DEPARTMENT OF THE NAVY
CRANE DIVISION
NAVAL SURFACE WARFARE CENTER
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N00164.AR.000869
NSWC CRANE
5090.3a

IN REPLY REFER TO

5090/S4.7.5
Ser RP3/4119

20 APR 2004

U.S. Environmental Protection Agency, Region V
Waste, Pesticides, & Toxics Division
Waste Management Branch
Corrective Action Section
ATTN: Mr. Peter Ramanauskas (DW-8J)
77 West Jackson Blvd.
Chicago, IL 60604

Dear Mr. Ramanauskas:

Crane Division, Naval Surface Warfare Center (NSWC Crane) submits change pages for the Draft Solid Waste Management Unit (SWMU) 03 Soils Data Gap Quality Assurance Project Plan (QAPP) Addendum. These changes are submitted so as to create a Final version of the QAPP. Two copies are provided as enclosure (1). In addition, enclosure (2) contains two copies of responses to the U. S. EPA comments dated March 24, 2004 and March 30, 2004. The permit required Certification Statement is provided as enclosure (3).

If you require any further information, my point of contact is Mr. Thomas J. Brent, Code RP3-TB, at 812-854-6160, email brent_t@crane.navy.mil.

Sincerely,

James M. Hunsicker

JAMES M. HUNSICKER
Manager, Environmental Protection
By direction of the Commanding Officer

Encl:
(1) SWMU 03 Soils Data Gap QAPP Change Pages
(2) Responses to Comments
(3) Certification Statement

Copy to:
ADMINISTRATIVE RECORD
SOUTHNAVFACENGCOM (Code ES32) (w/o encl)
IDEM (Doug Griffin)
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I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

James Hunacek
SIGNATURE

Manager, Environmental Protection
TITLE

4/20/04
DATE

5090
Ser 095/2320

25 SEP 2002

The letter Ser RP3/4119 was for the submittal of the change pages, response to comments, and certification statement for the Draft SWMU 03 Soils Data Gap Quality Assurance Project Plan Addendum. Awaiting submittal of original report (12/15/04).

ENCLOSURE (1)
CHANGE PAGES TO QAPP ADDENDUM NO. 1 FOR THE AMMUNITION BURNING GROUNDS, LITTLE SULPHUR CREEK, AND OLD JEEP TRAIL RCRA PHASE III RFI/CMS

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

Contract Task Order 0311

April 2004

020410/P

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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CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0311

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TABLE OF CONTENTS

(Pages 1 through 6 of 6)

TABLE OF CONTENTS

SECTION **PAGE NO.**

ACRONYMS **4**

1.0 INTRODUCTION **1-1**
1.1 PROJECT BACKGROUND AND STATUS 1-2
1.2 PROJECT OBJECTIVES 1-3
1.3 SITE PHYSICAL DESCRIPTION 1-4
1.3.1 Physiography, Topography, and Ground Cover 1-4
1.3.2 Geology and Stratigraphy 1-4
1.3.3 Hydrology and Hydrogeology 1-7
1.3.5 Surface Hydrology and Drainage System 1-11
1.4 SITE HISTORY 1-11
1.4.1 Historical Operations 1-11
1.5 PREVIOUS ENVIRONMENTAL INVESTIGATIONS AND CONCLUSIONS 1-13
1.5.1 Phase III Soils Study at ABG 1-13
1.5.2 Phase III Ground Water Release Characterization and RCRA Quarterly Monitoring at the ABG 1-14
1.5.3 Soil and Ground Water Investigations at the OJT Area 1-14
1.5.4 Dye Tracer Studies and Springs 1-15
1.5.5 LSC 1-17
1.6 CONCEPTUAL SITE MODEL AND PROBLEM DESCRIPTION 1-17
1.7 INVESTIGATIVE APPROACH 1-20
1.7.1 Investigative Strategy 1-20
1.7.2 Target Parameters and Rationale – Soil Samples 1-20
1.7.3 Target Parameters and Rationale – Ground Water Samples 1-21
1.7.4 Data Use and Decision Logic 1-22

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES **2-1**

3.0 SAMPLING AND ANALYSIS PLAN **3-1**
3.1 GENERAL APPROACH 3-1
3.2 SAMPLE IDENTIFICATION SYSTEM 3-2
3.3 FIELD MEASUREMENTS 3-2
3.4 AVOIDANCE OF UNEXPLODED ORDNANCE 3-2
3.5 SAMPLING LOCATIONS, ANALYSES, AND RATIONALES 3-2
3.5.1 Surface and Subsurface Soils and Perched Water 3-3
3.5.2 Ground Water 3-4
3.5.3 Surface Water / Sediment 3-5
3.6 INVESTIGATION EQUIPMENT AND PROCEDURES 3-5
3.6.1 UXO Screening of Selected Drilling Sites 3-5
3.6.2 DPT Sampling for Surface and Subsurface Soil Samples 3-5
3.6.3 Inspection and Repair of Existing Monitoring Wells 3-7
3.6.4 Well Development 3-8
3.6.5 Water-Quality Field Measurements 3-8
3.6.6 Low-Flow Sampling of Monitoring Wells 3-8
3.6.7 Ground Water-Level Measurements 3-9
3.7 QUALITY CONTROL SAMPLES 3-10

TABLE OF CONTENTS (Continued)

SECTION **PAGE NO.**

3.8 SAMPLE HANDLING, PACKAGING, AND SHIPPING 3-10
3.8.1 Sample Preservation 3-10
3.8.2 Sample Labeling 3-10
3.8.3 Sample Packaging 3-10
3.8.4 Sample Shipping 3-11
3.8.5 Sample Custody 3-11
3.9 RECORD KEEPING 3-11
3.9.1 Field Log Books 3-11
3.9.2 Direct Push Technology Boring Installation 3-12
3.9.3 Well Development Log Sheets 3-12
3.9.4 Equipment Calibration Logs 3-12
3.9.5 Sample Collection Logs 3-12
3.9.6 Chain-of-Custody Forms 3-12
3.9.7 Shipping Forms/Air Bills 3-13
3.9.8 Permanent Record File 3-13
3.10 SURVEYING 3-13
3.11 EQUIPMENT DECONTAMINATION 3-13
3.12 MANAGEMENT OF INVESTIGATION-DERIVED WASTE 3-14
3.13 SAFETY 3-15
3.13.1 Health and Safety Plan 3-15
3.13.2 Health and Safety Training 3-15
3.13.3 Personal Protective Clothing and Equipment 3-15
3.13.4 Safety Meetings 3-15
3.14 ORGANIZATION AND LOGISTICS OF FIELD INVESTIGATIONS 3-16
3.14.1 Personnel 3-16
3.14.2 Subcontractors 3-16
3.14.3 Mobilization and Demobilization 3-16

4.0 SAMPLE CUSTODY, EQUIPMENT CALIBRATION, DATA MANAGEMENT, AND GENERAL QA/QC PROCEDURES 4-1
4.1 SAMPLE CUSTODY 4-1
4.2 CALIBRATION PROCEDURES AND FREQUENCIES 4-1
4.3 ANALYTICAL AND MEASUREMENT PROCEDURES 4-1
4.3.1 Field Measurement Procedures 4-2
4.3.2 Laboratory Analytical and Measurement Procedures 4-2
4.4 INTERNAL QUALITY CONTROL CHECKS 4-2
4.5 DATA REPORTING , MANAGEMENT, REDUCTION, AND VALIDATION 4-3
4.6 PERFORMANCE AND SYSTEM AUDITS 4-3
4.7 PREVENTIVE MAINTENANCE PROCEDURES 4-4
4.8 CORRECTIVE ACTION 4-4
4.9 QUALITY ASSURANCE REPORTS TO MANAGEMENT 4-4

REFERENCES R-1

TABLE OF CONTENTS (Continued)

APPENDICES

A STANDARD OPERATING PROCEDURES FOR FIELD WORK
B BORING LOGS AND MONITORING WELL CONSTRUCTION LOGS
C STANDARD OPERATING PROCEDURES FOR LABORATORY WORK

TABLES

NUMBER

1-1 Summary of Previous Investigations
1-2 Key Operations and Potential Source Areas at the Ammunition Burning Grounds
1-3 Specific Fixed-Based Laboratory Analytical Methodologies and Corresponding Target Analyte Lists
1-4 Monitoring Wells and Springs to be Sampled During the CMS
2-1 Key Project Personnel
3-1 Field Screening and Measurements
3-2 Soil Samples and Laboratory Analyses
3-3 Ground Water Samples and Laboratory Analyses
3-4 Summary of Soil and Aqueous Sample Analyses and Quality Control Samples
3-5 Summary of Sample Analyses, Container Types and Volumes, Preservation Requirements, Holding Times, and Analytical Laboratory for Aqueous and Soils
3-6 Physical Characteristics of Monitoring Wells for Water Level Measurements
3-7 Non-Calibration Quality Control Sample Usage Frequencies, Acceptance Limits, and Corrective Actions
4-1 Summary of Organic, Inorganic, and Miscellaneous Analytical Laboratory Procedures for Solid and Aqueous Samples
4-2 Metals Quality Control Limits, Matrix Spike, and Laboratory Duplicate Samples
4-3 Metals Quality Control Limits for Laboratory Control Samples
4-4 Explosives (8330) Quality Control Limits for Matrix Spike/Matrix Spike Duplicate Samples
4-5 Explosives (8330) Quality Control Limits for Laboratory Control Samples
4-6 Volatile Organic Compounds Quality Control Limits for Matrix Spike/Matrix Spike Duplicate Samples
4-7 Volatile Organic Compounds Quality Control Limits for Laboratory Control Samples
4-8 Miscellaneous Parameters Quality Control Limits for Matrix Spike/Matrix Spike Duplicate Samples
4-9 Miscellaneous Parameters Quality Control Limits for Laboratory Control Samples
4-10 Quality Control Limits for Surrogate Compound Recoveries
4-11 Quality Control Limits for Laboratory Duplicate Sample Precision

FIGURE

NUMBER

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

SECTION 1.0

Revised Text

(Pages 1 through 22 of 22)

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.

Revised Tables

(Tables 1-1 through 1-4)

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

SECTION 3.0

(Pages 3, 4, and 17 of 17)

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.

- 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.

(Tables 3-1 through 3-7)

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 (except 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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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)
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

TABLE 3-6

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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)
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.

SECTION 4.0

(Table 4-1)

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.

APPENDIX A

(SOP_CTO126-05)

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

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.:	

(SOP_CTO126-09)

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

(SOP_CTO126-10)

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: _____ Depth to Bottom (ft.): _____ Responsible Personnel: _____
Site: _____ Static Water Level Before (ft.): _____ Drilling Company: _____
Date Installed: _____ Static Water Level After (ft.): _____ Project Name: _____
Date Developed: _____ Screen Length (ft.): _____ Project Number: _____
Dev. Method: _____ One Well Volume (gal/L): _____ PID Readings: Bore Hole_____ppm
Pump Type: _____ Casing ID (in.): _____ 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.)

(SOP_CTO126-16)

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) 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___

ENCLOSURE (2)
RESPONSES TO COMMENTS

ATTACHMENT (A)
FINAL REPSONSES TO U.S. EPA COMMENTS
DATED MARCH 24, 2004

RESPONSES TO U.S. EPA COMMENTS RECEIVED FROM:
Ramanauskas.Peter@epamail.epa.gov
[mailto:Ramanauskas.Peter@epamail.epa.gov]
Sent: Wednesday, March 24, 2004 16:45
To: brent_t@crane.navy.mil; Gates, William H CIV EFDSOUTH
Cc: Debus.Allen@epamail.epa.gov
Subject: ABG/OJT QAPP Addendum Comments
(MARCH 26, 2004)

Gentlemen,

Included herein are my comments on the ABG/OJT QAPP Addendum #1. I thought I'd share these with you as soon as I had them finished. Allen may have some additional comments/questions and I will forward those (if any are generated):

Comment 1:

The first bullet on page 1-3 mentions lack of chemical concentration data for deep soils. Lack of data for which chemicals (explosives, VOC, metals)?

Response 1:

The primary data gaps that have been identified for deep soils are for explosives (primarily RDX) and volatile organics (primarily TCE).

The first bullet has been revised to read as follows.

- *Lack of chemical concentration data, except for a few locations, in deep soil [i.e., greater than 60 ~~to 90~~ inches below ground surface (bgs)] at the ABG MTA. This results in the inability to correlate observed soil concentrations of explosives, volatiles, and metals with observed groundwater concentrations of the same chemicals.*

Comment 2:

The third bullet on page 1-3 mentions that the VOC source area near OJT well 03-07 was insufficiently delineated. This implies that the objectives of the original RFI to delineate extent of contamination were not met. If this is the case, we should revisit the decision points we use in our RFIs in determining when an area is fully delineated.
Ensuring that we have complete horizontal and vertical delineation at the RFI stage will save us from having to come back to delineate an area further for CMS work. This bullet should also reflect insufficient delineation of explosives contamination at OJT as the last sentence in Section 3.5.1.2. states soil samples will be used for energetic compound delineation.

Response 2:

The information that was collected during the RFI process was sufficient to achieve the principal RFI objective, which is to determine whether contamination is present in concentrations that present significant risk to human or ecological receptors. Delineating the extent of contamination during the RFI process certainly is desirable. However, it is not necessary to complete the risk characterization process. In the case of the ABG Main Treatment Area (MTA), the soils, groundwater, and surface water RFIs had been approved. The need for additional information was not determined until the RFI data were evaluated during the development of the CMS.

The primary objective for collection of soil samples at the OJT is to fill a CMS data gap in regards to TCE. No CMS data gap was identified for explosives at the OJT. However, samples will be analyzed for explosives to provide additional data for those compounds.

The third bullet has been revised to read as follows.

- ~~Insufficiently delineated source area for VOCs at the OJT near well 03-07~~. 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 during the CMS and provide additional information on explosives concentrations.

The last sentence in Section 3.5.1.2 has been revised to read as follows.
The soil samples from these borings will be used to help delineate the horizontal and vertical extent of TCE ~~and energetic compounds~~.

Comment 3:

The first bullet of Section 1.2 should be modified to include not only better definition of horizontal and vertical nature and extent of VOCs, but explosives and metals as well in ABG and OJT. If an objective is source area delineation, how will these source areas be bounded for the purposes of the CMS and estimating contaminated soil volumes potentially requiring remediation? What levels will the soil samples be screened against? Risk based levels in Table 1-3 appear to be the lowest risk-based criteria available. Do these levels consider soil migration to groundwater numbers if an objective for this work is to perform horizontal and vertical delineation of source areas which could be impacting groundwater?

Response 3:

The major data gap that has been identified relates to soil sources of TCE and RDX that could account for the observed concentrations of TCE and RDX in groundwater. Evaluations of groundwater monitoring data collected since the 1980s shows no clear trend of decreasing concentrations at the Main Treatment Area. This implies that a continuing source exists at the ABG. In order to develop potential corrective measures alternatives for groundwater it is necessary to develop a conceptual site model. The conceptual site model includes an identification of the location of the source of contamination (soil, groundwater, bedrock, etc.), the vertical and horizontal extent of contamination, and the rate of movement between the source and groundwater. It was initially assumed that the soils RFI would provide adequate information to develop the conceptual site model. However, the contaminant concentrations in the soils could not account for the observed concentrations in groundwater. Therefore, it was not possible to directly relate the location and concentrations of groundwater contamination to soil sources. In addition, both TCE and RDX are mobile contaminants and may have moved through the soil column into the bedrock. If this is the case, soil remediation would be of little value and potentially a waste of money. Therefore, the primary objective of this CMS field investigation is to determine whether significant masses of TCE and RDX can be found in the soil column. If significant masses of RDX and TCE are not found in the soil column, remediation of soil may not be warranted.

The soil data will be screened against site-specific criteria for protection of groundwater. The site-specific criteria developed for protection of groundwater (or any other risk-based reasons) will be calculated during the CMS. These preliminary remediation goals (PRGs) will not only be based on risk-related criteria, but will also have dilution, dispersion, biodegradation, and possibly other factors included in the development of these numbers. All of the soils data collected for the ABG MTA and the OJT area (including the older USACE data) will be screened against the PRGs and contoured on maps. This information and data will be used to estimate the locations and

volumes of soil that need to be remediated, which will in turn be used to help formulate the remedial options and estimate remediation costs during the CMS.

However, if it is determined that major contaminant source(s) have migrated to the bedrock, remediation of soil exceeding criteria for protection of groundwater may not have any meaningful impact on groundwater concentrations. In that case, the focus of corrective measures studies will be on alternatives for remediation of groundwater.

Regarding Table 1-3 and the risk-based limits presented therein, the table is the standard table used by the Navy to select analytical methods. The table helps to verify that the methods will yield reasonably low detection limits. The limits presented in the table are comparable to those used during the RFI and include migration to ground water considerations. The analytical methods selected for this CMS are the same as those used to support the RFI. Recognizing that cleanup levels will not necessarily be as low as the risk-based screening limits, these methods should yield more than enough sensitivity to support the CMS.

Comment 4:

Referring to Section 1.5.4., what happened to the Direct Yellow 96 dye and Phorwrite AR mixture added to well 03C03P2 during the dye tracer study of January 20, 1990?

Response 4:

A new sentence has been added at the end of the first paragraph in Section 1.5.4 as follows:

"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."

Two other minor changes have been made to the paragraph to clarify whether the text is referring to well 03C02P2 or 03C03P2.

Comment 5:

Add additional text to the first full paragraph on page 1-17 stating that any detections of pesticides, herbicides, and PCBs were below human health and/or ecological risk-based screening levels (where warranted).

Response 5:

The following text has been inserted at the end of the second paragraph of Section 1.6:

"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 methoxychlor concentration (17 ug/kg) was less than five times greater than the 3.59 ug/kg risk-based screening level (TtNUS, 2003). Hence, these compounds are not considered to be significant."*

Comment 6:

The well number referenced in the sentence beginning "Large solution cavities" in Section 1.6 should be 03C02P2.

Response 6:

The correction has been made.

Comment 7:

Referring to the first paragraph of Section 1.7.2., there is no rationale presented on why metals analysis in soils is sporadic as indicated in Table 3-2.

Response 7:

As noted in the response to Comment 3 the major focus of this CMS investigation is on chlorinated volatile organics and explosives. Several metals (antimony, arsenic, manganese) were identified in the Current Contamination Risk Assessment (CCRA) as risk drivers for the Main Treatment Area. Certain metals (barium, selenium, zinc, and manganese) have been found in statistically significant concentrations and above Alternate Concentration Levels (ACLs) in wells at the Main Treatment Area during the ongoing RCRA monitoring program. Therefore, metals will be considered during the CMS. However, limited resources are available for this fieldwork. Therefore, only a reduced set of samples will be analyzed for metals, so that these analyses will not impinge on the number of VOC and explosives analyses.

Because holding times for total metals analyses (excluding mercury) are 180 days for properly preserved samples, the potential exists to conduct a metals analysis on samples that were not originally scheduled for that analysis. Therefore, if the planned metals data indicate a need to analyze other samples for metals, that will be done.

Comment 8:

The second paragraph of Section 1.7.2. and the last paragraph of Section 3.5.1. note that VOCs will not be analyzed for in the to 6 feet of soil unless elevated PID values are present. This may need to be reconsidered as the OJT RFI samples at 0 to 2 feet and 2 to 6 feet showed TCE over a soil to groundwater migration screening value at DAF 1. If an objective of this project is to perform horizontal and vertical delineation of source areas in soils, an appropriate soil screening value reflective of the potential the contaminants to leach to groundwater should be set and measured for in all vertical intervals.

Response 8:

The soil sampling program for the ABG and OJT areas are intended to identify and delineate "hot spots" of VOCs (i.e., contaminated soil areas that have VOC concentrations high enough to account for the levels of TCE that have been observed in groundwater). A large number of shallow (0-60 inches deep) soil samples have been collected by the USACE and the analyses identified a few locations that had minor concentrations of VOCs. Therefore, the deeper soils and the bedrock surface is the focus of this CMS investigation as a likely location of highest VOC concentrations. However, as stated in paragraph 2 of Section 1.7.2, shallow soils will be collected and analyzed for VOCs if the photoionization detector indicates that VOCs might be present. If all of the shallow soils were analyzed for VOCs, that would reduce the number of deep samples that could be collected and analyzed, thereby diluting the thoroughness of the deep investigation. Thus, the current sampling strategy is considered optimal for tracking down potential soil VOC hot spots.

No changes have been made to the text in Sections 1.7.2 or 3.5.1.

Comment 9:

The fourth paragraph of Section 1.7.2. states that soil samples will be analyzed for RDX degradation products. Table 3-2 states that the RDX degradation product list is found in

Table 1-3. Table 1-3 lists all explosives with no distinctions as to what degradation products are. In addition, what about other degradation products from compounds such as TNT, HMX or other parent compounds?

Response 9:

Table 1-3 has been changed to group the RDX degradation products under a single heading. The primary TNT degradation products (2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene) are measured as part of the SW-846 Method 8330 analysis. HMX is a minor site contaminant and is consequently not scheduled for degradation product analysis. That analysis would require additional method development. The concomitant project delay and expense do not seem to be warranted and project resources would not support it.

Comment 10:

Referring to the well selection for OJT groundwater sampling in Section 1.7.3., if funding is available under this project, it would be good to sample all OJT wells since there was only one round of groundwater sampling performed under the RFI and RDX appeared in all groundwater wells.

Response 10:

The select monitoring wells at ABG are being sampled and analyzed because most of them have not been sampled and analyzed since 1991; hence, the data from these wells are 13 years old and probably do not reflect the current conditions of groundwater contamination. The six wells at OJT (see Table 3-3) that are scheduled for resampling are the ones that exhibited the highest TCE and/or RDX concentrations during the 2001 sampling period. These wells will be resampled to determine if the levels of TCE and RDX in these wells are still decreasing and how fast. For example, historical data show the TCE concentrations at OJT have always been highest in monitoring well 03-07. TCE has declined in this well from 19,000 µg/L in 1982, to 4,000 µg/L in 1994, and 640 µg/L in 2001. The TCE and RDX has also declined in most of the other wells over time. Hence, there are no existing data that suggests concentrations are increasing or that a plume of contaminated ground water is increasing in size or moving downgradient. As stated above, the purpose of resampling the six wells is to evaluate the current concentrations of TCE and RDX in the "hot areas." There is no need to resample the wells with lower concentrations because these wells have concentrations that probably have not changed much. In addition, all of the wells in the OJT area have been sampled on more than one occasion during the 1980s and 1990s by the USACE, so there is more than one round of data that will be used for the CMS.

No changes have been made to the QAPP in response to this comment.

Comment 11:

Referring to Table 1-2: a) the well reference for Sampling Area G should be 03C08P2; b) sampling should be done on all sides of Sampling Area J (Storage Area and Solvent Burn Pan) to evaluate that area (4 samples).

Response 11:

a. The well reference for sampling area G on Table 1-2 has been changed to "03C08P2."
b. Only one soil boring has been proposed for Area J, because it is an actively operating burn pan area. Contamination from this source is not expected. This area is also used for a storage and staging area. Again, no historical data suggests that spills or releases have occurred in this area. However, one boring is being performed to reinforce the supposition that the soils in this area are clean. If more borings are designated for this area, then the number of borings in other

areas of greater importance would need to be reduced. If the results of soil analyses from the one boring in this area exhibit significant contamination, then additional borings may be performed at a later date, if necessary.

No change has been made to the proposed number of soil borings.

Comment 12:

Referring to Section 3.5.1.2., additional borings should be added to delineate around 03SB48 which was a hotspot for VOCs/TCE and metals. If an objective of this project is to perform horizontal and vertical delineation of source areas, there will need to be additional sampling around the Burn Pit.

Response 12:

Numerous soil cores were collected and analyzed in 2001 from around the Burn Pit, the Burn Area, and well 03-07 during the OJT RFI. Very few soil samples contained VOCs and most of the concentrations of VOCs that were detected in soil were relatively low. Based on the potentiometric surface of groundwater in the vicinity of well 03-07 (Figure 3-2), groundwater is generally flowing from the north and northwest toward the southeast and east. Therefore, the Navy and TtNUS believe that the VOC source area may be to the northwest, north, or northeast of well 03-07, not south of 03-07. The level of TCE detected in soils from boring 03SB48 were very minor and could not account for the level of TCE observed in well 03-07. Thus, the Navy and TtNUS prefer to leave the sampling strategy as is, with six new soil borings located north of well 03-07.

Comment 13:

Section 3.6.3 refers to SOP CTO126-09. Step 3.10 in that SOP refers to Table 4-4 of the QAPP. It seems the proper reference should be Table 3-6.

Response 13:

The correction has been made.

Comment 14:

For Table 3-2, should the superscript '3' on Explosives and Target Analyte List Metals instead be '4'?

Response 14:

The correction has been made.

Comment 15:

Table 3-3 is missing well 03-31 which is shown as being sampled on Figure 3-3. This table also refers to wells 03TW01 - 03TW06. Are these temporary wells? If so, they don't appear to be mentioned anywhere in the text. Please provide clarification on the location and purpose of these wells.

Response 15:

Table 3-3 has been modified to indicate that:

- A groundwater sample will be collected from well 03-31. This sample will be analyzed for VOCs, Explosives, and metals.
- The sample for well 03C10 has been deleted. Numerous samples have been collected from this well between 1998 and 2001 as part of the RCRA Quarterly Monitoring Program. Additional data from this well are not required.

Wells 03TW01 through 03TW06 are perched groundwater samples which will be collected from DPT borings. These are discussed in the fourth paragraph of Section 3.1 and Section 3.5.1. "TW" in Table 3-3 refers to a temporary well (i.e. a DPT boring). This terminology was used to allow these samples to be identified as ground water samples. A footnote has been added to Table 3-3 to explain that "TW" in the columns for "Location" and "Sample Number" stands for temporary wells. Ground water will be collected from the soil-bedrock interface in the DPT borings. Since it is not known where ground water will be encountered in these borings ahead of time, their locations can not be placed on a map.

ATTACHMENT (B)
FINAL RESPONSES TO U.S. EPA COMMENTS
DATED MARCH 30, 2004

-----Original Message-----
From: Ramanauskas.Peter@epamail.epa.gov
[mailto:Ramanauskas.Peter@epamail.epa.gov]
Sent: Tuesday, March 30, 2004 14:25
To: Gates, William H CIV EFDSOUTH
Cc: brent_t@crane.navy.mil
Subject: Re: FW: Final Responses to March 24 04 EPA Comments

Bill,

Attached are my replies to a couple of the responses and Allen's comments on groundwater (that's all he's been able to look over thus far). In the future, I would ask that you provide us with some more time to review prior to initiating fieldwork. While we're trying to provide a quick turnaround so you can get the work done, this one cuts it very close.

Thanks,
Pete

Allen's Comments:

1.) Table 1-3, page 3 of 5 should refer to SW-846 method 5035A in the case of soil VOCs sampling & analysis (i.e. besides 8260B).

Response:
Footnote 2 of Table 1-3 has been extended to add the following statement:

"See Table 4-1 for sample preparation methods)." In addition, Table 4-1 has been changed to identify SW-846 method 5035A (rather than 5035) as the sample preparation method for soil sample VOC analysis.

2.) Table 1-3, page 3 of 5 refers to method 8321A as the basis for perchlorate analysis. I would have thought that for this analyte based on the chemistry that their SOP would have been founded on an anion chromatography method (9056) instead. The STL SOP isn't present however, presumably because STL regards this as proprietary. It will be difficult to approve this SOP with much conviction unless we can review it first.

Response:
As shown in Table 4-1 of this QAPP Addendum No. 1, EPA method 314.0, is the primary perchlorate analytical method. This method, which is comparable to SW-846 method 9056, is an ion chromatographic method. When perchlorate is detected in a sample, the sample will be re-analyzed by SW-846 method 8321, which uses LC/MS to verify or refute the presence of perchlorate in the sample. This is being done because the ion chromatographic method is subject to false positive interferences and LC/MS is unsurpassed in its ability to positively identify perchlorate ion.

Table 4-1 has been modified by inserting the following text after the heading for perchlorate analysis by Method 8321A:

"(Confirmatory analysis only, for perchlorate detected by Method 314.0)"

As noted by in the comment STL regards the SOP as proprietary. However, STL will submit this procedure directly to EPA for review using the procedures described in 40 CFR 270.12 for submission of confidential information for RCRA Permit Applications.

3.) In Table 1-3, page 3 of 5, under the list of aqueous VOCs constituents, benzene's lab RL value should be shaded. (Ditto for toluene and 1,3 dichloropropene on page 4 of 5.).

Response
The toluene RL value (and the TV) are correctly displayed and have not been changed.

The following values, including the benzene and dichloropropene RL values, have been shaded for aqueous samples:

- Thallium ("1" has been shaded in the RL column, page 2 of 5).
- Benzene ("1" has been shaded in the RL column, page 3 of 5).
- Carbon Tetrachloride ("1" has been shaded in the RL column and "0.3" has been shaded in the TV column, page 4 of 5).
- cis-1,3-Dichloropropene ("1" has been shaded in the RL column, page 4 of 5).
- Methacrylonitrile ("5" has been shaded in the RL column, page 4 of 5).
- Tetrachloroethene ("1" has been shaded in the RL column, page 4 of 5).
- trans-1,3-Dichloropropene("1" has been shaded in the RL column, page 4 of 5).

4.) For risk assessment purposes, when data is reported as 'less than detectable' it it intended to report the RL or the TL value? This should be stated in the QAPP.

Footnote no. 1 has been extended in Table 1-3 by addition of the following text:

"All results will be reported to the TVs. Results between the TV and the RL will be J-flagged."

My remaining comments/notes:

Response to Comment 8:

I accept the response, but I will expect that areas exceeding generic migration to groundwater numbers will be evaluated for remediation in the CMS, unless the Navy calculates an acceptable site specific alternative migration to groundwater value (as noted in response to comment 3).

Response.

Site Specific migration to groundwater values will be calculated. Information collected during the field investigation will include total organic carbon contents of soil, and soil porosity.

Response to Comment 11:

The response states no historical data suggest spills or releases. I assume this "historical data" is from the USACE RFIs? As noted in the response, this is an actively operating burn area - as such, are there any documentation of releases during operations (i.e., more recent)?

No significant releases have occurred since the USACE RFIs were conducted. However, the most recent IDEM inspection identified track out from the Flashing Pit #9 (i.e., the lower dunnage burn pad). The Agreed Order dated March 26, 2004 (Case No. 2003-13398-H), states that "Respondent had allowed the deposit of contaminants upon the land. Discoloration was observed on the ground near the front gate of the Ammunition Burning Grounds Flashing Pit #9." In short, this discoloration occurred as a result of heavy equipment tracking ash residue out of the

dunnage burn pad while removing the ash. Please note that this is typically cleaned up as soon as it is verified safe to do so. Although the ash residue is sent off-site as a hazardous waste, the Navy believes that this would not be a significant source of RDX or TCE contamination.