acceptance Criteria	Acceptance Criteria	Sporadic Marginal Failure	Acceptance Criteria
MDL Study	See 40 CFR 136B. S/N > 3 for MDL verification. Every 12 months, or quarterly for MDL verification checks.	Detection limits ≤ 1/2 RL listed in appropriate AFCEE table. Every 12 months.			
Retention Time Window Width	± 3s over a 72 hour period for each analyte	± 3s over a 72 hour period for each analyte			± 3s over a 72 hour period for each analyte or 0.03 minutes, whichever is greater.
Minimum Five Point Initial Calibration	Option 1: Averaged - RSD ≤ 20%	Option 1: Averaged - Grand mean RSD ≤ 20% and no RSD > 30%	Option 1: Averaged - RSD ≤ 20%		Option 1: Averaged - RSD ≤ 20%
	Option 2: Averaged - Grand mean RSD ≤ 20% and no RSD > 30%	Option 2: Averaged - Grand mean RSD of average CF of all analytes ≤ 20% and average CF of each analyte < 30%	Option 2: Averaged - Grand mean RSD ≤ 20% and no RSD > 40%		Option 2: Linear - r ≥ 0.99

Agency Requirements for Method 8330

QC Check	DoD Acceptance Criteria	AFCEE Acceptance Criteria	USACE Acceptance Criteria	USACE Sporadic Marginal Failure	SW 846 Acceptance Criteria
	Option 3: Linear - $r \geq 0.995$	Option 3: Linear - $r \geq 0.995$	Option 3: Linear - $r \geq 0.995$		Option 3: Non-linear - $r^2 \geq 0.99$, minimum of 6 pts for 2nd order, 7pts for 3rd order
	Option 4: Non-linear - $r^2 \geq 0.990$, minimum of 6 pts for 2nd order, 7pts for 3rd order	Option 4: Non-linear - $r^2 \geq 0.990$, minimum of 6 pts for 2nd order, 7pts for 3rd order	Option 4: Non-linear - $r^2 \geq 0.990$, minimum of 6 pts for 2nd order, 7pts for 3rd order		AND $\%D \leq 20\%$ at each calibration level recommended
Second Source	$\%D \leq 20\%$	$\%D \leq 15\%$	$\%D \leq 15\%$		
Retention Time	Set at retention time of midpoint standard of ICAL				Set at retention time of first CCV of the analytical sequence, or of the midpoint standard if samples were ran after the ICAL
Continuing Calibration Verification	Option 1: $\%D \leq 15\%$	$\%D \leq 15\%$	Option 1: $\%D \leq 15\%$		$\%D \leq 15\%$
	Option 2: Grand mean $\%D \leq 15\%$ and no $\%D > 20\%$	Every 10 samples, beginning and end of analytical sequence	Option 2: Grand mean $\%D \leq 15\%$ and no $\%D > 30\%$		Beginning and end of each day

Agency Requirements for Method 8330

QC Check	DoD Acceptance Criteria	AFCEE Acceptance Criteria	USACE Acceptance Criteria	USACE Sporadic Marginal Failure	SW 846 Acceptance Criteria
	Every 10 field samples, beginning and end of analytical run				Every 10 samples
Method Blank	No analytes ≥ 1/2 RL. No common laboratory contaminant analytes ≥ RL	No analytes ≥ RL	No analytes ≥ 1/2 RL		Less than the laboratory detection limit OR
					Less than 5% of the regulatory limit OR
					Less than 5% of the sample result WHICHEVER IS GREATER
Laboratory Control Sample	See appropriate DoD table, or use in-house limits if not listed	See appropriate AFCEE table	60%-120% recovery	40%-150% recovery	Lab-derived. If no lab-derived limits are in place yet, use 70%-130% by default
Matrix Spike	Same as LCS	Same as LCS	50%-140% recovery	40%-150% recovery	Lab-derived
Matrix Spike Duplicate	RPD ≤ 30%	Water: RPD ≤ 30%, Soil: RPD ≤ 50%	RPD ≤ 50%	RPD ≤ 60%	Lab-derived
Surrogate	Same as LCS	Same as LCS	Blank Spike		Lab-derived

Agency Requirements for Method 8330

QC Check	DoD Acceptance Criteria	AFCEE Acceptance Criteria	USACE Acceptance Criteria	USACE Sporadic Marginal Failure	SW 846 Acceptance Criteria
Spike			Water: 60%-140 recovery		
			Blank Spike Soil: 50%-150% recovery		
			Matrix Spike: 70%-130%		
Confirmation of positive results	RPD ≤ 40	RPD ≤ 40%, J flag if greater	RPD ≤ 40%		RPD ≤ 40%
Results reported between MDL and RL	Apply J flags	Apply F flags			
Allowable Sporadic Marginal Excedences/ Failures	> 90 analytes - 5		91 - 105 analytes - 7		
	71 - 90 analytes - 4 51 - 70 analytes - 3 31 - 50 analytes - 2 11 - 30 analytes - 1 < 11 analytes - 0		76 - 90 analytes - 6 61 - 75 analytes - 5 46 - 60 analytes - 4 31 - 45 analytes- 3 16 - 30 analytes - 2 5 - 15 analytes - 1		

Extraction Method for Ordnance Compounds in Soils (8330A)

Method # LTL-3161

March 8, 2004

Revision Number: #9

Written by: [illegible] Date: 3.8.04

Reviewed by: Harry Romberg Date: 3-8-04

Approved by: Kathy Kreps Date: 3-9-04

UNCONTROLLED

1. **PURPOSE** - In this method the ordnance compounds are extracted from neutral soil with acetonitrile. The sample is air dried, sonicated, and extract salted-out and analyzed by HPLC. This method also includes Low Concentration requirements

2. **SAFETY** - During the conduct of this method, the extractionist will be exposed to a variety of reagent chemicals and solvents. The health effects of these various chemicals may be ascertained by reading the material safety data sheets (MSDS) available in the general files. Additionally, the samples by their very nature, may contain significant levels of hazardous materials. It is incumbent on each extractionist to exercise due care and caution while executing this method. The company will provide any protective equipment or clothing needed to assure employee safety.

3. **DEFINITIONS**

Method Blank – An analytical control consisting of all reagents and surrogate standards that is carried throughout the entire analytical procedure. The method blank is used to define the level of laboratory, background, and reagent contamination.

Blank Spike - An analytical control consisting of all reagents, target analytes, and surrogate standards that is carried throughout the entire analytical procedure.

Matrix Spike – Aliquot of a matrix spiked with known quantities of specific compounds and subjected to the entire analytical procedure in order to indicate the appropriateness of the method for the matrix by measuring recovery.

Matrix Spike Duplicate – A second aliquot of the same matrix as the matrix spike that is spiked in order to determine the precision of the method.

Surrogates – Compounds added to each blank, blank spike, sample, matrix spike and spike duplicate to evaluate analytical efficiency by measuring recovery.

4. **REAGENTS**

4.1. All reagents shall be of AR grade or better.

4.2. All solvents shall be distilled in glass unless otherwise indicated.

4.3. The following special reagents shall be prepared:

4.3.1. Ottawa Sand - prepared by soxhleting for 8 hours with methylene chloride and muffling for four hours at 400°C.

4.3.2. 0.045 M Calcium Chloride - prepared by dissolving 5.0 gm in 1000 mL of DIW.

4.3.3. Surrogate solution prepared in methanol:

3,4-Dinitrotoluene	400 µg/mL

4.3.4. Matrix spiking (MS) solution prepared in methanol:

1,3-Dinitrobenzene	80 µg/mL
2,4-Dinitrotoluene	80 µg/mL
2,6-Dinitrotoluene	80 µg/mL
HMX	80 µg/mL
RDX	80 µg/mL
Nitrobenzene	80 µg/mL
2-Nitrotoluene	80 µg/mL
3-Nitrotoluene	80 µg/mL
4-Nitrotoluene	80 µg/mL
Tetryl	80 µg/mL

TNT	80 µg/mL
1,3,5-Trinitrobenzene	80 µg/mL
2-amino-4,6-dinitrotoluene	80 µg/mL
4-amino-2,6-dinitrotoluene	80 µg/mL

4.3.5. By request: Special Matrix spiking solution for PETN/NG in methanol:

PETN	50 µg/mL
Nitroglycerin	100 µg/mL

4.3.6. By request: Special Matrix spiking solution for 6 Attenuation compounds in methanol:

2,4-DA-6-NT	80 µg/mL
2,6-DA-4-NT	80 µg/mL
3,5-DNA	80 µg/mL
MNX	80 µg/mL
TNX	80 µg/mL
4,4'-TN-AZOXY	80 µg/mL

4.3.7. By request: Special Matrix spiking solution for MNX in methanol:

MNX	80 µg/mL

4.3.8. By request: Special Matrix spiking solution for DNX in methanol:

DNX	80 µg/mL

5. **EQUIPMENT**

5.1. Ultrasonic bath

5.2. #30 mesh sieve

5.3. Disposable cartridge filters - 0.45 µm Teflon filter

5.4. Standard laboratory glassware to include:

5.4.1. 20 x 150 mm culture tubes

5.5. Volumetric measurements are to be made with graduated serological pipets or a calibrated fixed volume microdispenser and individually calibrated vials.

6. **SAMPLE COLLECTION & PRESERVATION** – Samples are normally collected in glass containers with Teflon-lined caps. All samples and sample extracts are stored at 4°C ± 2°C. Soil samples must be extracted within 14 days of collection.

7. **POLLUTION PREVENTION & WASTE MANAGEMENT** – Sample extracts, standards and solvent rinses are disposed of by depositing them in the hazardous waste container located in the solvent locker. Waste segregation and disposal from the point of collection is further covered in LTL-2001.

8. **PERSONNEL QUALIFICATIONS** – This method is restricted to use by, or under the supervision of, experienced chemist/extractionists who have demonstarated the ability to perform the described extraction procedures and techniques.

9. **QUALITY CONTROL** - The normal level of quality control will consist of blank, blank spike, matrix spike and matrix spike duplicate (MS and MSD). This is performed on a per batch basis to include no more than 20 samples. The level of quality control will be indicated to the extractionist at the time the job is assigned. These samples serve to provide a measure of the recovery efficiency for the analyte and to provide data for statistical evaluation of the sample. In those instances that a client requires additional or different quality control measures, the extractionist will be directed accordingly in writing.

10. **METHODOLOGY**

10.1. Sample Extraction

10.1.1. Mix sample thoroughly in its original container if there is space available, otherwise mix in solvent rinsed aluminum tray.

10.1.2. Weigh approximately 20-30 grams into a labeled, large aluminium weighing tin. Place in hood and air dry for 48 hours or until a constant weight is attained.

10.1.3. Grind and sieve.

10.1.4. Weigh 2.0 grams of air dried soil that passed through the sieve into a 20 x 150 mm culture tube. (Low Conc: 5.0 grams)

10.1.5. Prepare two additional aliquots of a sample, randomly selected or client designated, if Quality Control is required.

10.1.6. Prepare a blank and blank spike with 2.0 grams Ottawa sand.

10.1.7. Pipet 100 µL surrogate solution to each culture tube.

10.1.8. Pipet 500 µL matrix spiking solution to each of the QC culture tubes. (When indicated, use 250 µL PETN/NG and 500 µL all other special matrix spiking solution.)

10.1.9. Add 9.9 mL acetonitrile to each sample culture tube and blank and 9.4 mLs to QC and blank spike. (Use 9.65 mL if PETN/NG is used.)

10.1.10. Sonicate the samples for 18 hours in a sonic bath packed with ice in the cold room.

10.2. Salting Out

10.2.1. Remove samples from ice bath and allow to come to room temperature.

10.2.2. Transfer 5.0 mL of supernatant to a 16 x 100 mm culture tube.

10.2.3. Add 5.0 mL calcium chloride solution to each sample.

10.2.4. Mix and let stand for 15 minutes.

10.2.5. Centrifuge each sample.

10.2.6. Filter through a 0.45µm PTFE syringe filter into 4 mL **amber** vial, discarding first 3 mL.

10.2.7. Label the extract and deliver to 940.

10.2.8. Complete all paperwork and bench sheet. Bench sheet to include PTFE filter lot #, sonic bath start and finish time, date and time of transfer to 940 and extract location. Clip the T-card on the folder and place in GC room extraction folder box. The file folder color will be red and the blank name will be ____HOR.SM_.

11. **REFERENCES** - The following USEPA methods are the official methods on which this Laucks Testing Laboratory method is based. The primary methods are those which most closely parallel the Laucks procedure and are referenced by their USEPA series and number. In those instances for which there are no official EPA methods, the most suitable reference is given under the miscellaneous references section. The additional reference section cites those methods which contain additional information. These methods will frequently be official methods, which apply in part to, or support the Laucks method.

PRIMARY REFERENCES:

Test Methods for Evaluating Solid Waste, USEPA, SW-846 - 8330A (1998)

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OPERATION-SPECIFIC STANDARD OPERATING PROCEDURE

TITLE: DETERMINATION OF PERCHLORATE BY LIQUID CHROMATOGRAPHY COUPLED WITH ELECTROSPRAY MASS SPECTROMETRY (LC/MS) BASED ON METHOD 8321

(SUPERSEDES: NONE)

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