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FINAL SAMPLING AND ANALYSIS PLAN FOR RCRA FACILITY INVESTIGATION SOLID WASTE MANAGEMENT UNIT 22 (SWMU22) LEAD AZIDE POND NSA CRANE IN
5/1/2012
TETRA TECH

FINAL
Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan) Addendum

RCRA Facility Investigation
SWMU 22 – Lead Azide Pond

Naval Support Activity Crane
Crane, Indiana

Naval Facilities Engineering Command Midwest

Contract Number N62470-08-D-1001

Contract Task Order F279

May 2012

SAP Worksheet No. 1 -- Title and Approval Page

(UFP-QAPP Manual Section 2.1)

DRAFT
SAMPLING AND ANALYSIS PLAN ADDENDUM

March 2012

RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION

SWMU 22 – LEAD AZIDE POND NAVAL SUPPORT ACTIVITY CRANE CRANE, INDIANA

Prepared for:
Naval Facilities Engineering Command Midwest
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Prepared under:
Contract No. N62470-08-D-1001
Contract Task Order F279

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Government Chemist/Date
NAVFAC QA Review

SAP Worksheet No. 1 -- Title and Approval Page
(UFP-QAPP Manual Section 2.1)

DRAFT
SAMPLING AND ANALYSIS PLAN
ADDENDUM

December 2011

RESOURCE CONSERVATION AND RECOVERY ACT
FACILITY INVESTIGATION

SWMU 22 – LEAD AZIDE POND
NAVAL SUPPORT ACTIVITY CRANE
CRANE, INDIANA

Prepared for:
Naval Facilities Engineering Command Midwest
201 Decatur Avenue, Building 1A
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EXECUTIVE SUMMARY

Tetra Tech has prepared this Sampling and Analysis Plan Addendum (SAP Addendum) for the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at Solid Waste Management Unit (SWMU) 22 – Lead Azide Pond. The work will be performed at Naval Support Activity (NSA) Crane, located in Crane, Indiana under Contract Task Order (CTO) F279, Contract N62470-08-D-1001, Comprehensive Long-term Environmental Action Navy (CLEAN).

This SAP Addendum is a supplement to the existing Final Sampling and Analysis Plan, Phase I Resource and Recovery Act Facility Investigation, SWMU 22 – Lead Azide Pond (Tetra Tech, 2011) that was approved by the Navy and regulatory agencies in January 2011. Background information about SWMU 22 is presented in the August 2010 SAP. Only worksheets and figures that required revision are included in this SAP Addendum. Results of the initial sampling conducted January and April 2011, additional background information, and revisions to the Conceptual Site Model (CSM) are also included in this SAP Addendum. The purpose of this SAP Addendum is to update the Conceptual Site Model (CSM) based on the data collected during the initial round of the investigation and to collect additional data to address data gaps in order to complete the RFI that includes a Human Health Risk Assessment (HHRA) and a screening level Ecological Risk Assessment (ERA). This SAP Addendum presents a plan for supplemental sampling and analysis to be performed at the site. Details of the work not explicitly described in this SAP Addendum will be performed in accordance with the approved SAP.

SWMU 22 is the area referred to as the Explosive Actuated Device (EAD)/ Booster Area or the "Backline". The Booster Area was designed and constructed to load 5-inch rockets during World War II. EADs were loaded with explosives such as lead azide, lead styphnate, tetryl, Royal Demolition Explosive (RDX), and black powder. Building 136 was used for the propellant portion, Building 138 was the pressing building for warheads, and Building 2520 was the final assembly building. A conveyor tunnel connected Buildings 136 and 2520 in support of the former process. The area is currently operated by the Army and is involved in the production of small explosive charges and fuse maintenance. The buildings associated with the Backline are scheduled to be demolished in 2011. An unlined retention pond (i.e., the lead azide pond) was located at the northern end of the Backline. It received overflow wastewater from sumps associated with the process buildings. The retention pond was removed in 1981. Information about SWMU 22 since the initial sampling in January and April 2011 identified various other primary explosives [i.e., RDX, pentaerythritol tetranitrate (PETN), trinitrotoluene (TNT), and nitroglycerin] that were being used in the Booster Area, principally in Building 138.

During the initial sampling at SWMU 22 in January and April 2011, surface and subsurface soil samples were collected from the Backline area between Building 2520 and Building 136. Additional surface soil samples were collected from an area with different vegetation south of Building 136, and surface and subsurface soils were collected from a grassy area also south of Building 136. Surface water and sediment samples were collected from the drainage swale below the former lead azide pond, from along the drainage on the northern portion of the site, and from along the tributary to Turkey Creek east of SWMU 22. Additional surface water samples were collected from locations upstream of SWMU 22 along the tributary to Turkey Creek, as well as from drainage pathways on the western side of SWMU 22, draining from the area of Building 138. The purpose of the investigation was to determine if any target analytes were present in excess of project screening levels (PSLs) identified and established in the SAP, and, if so, to determine the nature and extent of those analytes in soil, sediment, and surface water. The measured target analyte levels in the majority of samples did not exceed PSLs. However, concentrations of RDX and metals were detected in surface water at several locations above the human health PSL. Lead exceeding the human health PSL was detected in only one subsurface soil sample; the detection was within the footprint if the former lead azide pond. Based on the initial sampling results and newly gathered information about the operational history of Building 138, additional investigation is necessary to determine the nature and extent of contaminants at SWMU 22. The supplemental investigation will address these data gaps. The principal area of supplemental investigation will be in and around Building 138.

Surface and subsurface soil, surface water, sediment, and groundwater samples will be collected during the supplemental sampling and analysis program. The samples will be analyzed for explosives and metals. Additionally, sediment samples will be analyzed for total organic carbon (TOC), and select soil and surface water samples will be analyzed for pH. The samples from the supplemental investigation will be analyzed and evaluated in accordance with the requirements of the SAP, with sufficient sensitivity such that the results can be compared to appropriate human health and ecological risk screening values.

Protocols for sample collection, handling and storage, chain-of-custody, laboratory and field analyses, data validation, and reporting are addressed in the SAP. Additional site-specific field Standard Operating Procedures (SOP) required for the supplemental sampling are included in Appendix I. Sampling activities, as defined in this SAP Addendum, are scheduled to be performed in October 2011. A schedule is presented in Worksheet No. 16 of this SAP Addendum.

Field activities conducted under this SAP Addendum will be in accordance with the revised Site-Specific Health and Safety Plan (Tetra Tech, 2011).

SAP ADDENDUM WORKSHEETS

SAP Worksheets — Page No.

LIST OF SAP ADDENDUM FIGURES

SAP ADDENDUM APPENDICES

SAP Worksheet No. 2 -- SAP Identifying Information

(UFP-QAPP Manual Section 2.2.4)

Site Name/Number:	Naval Support Activity (NSA) Crane
Operable Units:	Solid Waste Management Unit (SWMU) 22
Contractor Name:	Tetra Tech
Contract Number:	N62470-08-D-1001
Contract Title:	Comprehensive Long-term Environmental Action Navy (CLEAN)
Work Assignment Number:	Contract Task Order (CTO) F279

1. This Sampling and Analysis Plan (SAP) Addendum was prepared in accordance with the requirements of the *Uniform Federal Policy for Quality Assurance Plans (UFP-QAPP)* (United States Environmental Protection Agency [USEPA], 2005) and *Guidance for Quality Assurance Project Plans*, USEPA QA/G-5, QAMS (USEPA, 2002).

2. Identify regulatory program: The Indiana Department of Environmental Management (IDEM) Hazardous Waste Closure and Corrective Action Programs, which implement and enforce the Resource Conservation and Recovery Act (RCRA), and related state laws and rules.

3. This SAP Addendum is a project-specific document.

4. List dates of scoping sessions that were held:

Scoping Session	Date
SAP Addendum Meeting	May 13, 2011

5. List dates and titles of any SAP documents written for previous site work that are relevant to the current investigation.

Title	Date
Final Sampling and Analysis Plan, Phase I Resource and Recovery Act Facility Investigation, SWMU 22 – Lead Azide Pond	January 2011

6. List organizational partners (stakeholders) and connection with lead organization:

IDEM (lead regulatory agency), USEPA Region 5 (regulatory oversight), Naval Facilities Engineering Command (NAVFAC) Midwest, NSA Crane (property owner), Tetra Tech (Navy contractor)

7. Lead organization: IDEM (regulatory oversight)

8. If any required SAP elements or required information are not applicable to the project or are provided elsewhere, then note the omitted SAP elements and provide an explanation for their exclusion below:

For SAP Addendum Worksheets that have not been revised, refer to the January 2011 SAP for details.

UFP-QAPP Worksheet No.	Required Information	Crosswalk to Related Information
A. Project Management		
Documentation		
1	Title and Approval Page	*Update included in this SAP Addendum*
2	Table of Contents SAP Identifying Information	*Update included in this SAP Addendum*
3	Distribution List	See original SAP
4	Project Personnel Sign-Off Sheet	See original SAP
Project Organization		
5	Project Organizational Chart	See original SAP
6	Communication Pathways	See original SAP
7	Personnel Responsibilities and Qualifications Table	See original SAP
8	Special Personnel Training Requirements Table	See original SAP
Project Planning/Problem Definition		
9	Project Planning Session Documentation (including Data Needs tables) Project Scoping Session Participants Sheet	*Update included in this SAP Addendum*
10	Problem Definition, Site History, and Background. Site Maps (historical and present)	*Update included in this SAP Addendum*
11	Site-Specific Project Quality Objectives	*Update included in this SAP Addendum*
12	Measurement Performance Criteria Table	See original SAP
13	Sources of Secondary Data and Information Secondary Data Criteria and Limitations Table	See original SAP
14	Summary of Project Tasks	*Update included in this SAP Addendum*
15	Reference Limits and Evaluation Table	*Update included in this SAP Addendum*
16	Project Schedule/Timeline Table	*Update included in this SAP Addendum*
B. Measurement Data Acquisition		
Sampling Tasks		
17	Sampling Design and Rationale	*Update included in this SAP Addendum*
18	Sampling Locations and Methods/ SOP Requirements Table Sample Location Map(s)	*Update included in this SAP Addendum*
19	Analytical Methods/Standard Operating Procedure (SOP) Requirements Table	See original SAP
20	Field Quality Control Sample Summary Table	*Update included in this SAP Addendum*
21	Project Sampling SOP References Table Sampling SOPs	*Update included in this SAP Addendum*
22	Field Equipment Calibration, Maintenance, Testing, and Inspection Table	*Update included in this SAP Addendum*
Analytical Tasks		
23	Analytical SOPs Analytical SOP References Table	See original SAP
24	Analytical Instrument Calibration Table	See original SAP
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	See original SAP

UFP-QAPP Worksheet No.	Required Information	Crosswalk to Related Information
Sample Collection		
26	Sample Handling System, Documentation Collection, Tracking, Archiving and Disposal Sample Handling Flow Diagram	See original SAP
27	Sample Custody Requirements, Procedures/SOPs Sample Container Identification Example Chain-of-Custody Form and Seal	See original SAP
Quality Control Samples		
28	Quality Control (QC) Samples Table Screening/Confirmatory Analysis Decision Tree	See original SAP
Data Management Tasks		
29	Project Documents and Records Table	See original SAP
30	Analytical Services Table Analytical and Data Management SOPs	See original SAP
C. Assessment Oversight		
31	Planned Project Assessments Table Audit Checklists	See original SAP
32	Assessment Findings and Corrective Action Responses Table	See original SAP
33	QA Management Reports Table	See original SAP
D. Data Review		
34	Verification (Step I) Process Table	See original SAP
35	Validation (Steps IIa and IIb) Process Table	See original SAP
36	Validation (Steps IIa and IIb) Summary Table	See original SAP
37	Usability Assessment	See original SAP

SAP Worksheet No. 9 -- Project Scoping Session Participants Sheet
(UFP-QAPP Manual Section 2.5.1)

Project Name: Supplemental RFI Sampling **Projected Date(s) of Sampling**: Fall 2011 **Project Manager**: Tim Evans			**Site Name**: SWMU 22 – Lead Azide Pond **Site Location**: Crane, Indiana		
Date of Session: May 13, 2011 **Scoping Session Purpose:** Internal Scoping Meeting					
Name	**Title**	**Affiliation**	**Phone #**	**E-Mail Address**	**Project Role**
Tim Evans	PM	Tetra Tech	412-921-7281	tim.evans@tetratech.com	Management
Peggy Churchill	Project DQO Facilitator	Tetra Tech	321-636-1300	peggy.churchill@tetratech.com	DQO Facilitator
Bob Jupin	Human Health Risk Assessor	Tetra Tech	412-921-8195	bob.jupin@tetratech.com	Human Health Risk Assessor
Aaron Bernhardt	Ecological Risk Assessor	Tetra Tech	412-921-8433	aaron.bernhardt@tetratech.com	Ecological Risk Assessor
Emily Glick	Geoscientist	Tetra Tech	412-921-8075	emily.glick@tetratech.com	Geoscience Support
Ralph Basinski	Crane Activity Coordinator	Tetra Tech	412-921-8308	ralph.basinski@tetratech.com	Management /Oversight

Comments/Decisions: Discussed initial RFI sampling results from Janury and April 2011. Discussed the steps for the Supplemental RFI in accordance with the UFP-SAP Addendum format.

Action Items: Tetra Tech assigned the task to prepare the draft UFP-SAP Addendum.

Consensus Decisions: The meeting participants developed project quality objectives (PQOs) using USEPA's seven-step DQO process. Consensus decisions included the following:

- Building 138 may be source of explosives in surface water at site. Data needs collected from around Building 138 to determine nature and extent of contamination.
- Historical building drawings of Building 138 will be reviewed to identify potential sources and pathways (e.g., floor drains, downspouts, etc.)
- Explosives in surface water may be related to discharge from groundwater. Therefore, groundwater will be investigated.
- Vertical study boundaries to include first water-bearing groundwater zone. One round of groundwater sampling will be performed.

- Sufficient data is available in the Backline Area to perform human health and ecological risk assessments.

- Chemicals of potential concern (COPCs) selection for sediments will include metals only.

- Decision rules will consider potential upgradient sources and the need for additional investigation.

SAP Worksheet No. 10 -- Conceptual Site Model

(UFP-QAPP Manual Section 2.5.2)

Section 10 of the January 2011 SAP presented a physical description, a site history, a summary of previous environmental investigations, current conditions, and a conceptual site model (CSM) for SWMU 22. Section 10 in this SAP Addendum 1) presents information about the site obtained from the January and April 2011 field events and summarizes the analytical and screening results, 2) identifies data gaps and updates the CSM for the site, 3) develops the supplemental sampling program for further characterization of SWMU 22.

10.1 PHYSICAL SITE DESCRIPTION AND SITE HISTORY

As described in the January 2011 SAP, SWMU 22 is within the area referred to as the Explosive Actuated Device (EAD)/Booster Area (Figure 10-2). SWMU 22 sits at an elevation of approximately 760 feet mean sea level (msl). The east and south sides of the Site slope gently down to an elevation around 650 feet msl. SWMU 22 can be considered as three distinct production areas:

- Building 136 – Propellant Portion Building (including Lead Azide Pond)
- Building 138 – Pressing Building
- Building 2520 – Final Assembly Building

In the 1960s, a detonator loading line was established in Building 136 where lead azide and other sensitive explosives were loaded into small detonators. Processes were conducted progressively in the Buildings 2855 through 2863 and 2905, located north of Building 136 and referred to as the “Backline.” Materials used reportedly included lead azide, tetrazene, lead styphnate, and NOL-130 (mixture of lead azide, lead styphnate, tetracene, barium nitrate, and antimony sulfide). Historic activities performed in Building 138 include pressing small charge weights in pellet form. Building 2533, located north of Building 138, reportedly has been used for mixing explosive powders. Historic activities performed in Building 2520 include the assembly of finished items (detonators or boosters). Building 2803, located southeast of Building 2520, was used to test rocket components in live firing tests. Buildings 136, 138, and 2520 are still in use. Buildings 2855 through 2863, 2905, and 2803 are not in use and scheduled for demolition in 2011.

Since the initial investigation activities in January and April 2011, the NSA Crane Environmental Site Remediation Manager (ESRM) identified a list of munitions operations for the Booster Area; the list is included as Appendix F. The list identifies the total number and types of items manufactured in the Booster Area and Building 138 by year, from 1964 through 1977. By total number, detonators were the principal munitions manufactured in the Booster Area and Building 138. The detonators included primary explosives such as those identified above. Boosters were the next highest count item to be manufactured in the area. The boosters typically included the following explosives: black powder, tetryl, Composition CH-6 [principally Royal Demolition Explosive (RDX)], pentolite [50 percent pentaerythritol tetranitrate (PETN) and 50 percent trinitrotoluene (TNT)], and RDX.

10.2 INITIAL SAMPLING AND ANALYSIS (JANUARY AND APRIL 2011)

Sampling Locations

In January 2011, surface and subsurface soil samples were collected from 11 locations at SWMU 22 (Figures 10-7 and 10-8). The samples were collected from biased locations in the Backline Area and an area south of the Backline. The locations were anticipated to have a greater potential for contamination from process activities. In addition, surface water and sediment samples were collected from 11 locations along drainages from SWMU 22 and the principal tributary to Turkey Creek. The water body samples were collected to identify contamination that may have been released or migrated from SWMU 22.

Based on the results of the January 2011 sampling, additional surface water and sediment samples were collected in April 2011 to identify the potential source area(s) of the contamination along the tributary to Turkey Creek. The surface water and sediment samples were collected from additional drainages identified at SWMU 22 and from locations further upstream of the site than the January 2011 samples to identify potential on-site or upstream source areas (Figure 10-9).

Samples were collected in January and April 2011 in accordance with the January 2011 SAP. The locations of the samples collected in January and April 2011 are shown on Figures 10-7 through 10-9. The results of the January and April 2011 sampling are discussed in the following text.

Results

The analytical results from the January and April 2011 sampling events were compared to the Project Screening Levels (PSLs) identified and established in the SAP. Metals concentrations were also compared to background levels found in the soil at NSA Crane. A summary of the analytical results from January and April 2011 is presented on tables in Appendix G, which include:

- Table 10-1 – Analytical Results for Surface Soil Samples
- Table 10-2 – Analytical Results for Subsurface Soil Samples
- Table 10-3 – Analytical Results for Surface Water
- Table 10-4 – Analytical Results for Sediment

Figures illustrating locations where target analyte concentrations were greater than the PSLs are presented on the Figures 10-10 (surface and subsurface soil), 10-11 (surface water), and 10-12 (sediment).

Soil

Soil samples (surface and subsurface) collected at SWMU 22 were analyzed for explosives, perchlorate, and RCRA metals. Soil samples from two locations were also analyzed for pH for evaluation of ecological risk, if necessary. As shown in the Tables 10-1 and 10-2 and on Figure 10-10, metals (primarily arsenic and lead) were identified in soil at concentrations that exceeded an applicable PSL. No explosives or perchlorate were detected in soil. Arsenic was detected in all surface and subsurface soil samples at concentrations greater than the human health PSL of 0.026 milligrams per kilogram (mg/kg). (For screening, the human health PSL for arsenic is the USEPA Regions 3, 6, and 9 Residential Regional risk-based migration-to-groundwater Soil Screening Levels adjusted for a dilution attenuation factor of 20.) The maximum arsenic concentration in surface soil occurred at 22SB003 (7.9 mg/kg), and the maximum concentration in the subsurface soil occurred at 22SB011 (6.1 mg/kg).

Concentrations of lead exceeded the ecological PSL (11 mg/kg) in surface soil samples from 22SB007 (11.8 mg/kg), 22SB008 (11.2 mg/kg), and 22SB011 (11.5 mg/kg) and the human health PSL (81 mg/kg) in duplicate subsurface soil sample from 22SB001 (144 mg/kg), which was within the footprint of the former lead azide pond at a depth of 3 to 5 feet and was the maximum detection of lead in the Backline Area.

The metals concentrations in soil were compared to background concentrations, in accordance with the SAP decision rules. For arsenic, the surface and subsurface concentrations were less than the background 95% Upper Tolerance Limit (UTL) concentrations of 11.83 mg/kg and 12.5 mg/kg, respectively. For lead, the surface and subsurface concentrations were less than the background 95% UTL concentrations of 27.0 mg/kg and 19.6 mg/kg, respectively, except for the concentration detected in the subsurface soil at 22SB001. Therefore, lead is identified as a chemical of potential concern (COPC) in soil.

Sufficient data exists to evaluate the potential risk in the Backline Area, and no further delineation is required. However, based on the additional information regarding operations in the area of Building 138 and potential contaminants associated with these operations as well as the analytical data from this area, additional soil data is needed to determine the nature and extent of contamination in the area of Building 138 and to support a risk assessment for the area.

Surface Water

Eleven surface water samples (22SW001 through 22SW011) were collected in January 2011at SWMU 22. The surface water samples were analyzed for explosives, RCRA metals (total and dissolved), and perchlorate. As shown in Table 10-3 and in Figure 10-11, explosives (RDX) and metals (arsenic, cadmium, lead, and mercury) were identified in the January 2011 surface water samples at concentrations that exceeded the applicable PSL. Explosives (HMX and RDX) were principally detected in four samples (22SW001, 22SW002, 22SW003, and 22SW011) collected from the tributary to Turkey Creek located east of SWMU 22. RDX concentrations in these samples exceed the human health PSL of 0.61 micrograms per liter (μg/L), ranging from 0.75 and 0.78 μg/L in the downstream section of the tributary to 0.79 and 0.82 μg/L in the upstream section. RDX and HMX were detected in samples 22SW09 and 22SW10 from the surface water body in the northern portion of SWMU 22, but the concentrations were less than those from the tributary east of SWMU 22.

Several metals (arsenic, cadmium, and mercury) were also identified in surface water collected during January 2011 at concentrations that exceeded the applicable PSL. Arsenic was detected at concentrations above the human health PSL of 0.045 μg/L in the surface water samples from locations 22SW004, 22SW006, and 22SW007 (dissolved) in the drainage from the former lead azide pond and locations 22SW009, 22SW010, and 22SW018 in the drainage along Highway 330. Arsenic was detected in the surface water sample 22SW011 at a concentration exceeding the human health PSL. Arsenic was not detected in surface water locations 22SW001, 22SW002, and 22SW003, the downstream locations in the tributary to Turkey Creek.

Cadmium and lead were detected above the ecological PSLs (0.36 and 11 μg/L, respectively) in surface water samples 22SW004 (lead only), 22SW006, and 22SW007, located in the drainage from the former lead azide pond, but were generally not detected in surface water locations 22SW001, 22SW002, and 22SW003, the downstream locations in the tributary to Turkey Creek. Cadmium and lead were also detected above the ecological PSL in the sample and its duplicate from location 22SW018 in the drainage from Building 138 and along Highway 330 but were not detected above the ecological PSL in the filtered samples.

Mercury was detected above the human health and ecological PSL in surface water samples from 22SW004 (dissolved), 22SW006, and 22SW007 (dissolved), located in the drainage from the former lead azide pond, from location 22SW009 (dissolved) in the drainage along Highway 330, and from location 22SW011 (dissolved) upstream on SWMU 22 in the tributary to Turkey Creek.

Perchlorate was not detected in the surface water samples collected in January 2011.

Based on the results from the January 2011 sampling, additional surface water samples (22SW012 through 22SW021) were collected in April 2011 to further delineate concentrations of explosives in surface water (Table 10-3 and Figure 10-11). Surface water sample 22SW013, located upstream and north of SWMU 22, had a RDX concentration of 0.98 μg/L, suggesting a potential unidentified, upstream source for the RDX in the tributary. The highest concentrations (2.5 μg/L at 22SW017 and 1.5 μg/L at 22SW018) of RDX, which exceeded the human health PSL, were detected in surface water in the drainages from Building 138.

In accordance with the decision rules in the SAP, the analytes exceeding the human health PSL (RDX, arsenic, and mercury) will be retained as COPCs. Sufficient data exists to evaluate the potential risk in the Backline Area and along the tributary to Turkey Creek, and no further delineation is required for these areas. However, based on the additional information regarding operations in the area of Building 138 and potential contaminants associated with these operations as well as the analytical data from this area, additional surface water data is needed to determine the nature and extent of contamination of metals in the drainages from Building 138 and to support a risk assessment for the area. In addition, as the surface water drainages at SWMU 22 may receive base flow from groundwater, assessment of the groundwater for the COPCs is required to fully determine the nature of extent of contamination.

Sediment

Eleven sediment samples (22SD001 through 22SD011) were collected in January 2011; the sediment samples were co-located with surface water samples. The sediment samples were analyzed for explosives, RCRA metals, and TOC (for evaluation of ecological risk, if necessary). Explosives were not detected in the sediments samples collected in January 2011. As shown in the Table 10-4 and on Figure 10-12, arsenic was detected in all sediment samples at concentrations exceeding the human health PSL (0.39 mg/kg), with a maximum concentration of 12.3 mg/kg from 22SD011, an upstream location along the tributary to Turkey Creek. (For screening purposes, the human health PSL for arsenic is the USEPA Regions 3, 6, and 9 Residential Regional Screening Level.) Mercury was detected above the ecological PSL in the location 22SW009, and cadmium, chromium, and lead were detected above the ecological PSLs in the duplicate sample from the same location.

Based on the results from the January 2011 sampling, an additional sediment sample (22SD018) and field duplicate were collected in April 2011 to further delineate concentrations of metals in the drainage along Highway 330 surface water (Table 10-4 and Figure 10-12). Arsenic was detected in the April 2011 sediment samples at concentrations (1.2 mg/kg and 1.5 mg/kg, respectively) exceeding the human health PSL (0.39 mg/kg).

In accordance with the decision rules in the SAP, arsenic, which exceeded the human health PSL, will be retained as a COPC. Sufficient data exists to evaluate the potential risk in the Backline Area and along the tributary to Turkey Creek, and no further delineation is required for these areas. However, based on the additional information regarding operations in the area of Building 138 and the analytical data from this area, additional sediment data is needed to determine the nature and extent of contamination of metals in the drainages from Building 138 and to support a risk assessment for the area.

10.3 CONCEPTUAL SITE MODEL

The SAP presented a CSM for SWMU 22 that assumed contamination at the site was related to the "Backline" (i.e., Building 136 and the associated process buildings and features) and the potential migration pathways from it. The potential contamination included explosives, perchlorate, and RCRA metals that may have been released from processes at the site. The SAP CSM identified that these potential releases may present complete exposure pathways to human and ecological receptors and/or serve as a source of contamination to groundwater and surface water and present complete exposure pathways to human and ecological receptors through those routes.

The January and April 2011 sampling data identified target analytes that exceeded the human health PSLs and background values (soil) and are identified as COPCs at the site are:

- Metals in surface water (arsenic and mercury) and sediment (arsenic) and subsurface soil (arsenic and lead)
- Explosives (RDX) in surface water.

Based on the contaminant concentrations and their distributions, the area of Building 138 appears more likely to be the source of site contamination rather than the Backline area (Building 136/Building 2520). As contamination in the Backline area has been characterized such that risk assessment may be performed, the focus of this supplemental sampling is to determine the nature and extent of contamination in the area of Building 138 and to determine if operations in Building 138 are the source of contamination identified in that area.

Investigation of groundwater concurrent with soil is included as part of the supplemental investigation based on previous experience at NSA Crane, that if explosives are detected in surface water samples, groundwater has historically had detections of such compounds. Monitoring wells are anticipated to be installed bedrock based on the initial soils investigation (January 2011) at SWMU 22 and the known geology at NSA Crane. The geology in this portion of NSA Crane is typified by a thin mantle of overburden (10 feet thick or less) overlying bedrock (Pennsylvanian-age shale with interbedded sandstones and siltstones). Groundwater was not encountered in the overburden during the initial soils investigation at SWMU 22. Groundwater in the shallow bedrock at NSA crane in this area typically occurs at 25 to 30 feet below ground surface.

10.3.1 Sources and Potential Contamination

The potential source of contamination associated with the Building 138 area is related to its history of booster pressing and manufacturing, as well as repair of other munitions components. As discussed in Section 10.1, NSA Crane has identified information of historical operations for the Booster Area, including Building 138, which is presented in Appendix F. Based on the components of items manufactured or handled in Building 138, potential site-related contaminants include explosives [RDX, HMX, PETN, TNT nitroglycerin (NG), nitrocellulose, tetryl, and black powder] and metals.

10.3.2 Contaminant Migration Pathways

The principal potential migration pathway is release of contaminants to soil through:

- Spills from material handling or accidents
- Leaks from underground piping
- Aerial deposition from exhaust fans, roof vents, or ventilators directly or indirectly to the soil via deposition to building roofs or road surfaces and subsequent transport via downspouts or runoff.

Releases may have also occurred through direct discharge of contaminants from spills to surface water drainage pathways. After release, contamination may 1) present a complete exposure pathway to human or ecological receptors, and/or 2) serve as a secondary source of contamination to surface water drainage pathways, surface water bodies, or groundwater. Contaminants may leach from the soil or infiltrate directly and migrate through the vadose zone to groundwater. Further transport of contaminants may occur in groundwater through diffuse discharge to surface water or as seeps.

NSA Crane public works drawings PW0607 and ORD 260 (included herein as Appendix H) show the layout of Building 138 and the associated buildings. Floor drains are shown in drawing ORD 260, and the underground sewer line from Building 138 is shown in drawing PW0607.

10.3.3 Receptors and Exposure Pathways

Receptors and exposure pathways remain the same as those presented in the SAP. Human receptors include persons who currently, or could in the future, interact with contaminated media. Persons currently using the site include industrial or construction workers and trespassers. However, given that the future land use is unknown, it is customary to evaluate the future use of a property as residential and recreational. Therefore, potential future receptors include residents and persons recreating at the site. Human receptors may be exposed to different media, based on their specific activities. These media include surface and subsurface soil, groundwater, surface water, and sediment. Potential exposure pathways may include dermal contact with, inhalation of, or ingestion of contaminated media, including soil groundwater, surface water, or sediment. Currently, groundwater from this site is not used at NSA Crane for potable or agricultural purposes.

Ecological receptors include animal and plant species that could be affected by the contaminants that are present. Typically, ecological receptors can be exposed only to surface media – surface soil, surface water, and upper layers of wetland sediments. Exposure of ecological receptors to groundwater and subsurface soil is not anticipated; however, contamination in subsurface soil or groundwater may serve as sources of contamination to sediments or surface water through subsurface transport or diffuse flow to streams located nearby Building 138. The exposure medium for ecological receptors is surface soil, sediment, and surface water.

Terrestrial plants, invertebrates, and vertebrates are exposed to the surface soil by direct contact and ingestion of soil and other food items. Aquatic and semi-aquatic vegetation, benthic invertebrates, and aquatic organisms may be exposed to the surface water and sediment by direct contact and/or ingestion of sediment and surface water and other food items. The benthic invertebrates or other aquatic organisms may be consumed by wildlife. Although terrestrial vertebrates may be exposed to chemicals found in the air via inhalation, this is not considered a significant pathway.

SAP Worksheet No. 11 -- Project Quality Objectives/Systematic Planning Process Statements

(UFP-QAPP Manual Section 2.6.1)

During preparation of the SAP, project quality objectives (PQOs) were developed for the RCRA Facility Investigation (RFI) sampling program. The PQOs for the supplemental sampling remain the same; this section describes the planning process that was used to develop the specific supplemental sampling plan and how that data will be used to complete the RFI.

11.1 PROBLEM DEFINITION

Based on a review of the data collected in January and April 2011, some target analytes are present in environmental media at SWMU 22 at concentrations that exceed PSLs and background values (soil) and were determined to be COPCs. However, the data collected during the January and April 2011 sampling event is not sufficient to fully delineate the extent of COPCs in the Building 138 area. Furthermore, the presence of explosives in surface drainages from SWMU 22 suggests a source may be present either in soils and is leaching to surface water or in groundwater and is discharges to surface water. Therefore, supplemental investigation in the area of Building 138, is needed to obtain data to address these data gaps.

11.2 IDENTIFY THE INPUTS TO THE DECISIONS

The following physical and chemical data will be required:

1. Chemical Data: Surface soil, subsurface soil, surface water, sediment, and groundwater chemical data are needed to determine if target analytes are present in site media at concentrations greater than risk-based screening criteria. The list of chemical target analytes and Project Screening Levels (PSLs) associated with these analytes for each matrix is presented in Worksheet No. 15. Selection of target analytes was based on site operational knowledge, the CSM, and the January and April 2011 sampling data. The sampling methods are presented in Worksheet No. 18 of this SAP Addendum. Analytical methods are presented in Worksheet No. 19 of the SAP.

2. Project Screening Levels: The SWMU 22 RFI requires chemical data that can be compared to current USEPA and IDEM residential surface soil, subsurface soil, sediment, surface water, and groundwater (if necessary) risk-based screening criteria. A comprehensive list of the relevant environmental and medium-specific risk-based screening levels for the target analytes was determined (for the metals and explosives). The risk and regulatory criteria applicable to SWMU 22 include the IDEM Risk Integrated System of Closure (RISC) Default Closure Tables, Residential and Industrial Closure Levels; USEPA Regions 3, 6, and 9 Residential Regional

Screening Levels (R-RSLs) and risk-based migration-to-groundwater Soil Screening Levels (R-SSLs) for human health risk screening and for use in a Human Health Risk Assessment (HHRA) during the RFI, if necessary. The surface soil, sediment, and surface water ecological benchmarks for ecological risk screening and for use in an Ecological Risk Assessment (ERA) include the USEPA Ecological Soil Screening Levels (Eco SSL) (for soil), USEPA Region 5 RCRA Ecological Screening Levels (R5 ESL) (for soil, sediment, and surface water), USEPA Region 3 Biological Technical Assistance Group (R3 BTAG) Freshwater Surface Water and Sediment Screening Benchmarks (for surface water and sediment), Nitroaromatic Munition Compounds: Environmental Effects and Screening Values from Talmage et al., (1999) (for surface water), toxicity data from Ecotoxicology of Explosives (Sunahara et al., 2009) (for soil and sediment), and ECORISK Database (Release 2.4) (LANL, 2009) (for soil). The criterion for each analyte represents the PSL for each environmental matrix listed in Worksheet No. 15.

3. Survey Data: Survey coordinate data will be collected and documented in order to map the sampling locations with sub-meter accuracy. The survey will be relative to the Indiana State Plane Coordinate System (West Zone).

The background data set for various media at NSA Crane will also be used to determine whether metals present on-site are naturally occurring, or are site-related. Background data are described in the Base-Wide Background Soil Investigation for Naval Surface Warfare Center Crane (Tetra Tech, 2001).

11.3 STUDY AREA BOUNDARIES

Supplemental sampling will be limited to those areas where the nature and extent of contamination is not complete (horizontally and/or vertically). The sampling program will consist of soil samples and groundwater samples from around Building 138 and surface water and sediment samples from locations in drainages leading from Building 138, to better define the nature and extent of the constituents. The proposed locations of these supplemental samples, which identify the horizontal study area boundaries, are shown on Figure 17-3. The vertical study boundary is as identified in the SAP. The vertical study boundary also extends to the first groundwater zone encountered, estimated to be less than 30 feet below ground surface in the shallow bedrock.

11.4 ANALYTIC APPROACH

The decision rules presented in the SAP were used to develop the supplemental sampling plan presented in this SAP Addendum. Those rules stated that supplemental sampling and analysis would be conducted to determine the nature and extent of COPCs in the site media. The site media identified by the January and April 2011 sampling event are surface soil, subsurface soil, groundwater, surface water, and sediment.

The decision rules for the supplemental data use are as follows:

1. If all target analyte concentrations in surface soil, subsurface soil, sediment, and surface water in the supplemental round of sampling are less than the PSLs, then prepare RFI Report with no further characterization; otherwise, advance to Rule 2. The target analytes include a specific list of explosives and RCRA metals (see Worksheet No. 15).

2. For each target analyte, if the maximum measured concentration in any medium exceeds its human health screening value and background value (if applicable), then classify the chemical as a Contaminant of Potential Concern (COPC) for that medium and risk type; otherwise, exclude the chemical from further consideration in the risk screening. Comparisons to background concentrations will only be used to evaluate metals contamination because the metals occur naturally in all environmental media; explosives do not occur naturally is not expected to be present at measurable concentrations due to natural causes at this site. The comparative method will be used as outlined in the Base-Wide Background Soil Investigation (Tetra Tech, 2001), when the soil type present at the site can be determined or matched to a particular soil type considered in the Background Study. The geochemical method will be used as outlined in the Background Study when the soil type present is unknown or cannot be matched to a particular soil type considered in the Background Study.

If COPCs are identified for any analyte, then evaluate data set to determine if nature and extent of is sufficiently characterized. If the characterization is sufficient, prepare RFI Report; risks associated with COPCs will be evaluated in the RFI Report. If additional data is needed to characterize the nature, then evaluate data needs and determine whether to propose additional investigation or propose collection of data as part of a Corrective Measure Study.

11.5 PERFORMANCE OR ACCEPTANCE CRITERIA

The SWMU 22 RFI has been designed to rely on a phased approach of step-wise discovery and directed investigations based on biased sampling agreed upon by the Project Team. Surface and subsurface soil, groundwater, surface water, and sediment sample locations were selected (to determine the nature and extent of contamination) from areas most likely to be contaminated, as well as areas that represent upgradient conditions for SWMU 22, based on the previous step in the investigation (i.e., the January and April 2011 investigations) and field observations.

By Project Team consensus, additional samples will be collected as described in this SAP Addendum from areas that were not investigated during the initial investigation in January and April 2011 to fully delineate the nature and extent of contamination in SWMU 22. If all data have been collected as planned and no data points are missing or rejected for quality reasons, the investigation completeness will be considered satisfactory. If any data gaps are identified, including missing or rejected data, the

Project Team will assess whether a claim of having obtained project objectives is reasonable. This assessment will depend on the number and type of potential data gaps; therefore, a more detailed strategy cannot be presented at this time. Project Team stakeholders will be involved in rendering the final conclusion by consensus regarding adequacy of the data.

11.6 PLAN FOR OBTAINING DATA

Based on the information presented above, a detailed plan was developed to obtain the necessary data to address the problem. The sampling design and rationale for all samples to be collected are provided in Worksheet No. 17.

SAP Worksheet No. 14 -- Summary of Project Tasks

(UFP-QAPP Manual Section 2.8.1)

14.1 FIELD INVESTIGATION TASK PLAN

Site-specific SOPs have been developed for field activities at NSA Crane and are located in Appendix A of the SAP. Additional site-specific SOPs for field tasks associated with the supplemental sampling are located in Appendix I. The field tasks for the supplemental sampling are the same as presented in the SAP with the following additional tasks:

- Monitoring Well Drilling and Installation
- Well Surveying
- Well Development
- Groundwater-Level Measurements
- Low-Flow Purging and Sampling of Monitoring Wells
- Hydraulic Conductivity Testing

Safety requirements for these additional tasks are addressed in the revised site-specific Health and Safety Plan.

Monitoring Well Drilling and Installation

Groundwater monitoring wells will be installed in accordance with SOP-14 (Monitoring Well Installation, Appendix I). Monitoring wells are proposed to be installed in SWMU 22 as part of the RFI. It is anticipated that the wells at SWMU 22 will be installed in bedrock. One bedrock hole will be cored to characterize stratigraphy, fracture distribution, and other features of the bedrock units at SWMU 22. Procedures for drilling and logging a boring in rock are included in SOP-08 (Borehole Advancement and Soil Coring Using DPT and Hand Auger Techniques, Appendix A), and SOP-15 (Drilling and Geologic Logging of Boreholes in Bedrock, Appendix A).

Permanent monitoring wells will be constructed of 2-inch-diameter, Schedule 40, flush-joint, polyvinyl chloride (PVC) riser pipe and slotted screen (see SOP-14 Monitoring Well Installation). In each well, the screen will be 10 feet long and have a slot size of 0.010-inch (factory slotted). Details regarding well construction sand pack and grout materials, the outer protective casing, the well pad, and the protective barrier posts are included in SOP-14 (Monitoring Well Installation).

Well Surveying

Newly installed monitoring wells will be surveyed for horizontal and vertical location by an Indiana-licensed surveyor. The ground surface, the top of the protective casing, and the top of the well riser will be surveyed. Horizontal locations will be surveyed to 0.1 foot, and vertical elevations will be surveyed to

0.01 foot. Horizontal coordinates will be relative to the Indiana State Plane Coordinate System (West Zone), and the vertical elevations will be relative to North American Vertical Datum (NAVD) 88.

Well Development

All new monitoring wells will be developed in accordance with SOP-16 (Monitoring Well Development, Appendix I) to remove fine sediment from inside and around the well screens. Existing wells (wells 08MWT008 and 08MWT012) may be re-developed if sediment greater than 0.1 foot has accumulated in the well bottom.

All groundwater removed from the well during the development process will be stored in a portable holding tank (already present at NSA Crane) and discharged into a designated man-hole for treatment at the NSA Crane water treatment facility (see SOP-11 - Management of Investigation Derived Waste, Appendix A).

Groundwater-Level Measurements

Prior to sampling, one synoptic round of water-level measurements and total well depth soundings will be obtained at each of the new monitoring wells installed at SWMU 22. All groundwater-level measurements collected within SWMU 22 will be taken within an 8-hour period using an electronic water-level meter. Water-level elevations will be recorded to within 0.01-foot accuracy from a marked reference point on the well riser pipe. Detailed procedures regarding water-level measurements are included in SOP-17 (Measurement of Water Levels in Monitoring Wells). Water levels will be recorded on a groundwater level measurement form, provided in SOP-17. The water-level meter will be decontaminated between each well measurement; decontamination procedures are addressed in SOP-12.

Low-Flow Purging and Sampling of Monitoring Wells

Low-flow sampling procedures will be used to collect groundwater samples from the monitoring wells [see SOP-18 (Low Flow Well Purging and Stabilization), SOP-19 (Groundwater Sampling), and SOP-20 (Calibration and Care of Water Quality Meters), Appendix A].

Hydraulic Conductivity Testing

Single-well, in-situ hydraulic conductivity tests (also referred to as slug tests) will be conducted in the newly installed monitoring wells to collect data to estimate hydraulic conductivity values at SWMU 22. The tests will be performed in accordance with procedures outlines in SOP-21 (Hydraulic Conductivity Testing).

14.2 ADDITIONAL PROJECT-RELATED TASKS

Additional project-related tasks are discussed in Section 14.2 of Worksheet No. 14 of the SAP.

SAP Worksheet No. 15 -- Reference Limits and Evaluation Table

(UFP-QAPP Manual Section 2.8.1)

Matrix: Surface Soil (depth: 0 to 2 feet)
Analytical Group: Explosives (SW-846 Method 8330B)

Analyte	CAS Number	Project Screening Levels (mg/kg)		Project Screening Level References[1]	Project Quantitation Limit Goal (mg/kg)	APPL		
		HH	ECO	HH / ECO		LOQ (mg/kg)	LOD (mg/kg)	DL (mg/kg)
1,3,5-Trinitrobenzene	**99-35-4**	78	**0.376**	R-SSL **/ R5 ESL**	**0.13**	**0.50**	**0.158**	**0.079**
1,3-Dinitrobenzene	**99-65-0**	**0.066**	0.655	**R-SSL /** R5 ESL	**0.022**	**0.50**	**0.1268**	**0.0634**
2,4,6-Trinitrotoluene (TNT)	**118-96-7**	**0.26**	6	**R-SSL /** Sunahara	**0.087**	**0.50**	**0.166**	**0.083**
2,4-Dinitrotoluene	**121-14-2**	**0.0058**	1.28	**R-SSL /** R5 ESL	**0.0019**	**0.50**	**0.166**	**0.083**
2,6-Dinitrotoluene	**606-20-2**	1.0	**0.0328**	R-SSL **/ R5 ESL**	**0.011**	**0.50**	**0.166**	**0.083**
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	46	---	R-SSL / None	15	0.50	0.16	0.08
3-Nitrotoluene	**99-08-1**	**0.068**	**---**	**R-SSL / None**	**0.023**	**0.50**	**0.142**	**0.071**
2-Nitrotoluene	**88-72-2**	**0.0058**	**---**	**R-SSL / None**	**0.0019**	**0.50**	**0.132**	**0.066**
4-Nitrotoluene	**99-99-0**	**0.078**	**---**	**R-SSL / None**	**0.026**	**0.50**	**0.16**	**0.080**
4-Amino-2,6-Dinitrotoluene	19406-51-0	1.1	---	R-SSL / None	0.37	0.50	0.15	0.075
2-Amino-4,6-Dinitrotoluene	35572-78-2	1.1	80	R-SSL / LANL	0.37	0.50	0.15	0.075
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8	24	25	R-RSL / LANL	8.0	0.50	0.182	0.091
Nitrobenzene	**98-95-3**	**0.0016**	1.31	**R-SSL /** R5 ESL	**0.0093**	**0.50**	**0.15**	**0.075**
Octahydro-1,3,5,7-tetranitro-1,3,5-triazine (RDX)	**121-82-4**	**0.0046**	98	**R-SSL /** Sunahara	**0.0015**	**0.50**	**0.16**	**0.08**
PETN	**78-11-5**	**0.5**	**---**	**R-SSL**	**0.17**	**2.50**	**1.158**	**0.579**
Nitroglycerin	**55-63-0**	**0.032**	**---**	**R-SSL**	**0.011**	**0.50**	**0.17**	**0.085**

CAS – Chemical Abstract Service
DL – Detection Limit
Eco - Ecological
HH – Human Health
LOD – Limit of Detection
LOQ – Limit of Quantitation

(1) Surface soil screening references: R-RSL – Regions 3, 6, and 9 Regional Screening Level, Direct Contact Residential (USEPA, 2011); R-SSL – Regions 3, 6, and 9 Soil Screening Level, Risk-Based Migration-to-Groundwater, Dilution Attenuation Factor (DAF) = 20 (USEPA, 2011); IDEM R-DCL – Residential Default Closure Level (IDEM, 2009); Eco SSL – Ecological Soil Screening Level (USEPA, 2008a); R5 ESL – Region 5 Ecological Screening Level (USEPA, 2003a); Sunahara – Ecotoxicity of Explosives (Sunahara et al., 2009); LANL – ECORISK Database (Release 2.4) (LANL, 2009). Refer to Appendix E for further explanation and justification of PSLs.

Bolded compounds indicate that the PSL is between the laboratory LOQ and LOD. Bolded and shaded compounds indicate that the PSL is less than both the laboratory LOQ and LOD. All results will be reported to LODs and any limitations on data use that result from having LODs that are greater than PSLs will be described in the RFI Report. The DLs are presented for informational purposes.

Matrix: Surface Soil (depth: 0 to 2 feet)
Analytical Group: RCRA Metals (SW-846 Methods 6020A and 7471A)

Analyte	CAS Number	Project Screening Levels (mg/kg)		Project Screening Level References(1)	Project Quantitation Limit Goal (mg/kg)	APPL		
		HH	ECO	HH / ECO		LOQ (mg/kg)	LOD (mg/kg)	DL (mg/kg)
Arsenic	**7440-38-2**	**0.026**	18	**R-SSL /** Eco SSL	**0.0087**	**0.60**	**0.176**	**0.088**
Barium	7440-39-3	1,500	330	R-RSL / Eco SSL	110	0.50	0.094	0.047
Cadmium	**7440-43-9**	7	**0.36**	R-RSL **/ Eco SSL**	**0.12**	**0.50**	**0.056**	**0.028**
Chromium	7440-47-3	38	26	IDEM R-DCL / Eco SSL	8.7	0.50	0.058	0.029
Lead	7439-92-1	81	11	IDEM R-DCL / Eco SSL	3.7	0.50	0.184	0.092
Mercury	7439-97-6	0.66	0.1	R-SSL / R5 ESL	0.033	0.1	0.0338	0.0169
Selenium	**7782-49-2**	5.2	**0.52**	IDEM R-DCL **/ Eco SSL**	**0.17**	**0.90**	**0.488**	**0.244**
Silver	7440-22-4	31	4.2	IDEM R-DCL / Eco SSL	1.4	0.20	0.072	0.036

(1) Surface soil screening references: R-RSL – Regions 3, 6, and 9 Regional Screening Level, Direct Contact Residential (USEPA, 2011); R-SSL – Regions 3, 6, and 9 Soil Screening Level, Risk-Based Migration-to-Groundwater, Dilution Attenuation Factor (DAF) = 20 (USEPA, 2011); IDEM R-DCL – Residential Default Closure Level (IDEM, 2009); Eco SSL – Ecological Soil Screening Level (USEPA, 2008a); R5 ESL – Region 5 Ecological Screening Level (USEPA, 2003a); Sunahara – Ecotoxicity of Explosives (Sunahara et al., 2009); LANL – ECORISK Database (Release 2.4) (LANL, 2009). Refer to Appendix E for further explanation and justification of PSLs.

Bolded compounds indicate that the PSL is between the laboratory LOQ and LOD. Bolded and shaded compounds indicate that the PSL is less than both the laboratory LOQ and LOD. All results will be reported to LODs and any limitations on data use that result from having LODs that are greater than PSLs will be described in the RFI Report. The DLs are presented for informational purposes.

Matrix: Subsurface Soil (depth: greater than 2 feet)
Analytical Group: Explosives (SW-846 Method 8330B)

Analyte	CAS Number	Project Screening Levels (mg/kg)	Project Screening Level References(1)	Project Quantitation Limit Goal (mg/kg)	APPL		
		HH	HH		LOQ (mg/kg)	LOD (mg/kg)	DL (mg/kg)
1,3,5-Trinitrobenzene	99-35-4	78	R-SSL	26	0.50	0.158	0.079
1,3-Dinitrobenzene	**99-65-0**	**0.066**	**R-SSL**	**0.022**	**0.50**	**0.1268**	**0.0634**
TNT	**118-96-7**	**0.26**	**R-SSL**	**0.087**	**0.50**	**0.166**	**0.083**
2,4-Dinitrotoluene	**121-14-2**	**0.0058**	**R-SSL**	**0.0019**	**0.50**	**0.166**	**0.083**
2,6-Dinitrotoluene	**606-20-2**	**0.0328**	**R5 ESL**	**0.011**	**0.50**	**0.166**	**0.083**
HMX	2691-41-0	46	R-SSL	15	0.50	0.16	0.08
3-Nitrotoluene	**99-08-1**	**0.068**	**R-SSL**	**0.023**	**0.50**	**0.142**	**0.071**
2-Nitrotoluene	**88-72-2**	**0.0058**	**R-SSL**	**0.0019**	**0.50**	**0.132**	**0.066**
4-Nitrotoluene	**99-99-0**	**0.078**	**R-SSL**	**0.026**	**0.50**	**0.16**	**0.080**
4-Amino-2,6-Dinitrotoluene	19406-51-0	1.1	R-SSL	0.37	0.50	0.15	0.075
2-Amino-4,6-Dinitrotoluene	35572-78-2	1.1	R-SSL	0.37	0.50	0.15	0.075
Tetryl	479-45-8	24	R-RSL	8.0	0.50	0.182	0.091
Nitrobenzene	**98-95-3**	**0.0016**	**R-SSL**	**0.0093**	**0.50**	**0.15**	**0.075**
RDX	**121-82-4**	**0.0046**	**R-RSL**	**0.0015**	**0.50**	**0.16**	**0.08**
PETN	**78-11-5**	**0.5**	**R-SSL**	**0.17**	**2.50**	**1.158**	**0.579**
Nitroglycerin	**55-63-0**	**0.032**	**R-SSL**	**0.011**	**0.50**	**0.17**	**0.085**

(1) Subsurface soil screening references: R-RSL – Regions 3, 6, and 9 Regional Screening Level, Direct Contact Residential (USEPA, 2011); R-SSL – Regions 3, 6, and 9 Soil Screening Level, Risk-Based Migration-to-Groundwater, Dilution Attenuation Factor (DAF) = 20 (USEPA, 2011); IDEM R-DCL – Residential Default Closure Level (IDEM, 2009). Refer to Appendix E for further explanation and justification of PSLs.

Bolded compounds indicate that the PSL is between the laboratory LOQ and LOD. Bolded and shaded compounds indicate that the PSL is less than both the laboratory LOQ and LOD. All results will be reported to LODs and any limitations on data use that result from having LODs that are greater than PSLs will be described in the RFI Report. The DLs are presented for informational purposes.

There is a PSL for human health only (there is no ecological PSL because there is no complete exposure path for ecological receptors).

Matrix: Subsurface Soil (depth: greater than 2 feet)
Analytical Group: RCRA Metals (SW-846 Methods 6020A and 7471A)

Analyte	CAS Number	Project Screening Levels (mg/kg)	Project Screening Level References(1)	Project Quantitation Limit Goal (mg/kg)	APPL		
		HH	HH		LOQ (mg/kg)	LOD (mg/kg)	DL (mg/kg)
Arsenic	**7440-38-2**	**0.026**	**R-SSL**	**0.0087**	**0.60**	**0.176**	**0.088**
Barium	7440-39-3	1,500	R-RSL	500	0.50	0.094	0.047
Cadmium	7440-43-9	7	R-RSL	2.3	0.50	0.056	0.028
Chromium	7440-47-3	38	IDEM R-DCL	13	0.50	0.058	0.029
Lead	7439-92-1	81	IDEM R-DCL	27	0.50	0.184	0.092
Mercury	7439-97-6	0.66	R-SSL	0.19	0.10	0.0338	0.0169
Selenium	7782-49-2	5.2	IDEM R-DCL	1.7	0.90	0.488	0.244
Silver	7440-22-4	31	IDEM R-DCL	10	0.20	0.072	0.036

DAF – Dilution Attenuation Factor

(1) Subsurface soil screening references: R-RSL – Regions 3, 6, and 9 Regional Screening Level, Direct Contact Residential (USEPA, 2011); R-SSL – Regions 3, 6, and 9 Soil Screening Level, Risk-Based Migration-to-Groundwater, DAF = 20 (USEPA, 2011); IDEM R-DCL – Residential Default Closure Level (IDEM, 2009). Refer to Appendix E for further explanation and justification of PSLs.

Bolded compounds indicate that the PSL is between the laboratory LOQ and LOD. Bolded and shaded compounds indicate that the PSL is less than both the laboratory LOQ and LOD. All results will be reported to LODs and any limitations on data use that result from having LODs that are greater than PSLs will be described in the RFI Report. The DLs are presented for informational purposes.

There is a PSL for human health only (there is no ecological PSL because there is no complete exposure path for ecological receptors).

Matrix: Sediment
Analytical Group: Explosives (SW-846 Method 8330B)

Analyte	CAS Number	Project Screening Levels (mg/kg)		Project Screening Level References(1)	Project Quantitation Limit Goal (mg/kg)	APPL		
		HH	ECO	HH / ECO		LOQ (mg/kg)	LOD (mg/kg)	DL (mg/kg)
1,3,5-Trinitrobenzene	99-35-4	220	8	R-RSL / Sunahara	2.7	0.50	0.158	0.079
1,3-Dinitrobenzene	**99-65-0**	**0.61**	**0.0081**	**R-RSL / R5 ESL**	**0.0027**	**0.50**	**0.1268**	**0.0634**
TNT	118-96-7	3.6	4	R-RSL / Sunahara	6.0	0.50	0.166	0.083
2,4-Dinitrotoluene	**121-14-2**	**1.6**	**0.0144**	**R-RSL / R5 ESL**	**0.0048**	**0.50**	**0.166**	**0.083**
2,6-Dinitrotoluene	**606-20-2**	**6.1**	**0.0398**	**R-RSL / R5 ESL**	**0.013**	**0.50**	**0.166**	**0.083**
HMX	2691-41-0	380	126	R-RSL / R5 ESL	42	0.50	0.16	0.08
3-Nitrotoluene	99-08-1	0.61	---	R-RSL / None	0.20	0.50	0.142	0.071
2-Nitrotoluene	88-72-2	2.9	---	R-RSL / None	0.97	0.50	0.132	0.066
4-Nitrotoluene	99-99-0	24	4.06	R-RSL / R3 SED BTAG	1.3	0.50	0.16	0.080
4-Amino-2,6-Dinitrotoluene	19406-51-0	15	---	R-RSL / None	5.0	0.50	0.15	0.075
2-Amino-4,6-Dinitrotoluene	35572-78-2	15	---	R-RSL / None	5.0	0.50	0.15	0.075
Tetryl	**479-45-8**	24	**0.1**	R-RSL **/ Sunahara**	**0.033**	**0.50**	**0.182**	**0.091**
Nitrobenzene	**98-95-3**	4.8	**0.145**	R-RSL **/ R5 ESL**	**0.048**	**0.50**	**0.15**	**0.075**
RDX	121-82-4	5.6	102	R-RSL / Sunahara	1.8	0.50	0.16	0.08
PETN	**78-11-5**	**0.5**	---	**R-RSL / None**	**0.17**	**2.50**	**1.158**	**0.579**
Nitroglycerin	55-63-0	0.61	---	R-RSL / None	0.2	0.50	0.17	0.085

(1) Sediment screening references: R-RSL – Regions 3, 6, and 9 Regional Screening Level, Direct Contact Residential (USEPA, 2011); IDEM R-DCL – Residential Default Closure Level (IDEM, 2009); R5 ESL – Region 5 Ecological Screening Level (USEPA, 2003a); R3 SED BTAG – Region 3 Biological Technical Assistance Group Freshwater Sediment Screening Benchmarks (USEPA, 2006a); Sunahara – Ecotoxicity of Explosives (Sunahara et al., 2009). Refer to Appendix E for further explanation and justification of PSLs.

Bolded compounds indicate that the PSL is between the laboratory LOQ and LOD. Bolded and shaded compounds indicate that the PSL is less than both the laboratory LOQ and LOD. All results will be reported to LODs and any limitations on data use that result from having LODs that are greater than PSLs will be described in the RFI Report. The DLs are presented for informational purposes.

Matrix: Sediment
Analytical Group: RCRA Metals (SW-846 Methods 6020A and 7471A)

Analyte	CAS Number	Project Screening Levels (mg/kg)		Project Screening Level References(1)	Project Quantitation Limit Goal (mg/kg)	APPL		
		HH	ECO	HH / ECO		LOQ (mg/kg)	LOD (mg/kg)	DL (mg/kg)
Arsenic	**7440-38-2**	**0.39**	9.79	**R-RSL /** R5 ESL	**0.13**	**0.60**	**0.176**	**0.088**
Barium	7440-39-3	1,500	---	R-RSL / None	500	0.50	0.094	0.047
Cadmium	7440-43-9	7	0.99	R-RSL / R5 ESL	0.33	0.50	0.056	0.028
Chromium	7440-47-3	430	26	IDEM R-DCL / R5 ESL	8.6	0.50	0.058	0.029
Lead	7439-92-1	81	35.8	IDEM R-DCL / R5 ESL	12	0.50	0.184	0.092
Mercury	7439-97-6	1	0.174	R-RSL / R5 ESL	0.058	0.10	0.0338	0.0169
Selenium	7782-49-2	39	2	R-RSL / R3 BTAG	0.67	0.90	0.488	0.244
Silver	7440-22-4	39	0.5	R-RSL / R5 ESL	0.17	0.20	0.072	0.036

(1) Sediment screening references: R-RSL – Regions 3, 6, and 9 Regional Screening Level, Direct Contact Residential (USEPA, 2011); IDEM R-DCL – Residential Default Closure Level (IDEM, 2009); R5 ESL – Region 5 Ecological Screening Level (USEPA, 2003a); R3 SED BTAG – Region 3 Biological Technical Assistance Group Freshwater Sediment Screening Benchmarks (USEPA, 2006a); Sunahara – Ecotoxicity of Explosives (Sunahara et al., 2009). Refer to Appendix E for further explanation and justification of PSLs.

Bolded compounds indicate that the PSL is between the laboratory LOQ and LOD. Bolded and shaded compounds indicate that the PSL is less than both the laboratory LOQ and LOD. All results will be reported to LODs and any limitations on data use that result from having LODs that are greater than PSLs will be described in the RFI Report. The DLs are presented for informational purposes.

Matrix: Surface Water
Analytical Group: Explosives (SW-846 Method 8330B)

Analyte	CAS Number	Project Screening Levels (µg/L)		Project Screening Level References[1]	Project Quantitation Limit Goal (µg/L)	APPL		
		HH	ECO	HH / ECO		LOQ (µg/L)	LOD (µg/L)	DL (µg/L)
1,3,5-Trinitrobenzene	99-35-4	110	10	T-RSL / Talmage	3.3	0.50	0.26	0.130
1,3-Dinitrobenzene	**99-65-0**	**0.37**	22	**T-RSL /** R5 ESL	**0.12**	**0.50**	**0.262**	**0.131**
TNT	118-96-7	1.8	100	T-RSL / R3 SW BTAG	0.73	0.50	0.266	0.133
2,4-Dinitrotoluene	**121-14-2**	**0.22**	44	**T-RSL /** R5 ESL	**0.073**	**0.50**	**0.25**	**0.125**
2,6-Dinitrotoluene	606-20-2	3.7	81	T-RSL / R5 ESL	1.2	0.50	0.25	0.125
HMX	2691-41-0	180	150	T-RSL / R3 SW BTAG	60	0.50	0.23	0.115
3-Nitrotoluene	**99-08-1**	**0.37**	750	**T-RSL /** R3 SW BTAG	**0.12**	**0.50**	**0.266**	**0.133**
2-Nitrotoluene	**88-72-2**	**0.31**	750	**T-RSL /** R3 SW BTAG	**0.10**	**0.50**	**0.252**	**0.126**
4-Nitrotoluene	99-99-0	4.2	1,900	T-RSL / R3 SW BTAG	1.4	0.50	0.266	0.133
4-Amino-2,6-Dinitrotoluene	19406-51-0	7.3	1,480	T-RSL / R3 SW BTAG	2.4	0.50	0.20	0.100
2-Amino-4,6-Dinitrotoluene	35572-78-2	7.3	1,480	T-RSL / R3 SW BTAG	2.4	0.50	0.25	0.125
Tetryl	479-45-8	15	---	T-RSL / None	5.0	0.50	0.266	0.133
Nitrobenzene	**98-95-3**	**0.12**	220	**T-RSL /** R5 ESL	**0.040**	**0.50**	**0.252**	**0.126**
RDX	121-82-4	0.61	360	T-RSL / R3 SW BTAG	0.20	0.50	0.246	0.123
PETN	78-11-5	7.3	425	T-RSL / TCEQ	2.4	2.50	1.214	0.607
Nitroglycerin	**55-63-0**	**0.37**	---	T-RSL / None	**0.12**	**0.50**	**0.26**	**0.130**

(1) Surface water screening references: T-RSL – Regions 3, 6, and 9 Regional Screening Level for Tapwater (USEPA, 2011); IDEM GW-DCL – Residential Groundwater Default Closure Level (IDEM, 2009); IDEM SW – Indiana Minimum Surface Water Quality Standards (IDEM, 2002); R5 ESL – Region 5 Ecological Screening Level (USEPA, 2003a); R3 SW BTAG – Region 3 Biological Technical Assistance Group Freshwater Surface Water Screening Benchmarks (USEPA, 2006b); Talmage – Nitroaromatic Munition Compounds: Environmental Effects and Screening Values (Talmage et al., 1999); USEPA Health Advisory – Interim Drinking Water Health Advisory Level (USEPA, 2009); TCEQ – Texas Commission on Environmental Quality Update to Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas RG-263. Refer to Appendix E for further explanation and justification of PSLs.

Bolded compounds indicate that the PSL is between the laboratory LOQ and LOD. Bolded and shaded compounds indicate that the PSL is less than both the laboratory LOQ and LOD. All results will be reported to LODs and any limitations on data use that result from having LODs that are greater than PSLs will be described in the RFI Report. The DLs are presented for informational purposes.

Matrix: Surface Water
Analytical Group: RCRA Metals (SW-846 Methods 6020A and 7470A)

Analyte	CAS Number	Project Screening Levels (µg/L)		Project Screening Level References[1]	Project Quantitation Limit Goal (µg/L)	APPL		
		HH	ECO	HH / ECO		LOQ (µg/L)	LOD (µg/L)	DL (µg/L)
Arsenic	**7440-38-2**	**0.045**	148	**T-RSL /** R5 ESL	**0.015**	**5.0**	**4.9**	**2.45**
Barium	7440-39-3	730	220	T-RSL / R5 ESL	73	5.0	1.5	0.75
Cadmium	**7440-43-9**	**1.8**	**0.15**	**T-RSL / R5 ESL**	**0.050**	**5.0**	**1.02**	**0.51**
Chromium	7440-47-3	50	42	IDEM SW / R5 ESL	14	5.0	2.74	1.37
Lead	**7439-92-1**	15	**1.17**	**IDEM GW-DCL / R5 ESL**	**0.39**	**5.0**	**3.16**	**1.58**
Mercury	**7439-97-6**	**0.063**	**0.0013**	**T-RSL / R5 ESL**	**0.00043**	**0.20**	**0.128**	**0.064**
Selenium	7782-49-2	10	5	IDEM SW / R5 ESL	1.7	5.0	6.34	3.17
Silver	7440-22-4	18	0.12	T-RSL / R5 ESL	0.040	1.0	0.498	0.249

(1) Surface water screening references: T-RSL – Regions 3, 6, and 9 Regional Screening Level for Tapwater (USEPA, 2011); IDEM GW-DCL – Residential Groundwater Default Closure Level (IDEM, 2009); IDEM SW – Indiana Minimum Surface Water Quality Standards (IDEM, 2002); R5 ESL – Region 5 Ecological Screening Level (USEPA, 2003a); R3 SW BTAG – Region 3 Biological Technical Assistance Group Freshwater Surface Water Screening Benchmarks (USEPA, 2006b); Talmage – Nitroaromatic Munition Compounds: Environmental Effects and Screening Values (Talmage et al., 1999); USEPA Health Advisory – Interim Drinking Water Health Advisory Level (USEPA, 2009). Refer to Appendix E for further explanation and justification of PSLs.

Bolded compounds indicate that the PSL is between the laboratory LOQ and LOD. Bolded and shaded compounds indicate that the PSL is less than both the laboratory LOQ and LOD. All results will be reported to LODs and any limitations on data use that result from having LODs that are greater than PSLs will be described in the RFI Report. The DLs are presented for informational purposes.

Matrix: Groundwater
Analytical Group: Explosives (SW-846 Method 8330B)

Analyte	CAS Number	Project Screening Levels (µg/L)	Project Screening Level References[(1)]	Project Quantitation Limit Goal (µg/L)	APPL		
					LOQ (µg/L)	LOD (µg/L)	DL (µg/L)
1,3,5-Trinitrobenzene	99-35-4	110	T-RSL	36.7	0.50	0.26	0.130
1,3-Dinitrobenzene	**99-65-0**	**0.37**	**T-RSL**	**0.12**	**0.50**	**0.262**	**0.131**
TNT	118-96-7	1.8	T-RSL	0.73	0.50	0.266	0.133
2,4-Dinitrotoluene	**121-14-2**	**0.22**	**T-RSL**	**0.073**	**0.50**	**0.25**	**0.125**
2,6-Dinitrotoluene	606-20-2	3.7	T-RSL	1.2	0.50	0.25	0.125
HMX	2691-41-0	180	T-RSL	60	0.50	0.23	0.115
3-Nitrotoluene	**99-08-1**	**0.37**	**T-RSL**	**0.12**	**0.50**	**0.266**	**0.133**
2-Nitrotoluene	**88-72-2**	**0.31**	**T-RSL**	**0.10**	**0.50**	**0.252**	**0.126**
4-Nitrotoluene	99-99-0	4.2	T-RSL	1.4	0.50	0.266	0.133
4-Amino-2,6-Dinitrotoluene	19406-51-0	7.3	T-RSL	2.4	0.50	0.20	0.100
2-Amino-4,6-Dinitrotoluene	35572-78-2	7.3	T-RSL	2.4	0.50	0.25	0.125
Tetryl	479-45-8	15	T-RSL	5.0	0.50	0.266	0.133
Nitrobenzene	**98-95-3**	**0.12**	**T-RSL**	**0.040**	**0.50**	**0.252**	**0.126**
RDX	121-82-4	0.61	T-RSL	0.20	0.50	0.246	0.123
PETN	78-11-5	7.3	T-RSL	2.4	2.50	1.214	0.607
Nitroglycerin	**55-63-0**	**0.37**	**T-RSL**	**0.12**	**0.50**	**0.26**	**0.130**

(1) Groundwater screening references: T-RSL – Regions 3, 6, and 9 Regional Screening Level for Tapwater (USEPA, 2011.

Bolded compounds indicate that the PSL is between the laboratory LOQ and LOD. Bolded and shaded compounds indicate that the PSL is less than both the laboratory LOQ and LOD. All results will be reported to LODs and any limitations on data use that result from having LODs that are greater than PSLs will be described in the RFI Report. The DLs are presented for informational purposes.

Matrix: Groundwater
Analytical Group: RCRA Metals (SW-846 Methods 6020A and 7470A)

Analyte	CAS Number	Project Screening Levels (µg/L)	Project Screening Level References[(1)]	Project Quantitation Limit Goal (µg/L)	APPL		
					LOQ (µg/L)	LOD (µg/L)	DL (µg/L)
Arsenic	**7440-38-2**	**0.045**	**T-RSL**	**0.015**	**5.0**	**4.9**	**2.45**
Barium	7440-39-3	730	T-RSL	73	5.0	1.5	0.75
Cadmium	7440-43-9	5	IDEM GW - DCL	1.7	5.0	1.02	0.51
Chromium	**7440-47-3**	**0.042**	**T-RSL**	**0.014**	**5.0**	**2.74**	**1.37**
Lead	7439-92-1	15	T-RSL	5	5.0	3.16	1.58
Mercury	7439-97-6	1.1	T-RSL	0.37	0.20	0.128	0.064
Selenium	7782-49-2	5	IDEM GW- DCL	1.7	5.0	6.34	3.17
Silver	7440-22-4	18	T-RSL	6	1.0	0.498	0.249

(1) Groundwater screening references: T-RSL – Regions 3, 6, and 9 Regional Screening Level for Tapwater (USEPA, 2011); IDEM GW-DCL – Residential Groundwater Default Closure Level (IDEM, 2009.

Bolded compounds indicate that the PSL is between the laboratory LOQ and LOD. Bolded and shaded compounds indicate that the PSL is less than both the laboratory LOQ and LOD. All results will be reported to LODs and any limitations on data use that result from having LODs that are greater than PSLs will be described in the RFI Report. The DLs are presented for informational purposes.

Matrix: Groundwater
Analytical Group: Perchlorate (SW-846 method 6850)

Analyte	CAS Number	Project Screening Levels (μg/L)	Project Screening Level References[(1)]	Project Quantitation Limit Goal (μg/L)	APPL		
					LOQ (μg/L)	LOD (μg/L)	DL (μg/L)
Perchlorate	**14797-73-10**	**2.6**	**T-RSL**	**0.87**	**0.60**	**0.400**	**0.200**

(1) Groundwater screening references: T-RSL – Regions 3, 6, and 9 Regional Screening Level for Tapwater (USEPA, 2011);

Bolded compounds indicate that the PSL is between the laboratory LOQ and LOD. Bolded and shaded compounds indicate that the PSL is less than both the laboratory LOQ and LOD. All results will be reported to LODs and any limitations on data use that result from having LODs that are greater than PSLs will be described in the RFI Report. The DLs are presented for informational purposes.

SAP Worksheet No. 16 -- Project Schedule/Timeline Table

(UFP-QAPP Manual Section 2.8.2)

Activities	Organization	Dates (MM/DD/YYYY)		Deliverable	Deliverable Due Date
		Anticipated Date of Initiation	Anticipated Date of Completion		
Supplemental Soil, Groundwater, and Surface Water/Sediment Sampling	Tetra Tech	4/09/12	4/27/12	RFI Report, SWMU 22	06/29/12 (Draft) 08/24/12 (Final)

SAP Worksheet No. 17 -- Sampling Design and Rationale

(UFP-QAPP Manual Section 3.1.1)

Samples will be collected as part of the supplemental sampling at SWMU 22 to further define the nature and extent of contamination in site media. The sampling strategy for the supplemental sampling at SWMU 22 is based on a judgmental (biased) sampling design. The objective of the sampling is to determine if residual contamination related to historical use of the site (focusing on Building 138 for this phase of investigation) is present at levels of concern. The analytes for the supplemental sampling are the same as for the initial sampling in the SAP, except for perchlorate. Analyses for the supplemental sampling will be performed for the following analytes:

- Explosives, including PETN and NG
- RCRA Metals
- Perchlorate (groundwater only)

Analysis for pH (soil and sediment only) and total organic carbon (TOC) (sediment only) will also be performed to support evaluation of metals data for ecological screening. The proposed soil, groundwater, surface water, and sediment sample locations are shown on Figure 17-3. Proposed sample depths and analyses are listed in Worksheet No. 18.

The following discusses the sampling locations, media to be sampled, and analyses. Proposed sampling locations are shown on Figure 17-3, and a matrix table of samples is provided in Worksheet No. 18. Soil borings will be advanced using direct-push technology (DPT) to collect soil samples. Surface water samples will be collected by directly filling the bottles from the stream. Water quality parameters [pH, specific conductivity, turbidity, temperature, oxidation-reduction potential (ORP), and dissolved oxygen (DO)] will be recorded at each sampling location. Sediment samples will be collected by filling the sample jars using either a decontaminated stainless steel trowel or dedicated disposable plastic trowel.

Groundwater samples will be collected due to detections of explosives in surface water at SWMU 22 during the initial investigation in January and April 2011. The initial sampling event will include well development, collection of one round of groundwater samples from monitoring wells in the upper water-bearing zone, and an elevation survey. Groundwater samples will also be analyzed for field parameters, including water levels, pH, specific conductivity, turbidity, temperature, ORP, and DO to support field sampling decisions.

Sampling and other field task methodologies are described in Worksheet No. 14.

17.1 SOIL SAMPLING

Six soil borings (22SB012 to 22SB018) will be advanced around Building 138, as shown on Figure 17-3. Soil samples will be collected from the three locations using a DPT rig (SOP-08, Appendix A) to assess whether soil conditions have been impacted due to past operations at Building 138. A surface soil sample and a subsurface soil sample will be collected from each location (SOP-10, Appendix A). Surface soils samples will be collected from the 0 to 2 feet interval, and subsurface soil samples will be collected from a depth of approximately 3 to 5 feet. In addition, a subsurface soil sample will be collected from each boring 22SB15 through 22SB17, located along the sewer line from Building 138, at the approximate depth of the bottom of the sewer and from boring 22SB18, located adjacent to the pit northwest of Building 138, at the approximate depth of the bottom of the pit. The depth of the bottom of the sewer will be determined from the invert elevation of the sewer manhole, and the depth of the pit will be determined from direct measurement. If refusal on bedrock is encountered before these depths, the samples will be collected from the 2-foot soil interval on the bedrock surface.

The surface and subsurface soil samples will be analyzed for explosives (including PETN and NG) and RCRA metals. One location (22SB012) will also be analyzed for pH in the surface and subsurface soil samples.

17.2 GROUNDWATER SAMPLING

Six monitoring wells (22MWT001 through 22MWT006) will be installed in the area surrounding Building 138 (Figure 17-3). No monitoring wells currently exist within SWMU 22, and groundwater flow direction is not known. Therefore, the wells will be located to identify groundwater flow direction and to assess potential groundwater contamination in the area. Well 22MWT001 and 22MWT006 will be installed as upgradient locations, based on topography, to assess possible groundwater quality flowing into SWMU 22. Monitoring well installation will be in accordance with SOP-13 through SOP-16 (Appendix I).

Groundwater samples will be collected from the five newly installed monitoring wells (22MWT001 through 22MWT006) (Figure 17-3) (SOP-19 Appendix I). The groundwater samples will be collected and analyzed for explosives (including PETN and NG), RCRA metals, and perchlorate. If groundwater is highly turbid (>10 NTUs), a filtered sample will also be collected for dissolved RCRA metals analysis.

17.3 SURFACE WATER AND SEDIMENT SAMPLING

Surface water and sediment samples will be collected from drainage pathways from Building 138 to provide additional coverage of the watercourses that may have been impacted by SWMU 22 activities. A total of seven collocated surface water and sediment samples (22SW/SD010, 22SW/SD017,

22SW/SD018, 22SW/SD022, 22SW/SD023, 22SW/SD024, and 22SW/SD025) will be collected from the drainages west and south of Building 138 within SWMU 22 (Figure 17-3). The locations include three points previously sampled in January and April 2011 (22SD/SW010, 22SD/SW017, and 22SD/SW018) where concentrations of metals exceeded PSLs.

Sediment samples from the drainages will be collected from the specified locations using a hand auger or sampling trowel (SOP-07 Appendix A). Surface water samples will be collocated with sediment samples and collected in accordance with SOP-05 (Appendix A). Surface water and sediment sampling will proceed from downstream locations to upstream locations.

The surface water and sediment samples (22SW/SD022 through 22SW/SD025) will be analyzed for explosives (including PETN and NG), RCRA metals, and TOC (sediment samples only). Surface water and sediment location 22SW/SD010 will be analyzed for PETN and NG and TOC (sediment only). Surface water and sediment locations 22SW/SD017 and 22SW/SD018 will be analyzed for RCRA metals (22SW/SD017 only), perchlorate (surface water only), and PETN and NG. If surface water is highly turbid (>10 NTUs), a filtered sample will also be collected for dissolved RCRA metals analysis. One surface water location (22SW023) will also be analyzed for pH; pH will be measured in the field using a water quality meter at the remaining surface water locations. The sediment sample at the same location (22SD023) will also be analyzed for pH.

17.4 GENERAL SAMPLING AND ANALYSIS

All surface soil, subsurface soil, groundwater, surface water and sediment samples will be analyzed using the same analytical laboratory as the January and April 2011 investigation.

Proposed sampling locations may be revised by the Tetra Tech Field Operations Leader (FOL) based on site access limitations, utility clearance, or site observations.

Field QC samples will be collected as part of the investigation, including field duplicates, trip blanks, equipment rinsate blanks, and field blanks. Worksheet No. 20 presents the field QC sample summary. Also, additional sample volume will be collected as necessary for the laboratory QC of matrix spike/matrix spike duplicate (MS/MSD) analyses (for explosives and TOC) and MS/laboratory duplicate analyses (for metals).

SAP Worksheet No. 18 -- Sampling Locations and Methods/SOP Requirements Table

(UFP-QAPP Manual Section 3.1.1)

Sampling Location	ID Number	Matrix	Target Depth (feet or inches bgs)	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference(1)
22SB012	22SB0120002	Soil	0 – 2'	Explosives (plus PETN & NG)	1	SOP-08, SOP-09, SOP-10
				RCRA Metals	1	
				pH	1	
	22SB012XXXX(2)	Soil	3 – 5' (3)	Explosives (plus PETN & NG)	1	
				RCRA Metals	1	
				pH	1	
22SB013	22SB0130002	Soil	0 – 2'	Explosives (plus PETN & NG)	1	SOP-08, SOP-09, SOP-10
				RCRA Metals	1	
	22SB013XXXX(2) and 22SBDUP01(4)	Soil	3 – 5' (3)	Explosives (plus PETN & NG)	1 + 1 FD	
				RCRA Metals	1 + 1 FD	
22SB014	22SB0140002	Soil	0 – 2'	Explosives (plus PETN & NG)	1	SOP-08, SOP-09, SOP-10
				RCRA Metals	1	
	22SB014XXXX(2)	Soil	3 – 5' (3)	Explosives (plus PETN & NG)	1	
				RCRA Metals	1	
22SB015	22SB0150002	Soil	0 – 2'	Explosives (plus PETN & NG)	1	SOP-08, SOP-09, SOP-10
				RCRA Metals	1	
	22SB015XXXX(2)	Soil	3 – 5' (3)	Explosives (plus PETN & NG)	1	
				RCRA Metals	1	
	22SB015XXXX(2)	Soil	X – X' (5)	Explosives (plus PETN & NG)	1	
				RCRA Metals	1	

Sampling Location	ID Number	Matrix	Target Depth (feet or inches bgs)	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference[(1)]
22SB016	22SB0160002	Soil	0 – 2’	Explosives (plus PETN & NG)	1	SOP-08, SOP-09, SOP-10
				RCRA Metals	1	
	22SB016XXXX[(2)]	Soil	3 – 5’ [(3)]	Explosives (plus PETN & NG)	1	
				RCRA Metals	1	
	22SB016XXXX[(2)]	Soil	X – X’ [(5)]	Explosives (plus PETN & NG)	1	
				RCRA Metals	1	
22SB017	22SB0170002	Soil	0 – 2’	Explosives (plus PETN & NG)	1	SOP-08, SOP-09, SOP-10
				RCRA Metals	1	
	22SB017XXXX[(2)]	Soil	3 – 5’ [(3)]	Explosives (plus PETN & NG)	1	
				RCRA Metals	1	
	22SB017XXXX[(2)]	Soil	X – X’ [(5)]	Explosives (plus PETN & NG)	1	
				RCRA Metals	1	
22SB018	22SB0180002	Soil	0 – 2’	Explosives (plus PETN & NG)	1	SOP-08, SOP-09, SOP-10
				RCRA Metals	1	
	22SB018XXXX[(2)]	Soil	X – X’ [(6)]	Explosives (plus PETN & NG)	1	
				RCRA Metals	1	
22MWT001	22GWT001 22GWT001-F[(7)]	Groundwater	NA	Explosives (plus PETN & NG)	1	SOP-18, SOP-19
				RCRA Metals	1	
22MWT002	22GWT002 22GWT002-F[(7)]	Groundwater	NA	Explosives (plus PETN & NG)	1	SOP-18, SOP-19
				RCRA Metals	1	
				Perchlorate	1	
22MWT003	22GWT003 22GWT003-F[(7)] and 22GWTDUP01[(4)] 22GWTDUP01-F[(7)]	Groundwater	NA	Explosives (plus PETN & NG)	1 + 1 FD	SOP-18, SOP-19
				RCRA Metals	1 + 1 FD	
				Perchlorate	1 + 1 FD	

Sampling Location	ID Number	Matrix	Target Depth (feet or inches bgs)	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference(1)
22MWT004	22GWT004 22GWT004-F(7)	Groundwater	NA	Explosives (plus PETN & NG)	1	SOP-18, SOP-19
				RCRA Metals	1	
				Perchlorate	1	
22MWT005	22GWT005 22GWT005-F(7)	Groundwater	NA	Explosives (plus PETN & NG)	1	SOP-18, SOP-19
				RCRA Metals	1	
				Perchlorate	1	
22MWT006	22GWT006 22GWT006-F(7)	Groundwater	NA	Explosives (plus PETN & NG)	1	SOP-18, SOP-19
				RCRA Metals	1	
				Perchlorate	1	
22SW010	22SW010	Surface Water	At water surface	PETN & NG	1	SOP-05, SOP-06
22SW017	22SW017 22SW017-F(7) and 22SWDUP01(4) 22SWDUP01-F(7)	Surface Water	At water surface	PETN & NG	1 + 1 FD	SOP-05, SOP-06
				RCRA Metals	1 + 1 FD	
22SW018	22SW018	Surface Water	At water surface	PETN & NG	1	SOP-05, SOP-06
22SW022	22SW022 22SW022-F(7)	Surface Water	At water surface	Explosives (plus PETN & NG)	1	SOP-05, SOP-06
				RCRA Metals	1	
22SW023	22SW022 22SW022-F(7)	Surface Water	At water surface	Explosives (plus PETN & NG)	1	SOP-05, SOP-06
				RCRA Metals	1	
				pH	1	
22SW024	22SW024 22SW024-F(7)	Surface Water	At water surface	Explosives (plus PETN & NG)	1	SOP-05, SOP-06
				RCRA Metals	1	
22SW025	22SW025 22SW025-F(7)	Surface Water	At water surface	Explosives (plus PETN & NG)	1	SOP-05, SOP-06
				RCRA Metals	1	
22SD010	22SD00100006	Sediment	0 – 6”	PETN & NG)	1	SOP-07
				TOC	1	

Sampling Location	ID Number	Matrix	Target Depth (feet or inches bgs)	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference[(1)]
22SD017	22SD0170006	Sediment	0 – 6”	PETN & NG	1	SOP-07
				RCRA Metals	1	
				TOC	1	
22SD018	22SD0180006	Sediment	0 – 6”	PETN & NG)	1	SOP-07
				TOC	1	
22SD022	22SD0220006 and 22SDDUP01[(4)]	Sediment	0 – 6”	Explosives (plus PETN & NG)	1 + 1 FD	SOP-07
				RCRA Metals	1 + 1 FD	
				TOC	1 + 1 FD	
22SD023	22SD0230006	Sediment	0 – 6”	Explosives (plus PETN & NG)	1	SOP-07
				RCRA Metals	1	
				pH	1	
				TOC	1	
22SD024	22SD0240006	Sediment	0 – 6”	Explosives (plus PETN & NG)	1	SOP-07
				RCRA Metals	1	
				TOC	1	
22SD025	22SD0250006	Sediment	0 – 6”	Explosives (plus PETN & NG)	1	SOP-07
				RCRA Metals	1	
				TOC	1	

1 SOP or worksheet that describes the sample collection procedures (Worksheet No. 21).
2 XXXX represents the interval of the sample from the top of the soil layer. Depth will be determined in the field based on visual and olfactory observations and where bedrock is encountered. For example, if sample is collected from 3 to 5 feet bgs, the depth will be recorded as 0305.
3 If bedrock is not encountered or there are no visual observations that cause a subsurface depth to be selected in a biased manner, then the 3- to 5-foot bgs depth interval will be selected.
4 Field duplicate locations may change in the field based on visual and olfactory observations.
5 Sample will be collected from depth of bottom of sewer line.
6 Sample will be collected from depth of bottom of pit.
7 For a filtered surface water sample, “-F” will be added to the end of the ID number (e.g. 22SW010-F).

SAP Worksheet No. 20 -- Field Quality Control Sample Summary Table

(UFP-QAPP Manual Section 3.1.1)

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSDs(1)	No. of Field Blanks	No. of Equip. Blanks	No. of VOC(2) Trip Blanks	No. of PT(3) Samples	Total No. of Samples to Lab
Supplemental Sampling									
Surface Soil	Explosives (plus PETN & NG)	7	0	1/1	0	1	0	0	8
	RCRA Metals	7	0	1/1	0	1	0	0	8
	pH	1	1	0/0	0	0	0	0	2
Subsurface Soil	Explosives (plus PETN & NG)	7	1	1/1	0	1	0	0	9
	RCRA Metals	7	1	1/1	0	1	0	0	9
	pH	1	1	0/0	0	0	0	0	2
Sediment	Explosives	4	1	1/1	0	0	0	0	5
	PETN & NG	7	1	1/1	0	0	0	0	8
	RCRA Metals	5	1	1/1	0	0	0	0	6
	pH	1	1	0/0	0	0	0	0	2
	TOC	7	1	1/1	0	0	0	0	8
Surface water	Explosives	4	1	1/1	0	0	0	0	5
	PETN & NG	7	1	1/1	0	0	0	0	8
	Total RCRA Metals	5	1	1/1	0	0	0	0	6
	Dissolved RCRA Metals	5	1	1/1	0	1*	0	0	7
	pH	1	1	0/0	0	0	0	0	2
Groundwater	Explosives (plus PETN & NG)	6	1	1/1	0	1	0	0	10
	Total RCRA Metals	6	1	1/1	0	1	0	0	10
	Dissolved RCRA Metals	6	1	1/1	0	1*	0	0	10
	Perchlorate	6	1	1/1	0	1	0	0	10

1 Although MS/MSDs are not typically considered field QC samples, they are included here because location determination is often established in the field. The MS/MSDs are not included in the total number of samples sent to the laboratory. For total and dissolved metals, a duplicate sample will be collected in place of an MSD.

2 VOC – Volatile Organic Compound.

3 PT – Proficiency Test samples.

* The equipment blank for dissolved metals, if collected, will be obtained by passing rinse water through a 0.45-micron filter.

SAP Worksheet No. 21 -- Project Sampling SOP References Table

(UFP-QAPP Manual Section 3.1.2)

Reference Number	Title, Revision Date, and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)	Comments
SOP-01	Sample Labeling, 05/10, Revision 0.	Tetra Tech	NA	Y (project-specific SOP)	Contained in SWMU 22 SAP
SOP-02	Sample Identification Nomenclature, 05/10, Revision 0.	Tetra Tech	NA	Y (project-specific SOP)	Contained in SWMU 22 SAP
SOP-03	Sample Custody and Documentation of Field Activities, 05/10, Revision 0.	Tetra Tech	Field logbook, sample log sheets, boring logs	Y (project-specific SOP)	Contained in SWMU 22 SAP
SOP-04	Sample Preservation, Packaging, and Shipping, 05/10, Revision 0.	Tetra Tech	NA	Y (project-specific SOP)	Contained in SWMU 22 SAP
SOP-05	Surface Water Sampling, 05/10, Revision 0.	Tetra Tech	NA	Y (project-specific SOP)	Contained in SWMU 22 SAP
SOP-06	Measurement of Water Quality Parameters, 05/10, Revision 0.	Tetra Tech	Multi-parameter water quality meter, such as a Horiba U-22	Y (project-specific SOP)	Contained in SWMU 22 SAP
SOP-07	Sediment Sampling, 05/10, Revision 0.	Tetra Tech	Stainless steel or disposable trowels	Y (project-specific SOP)	Contained in SWMU 22 SAP
SOP-08	Borehole Advancement and Soil Coring Using Direct-Push Technology (DPT) and Hand Auger Techniques, 05/10, Revision 0.	Tetra Tech	DPT rig, stainless steel augers, extension rods, and T-handle	Y (project-specific SOP)	Contained in SWMU 22 SAP
SOP-09	Soil Sample Logging, 05/10, Revision 0.	Tetra Tech	NA	Y (project-specific SOP)	Contained in SWMU 22 SAP
SOP-10	Surface and Subsurface Soil Sampling, 05/10, Revision 0.	Tetra Tech	Stainless steel auger bucket, extension rods, and T-handle	Y (project-specific SOP)	Contained in SWMU 22 SAP
SOP-11	Management of Investigation-Derived Waste, 05/10, Revision 0.	Tetra Tech	NA	Y (project-specific SOP)	Contained in SWMU 22 SAP
SOP-12	Decontamination of Field Sampling Equipment, 05/10, Revision 0.	Tetra Tech	Decontamination equipment, scrub brushes, 5-gallon buckets, spray bottles, phosphate free detergent, deionized water	Y (project-specific SOP)	Contained in SWMU 22 SAP
SOP-13	Global Positioning System, 05/10, Revision 0.	Tetra Tech	GPS unit	Y (project-specific SOP)	Contained in SWMU 22 SAP
SOP-14	Monitoring Well Installation, 06/11, Revision 0.	Tetra Tech	Air rotary or rotosonic drill rig	Y (project-specific SOP)	Contained in Appendix I
SOP-15	Drilling and Geologic Logging of Boreholes in Bedrock, 06/11, Revision 0.	Tetra Tech	Air rotary or rotosonic drill rig	Y (project-specific SOP)	Contained in Appendix I
SOP-16	Monitoring Well Development, 06/11, Revision 0.	Tetra Tech	Pump, surge block, Multi-parameter water quality meter, such as a Horiba U-22	Y (project-specific SOP)	Contained in Appendix I
SOP-17	Measurement of Water Levels in Monitoring Wells; 06/11, Revision 0.	Tetra Tech	Electronic Water Level Indicator	Y (project-specific SOP)	Contained in Appendix I

Reference Number	Title, Revision Date, and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)	Comments
SOP-18	Low-Flow Well Purging and Stabilization; 06/11, Revision 0.	Tetra Tech	Bladder or Peristaltic Pump, Multi-parameter water quality meter, such as a Horiba U-22, turbidity meter, PID	Y (project-specific SOP)	Contained in Appendix I
SOP-19	Groundwater Sampling; 06/11, Revision 0	Tetra Tech	Bladder or Peristaltic Pump, Multi-parameter water quality meter, such as a Horiba U-22, turbidity meter, PID	Y (project-specific SOP)	Contained in Appendix I
SOP-20	Calibration and Care of Water Quality Meters; 06/11, Revision 0.	Tetra Tech	Multi-parameter water quality meter, such as a Horiba U-22, turbidity meter	Y (project-specific SOP)	Contained in Appendix I
SOP-21	Hydraulic Conductivity Testing; 08/11, Revision 0.	Tetra Tech	Pressure Transducer and datalogger	Y (project-specific SOP)	Contained in Appendix I

SAP Worksheet No. 22 -- Field Equipment Calibration, Maintenance, Testing, and Inspection Table

(UFP-QAPP Manual Section 3.1.2.4)

Field Equipment	Activity[1]	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[2]	Comments
GPS	Positioning	Beginning and end of each day used	Accuracy: sub-meter horizontal dilution of precision (HDOP) <3, number of satellites at least six.	Wait for better signal, replace unit, or choose alternate location technique	Tetra Tech FOL or designee	SOP-13	SOP located in Appendix A.
Multi-Parameter Water Quality Meter (YSI 600 Series or similar)	Visual Inspection Calibration/ Verification	Daily Beginning and end of day	Manufacturer's guidance.	Operator correction or replacement	Tetra Tech FOL or designee	SOP-14	SOP located in Appendix A.
Turbidity Meter (LaMotte 2020 or similar)	Visual Inspection Calibration/ Verification	Daily Beginning and end of day	Manufacturer's guidance; calibrations must bracket expected values. Initial Calibration Verification (ICV) must be <10 NTUs.	Operator correction or replacement	Tetra Tech FOL or designee	SOP-06	SOP located in Appendix A.

1 Activities may include calibration, verification, testing, maintenance, and/or inspection.
2 From the Project Sampling SOP References table (Worksheet No. 21).

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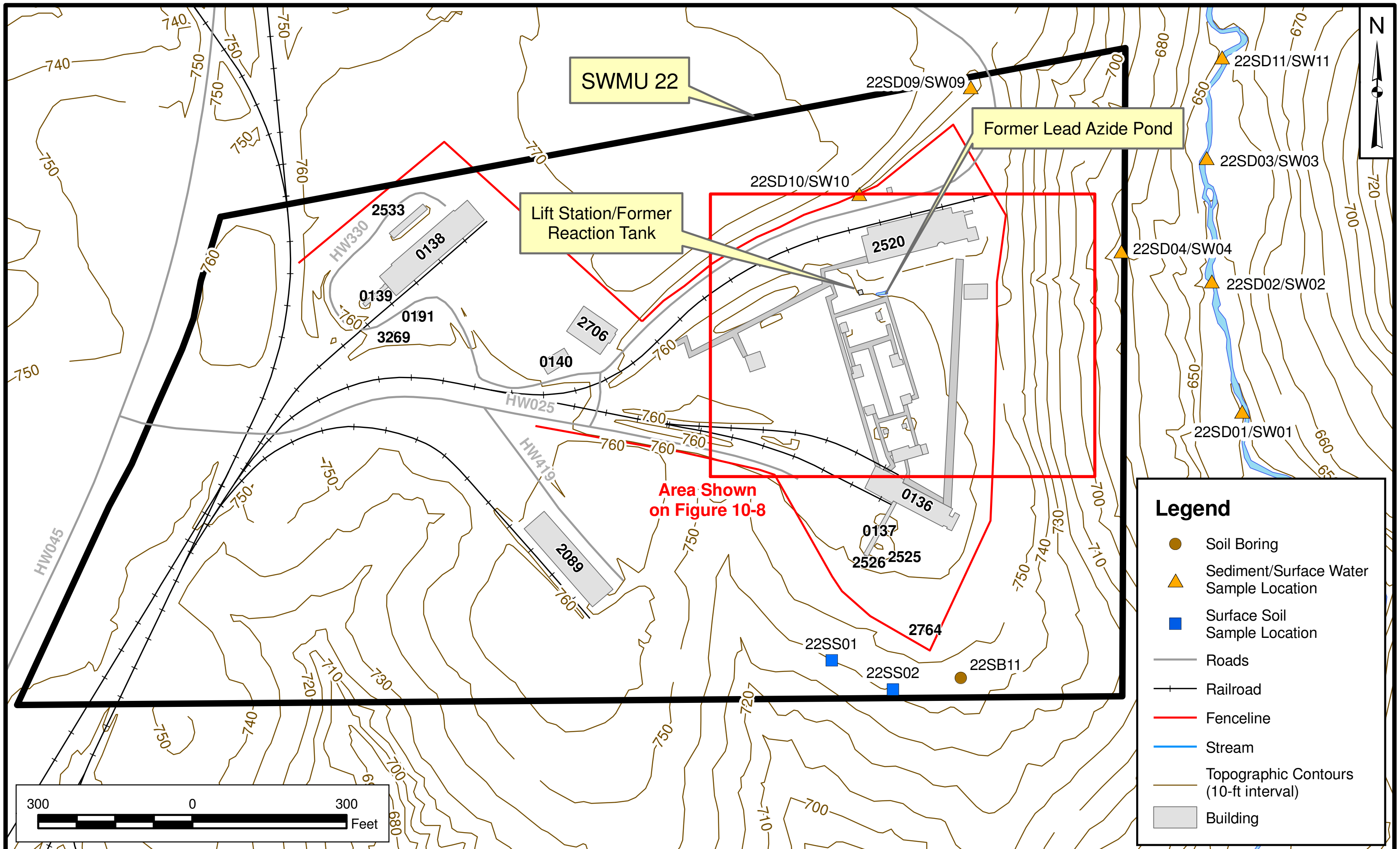

DRAWN BY J. ENGLISH	DATE 07/06/11	TETRA TECH	CONTRACT NUMBER CTO F279
CHECKED BY T. EVANS	DATE 08/25/11	SWMU 22 SAMPLE LOCATIONS - JANUARY 2011	APPROVED BY ____ DATE ____
REVISED BY ____	DATE ____	SWMU 22 - LEAD AZIDE POND NSA CRANE	APPROVED BY ____ DATE ____
SCALE AS NOTED		CRANE, INDIANA	FIGURE NO. FIGURE 10-7 REV 0

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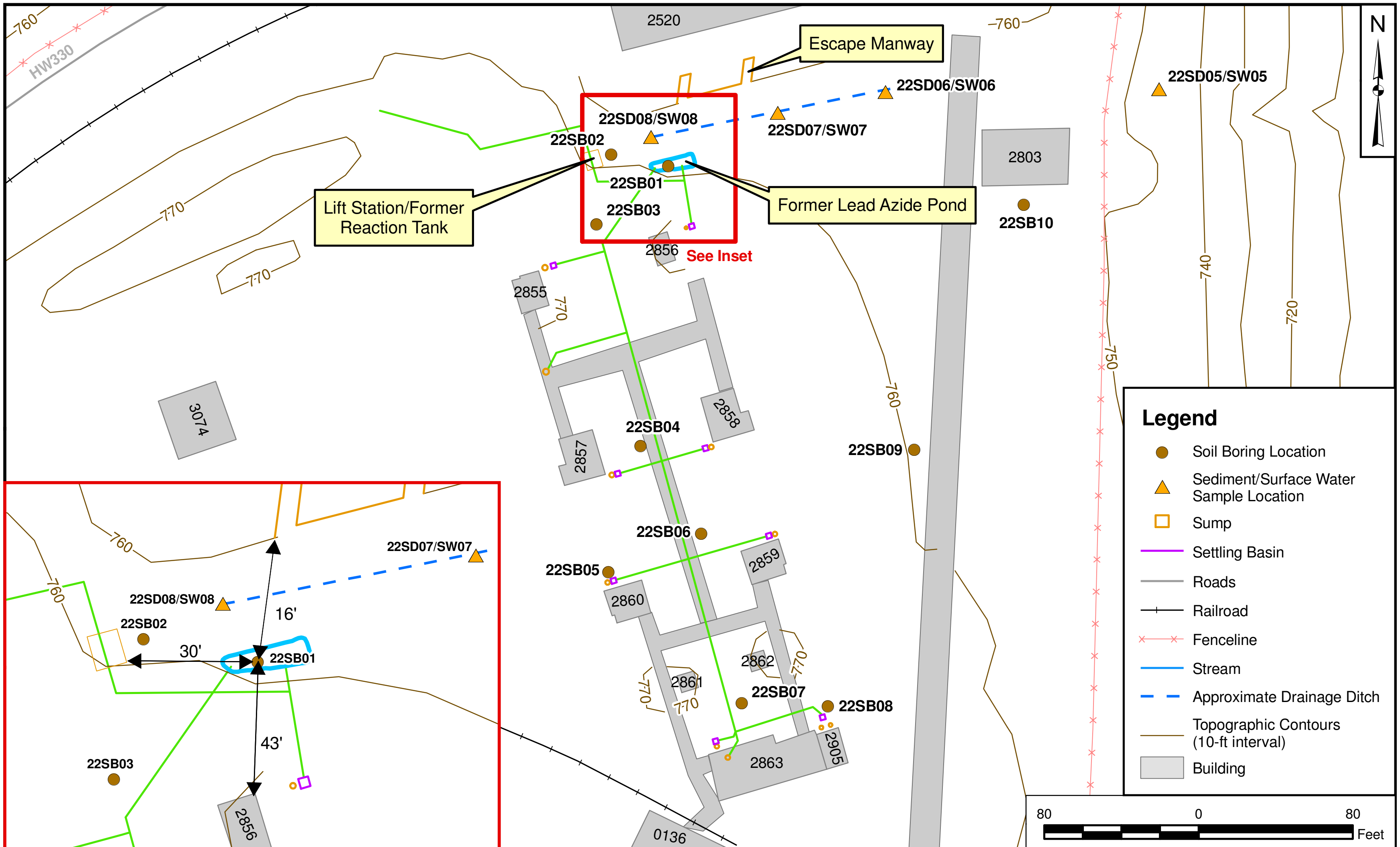

DRAWN BY	DATE
J. ENGLISH	07/06/11
CHECKED BY	DATE
T. EVANS	08/25/11
REVISED BY	DATE
___	___
SCALE	
AS NOTED	

TETRA TECH

BACKLINE SAMPLE LOCATIONS - JANUARY 2011
SWMU 22 - LEAD AZIDE POND
NSA CRANE
CRANE, INDIANA

CONTRACT NUMBER	
CTO F279	
APPROVED BY	DATE
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APPROVED BY	DATE
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FIGURE NO.	REV
FIGURE 10-8	0

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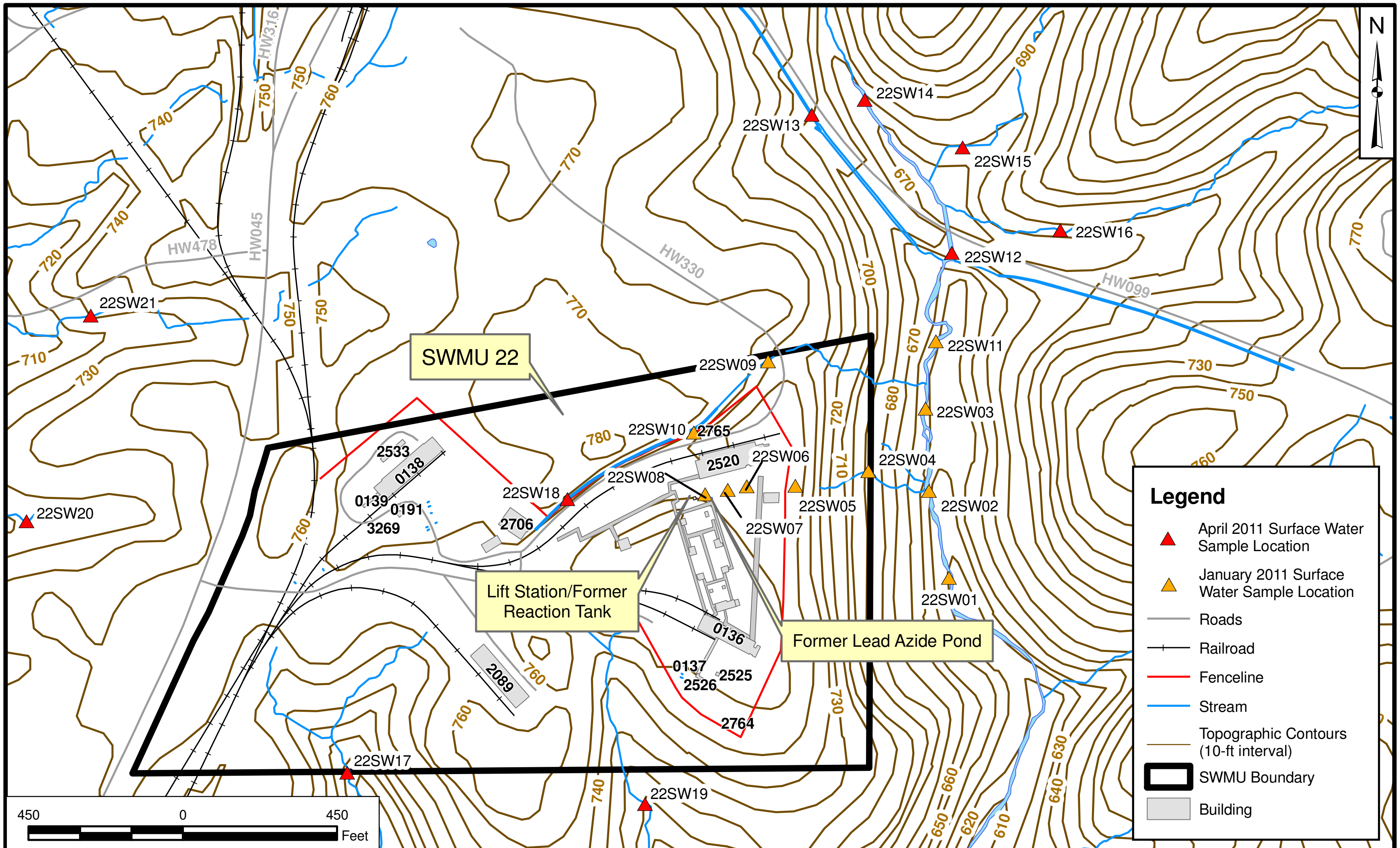

DRAWN BY J. ENGLISH — DATE 07/06/11	TETRA TECH	CONTRACT NUMBER CTO F279
CHECKED BY T. EVANS — DATE 08/25/11	SWMU 22 SURFACE WATER SAMPLE LOCATIONS - APRIL 2011 SWMU 22 - LEAD AZIDE POND NSA CRANE CRANE, INDIANA	APPROVED BY ____ — DATE ____
REVISED BY ____ — DATE ____		APPROVED BY ____ — DATE ____
SCALE AS NOTED		FIGURE NO. FIGURE 10-9 — REV 0

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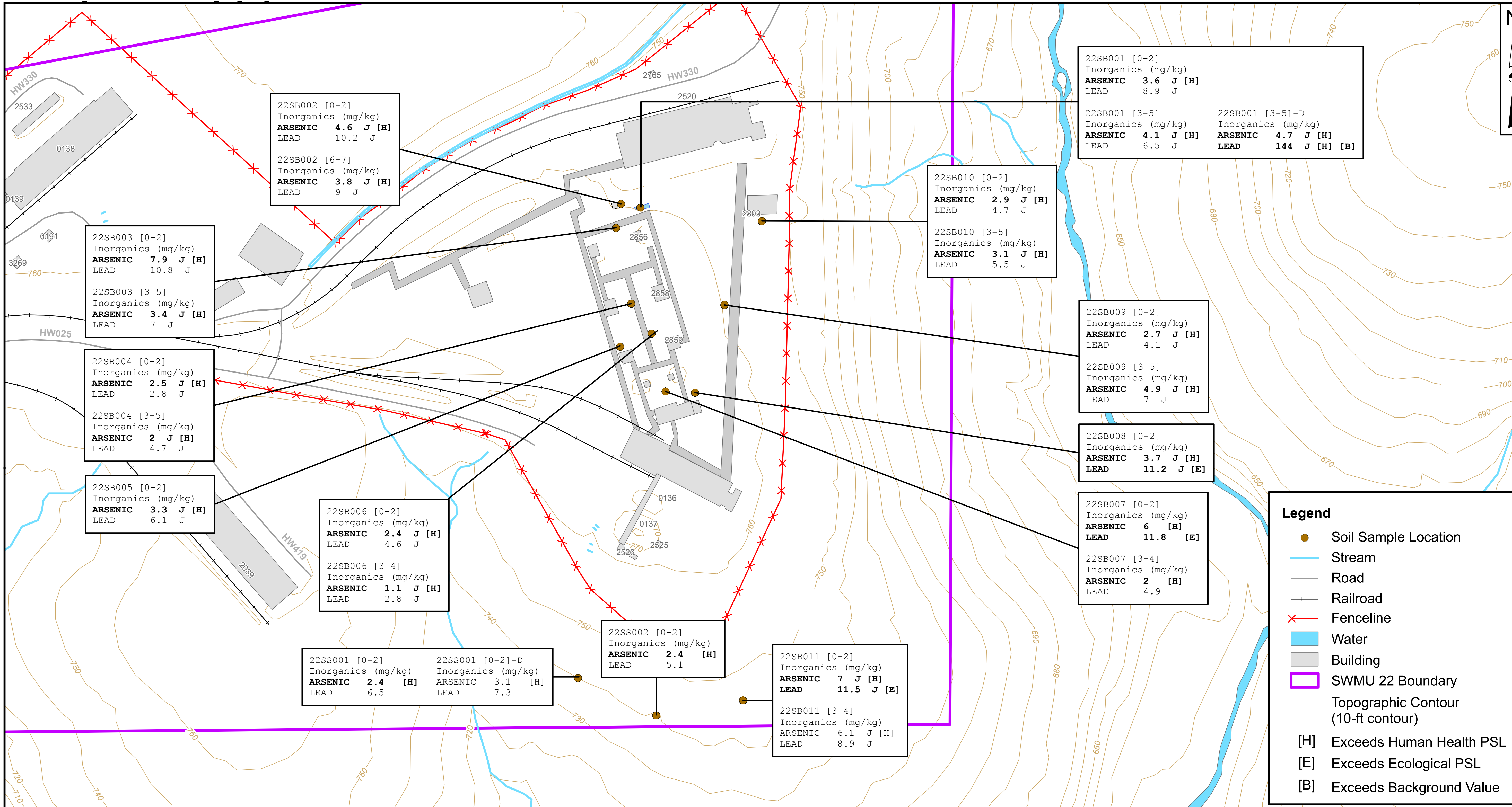

DRAWN BY	DATE
J. ENGLISH	10/10/11
CHECKED BY	DATE
T. EVANS	10/10/11
REVISED BY	DATE
SCALE	AS NOTED

NAVFAC

SOIL SAMPLE RESULTS - JANUARY 2011
SWMU 22 - LEAD AZIDE POND
NAVAL SUPPORT ACTIVITY
CRANE, INDIANA

CONTRACT NUMBER	CTO NUMBER
02362	F279
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO. FIGURE 10-10	REV 0

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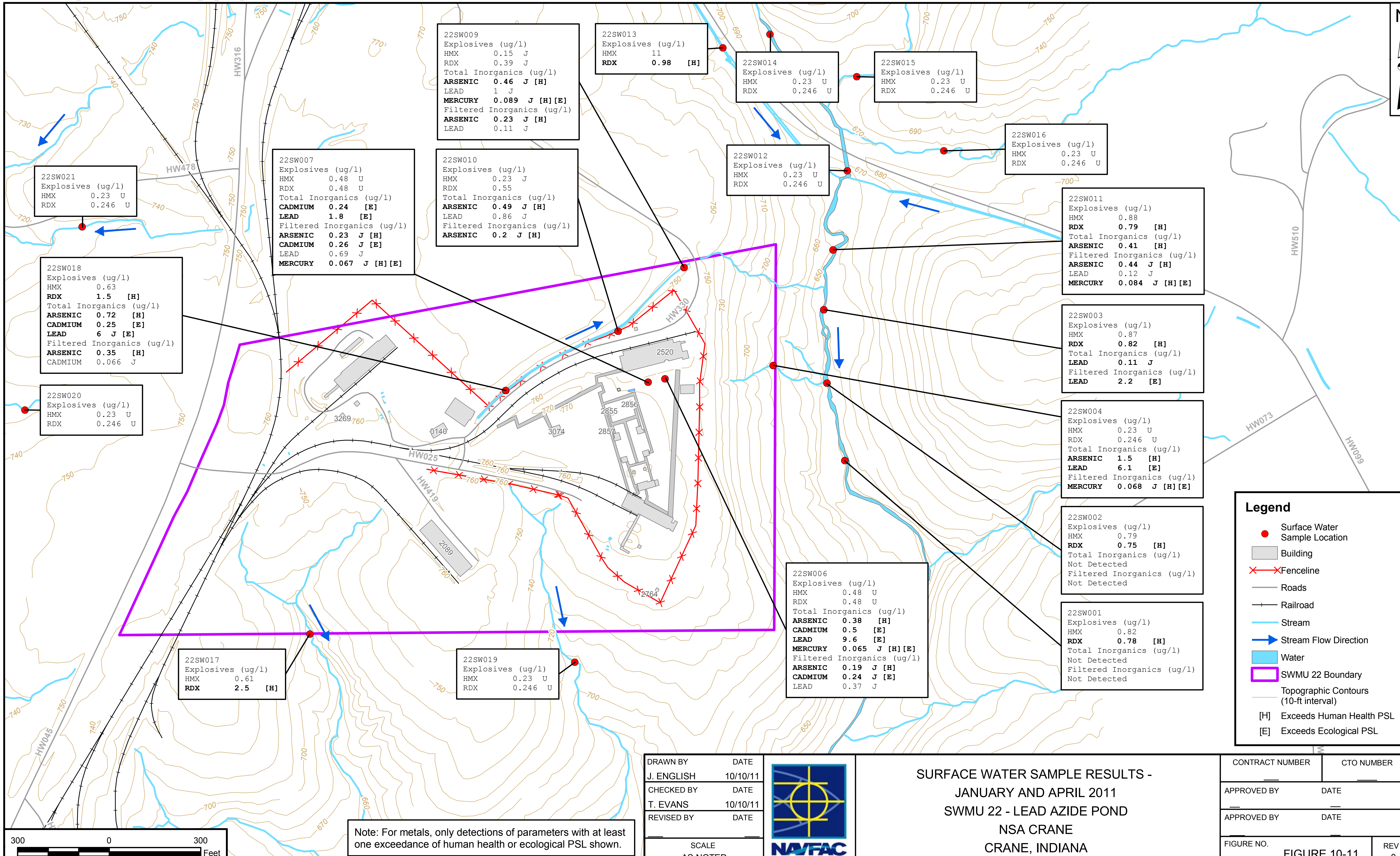

Note: For metals, only detections of parameters with at least one exceedance of human health or ecological PSL shown.

DRAWN BY	DATE
J. ENGLISH	10/10/11
CHECKED BY	DATE
T. EVANS	10/10/11
REVISED BY	DATE
—	—
SCALE	
AS NOTED	

NAVFAC

SURFACE WATER SAMPLE RESULTS -
JANUARY AND APRIL 2011
SWMU 22 - LEAD AZIDE POND
NSA CRANE
CRANE, INDIANA

CONTRACT NUMBER	CTO NUMBER
—	—
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
FIGURE NO. FIGURE 10-11	REV 0

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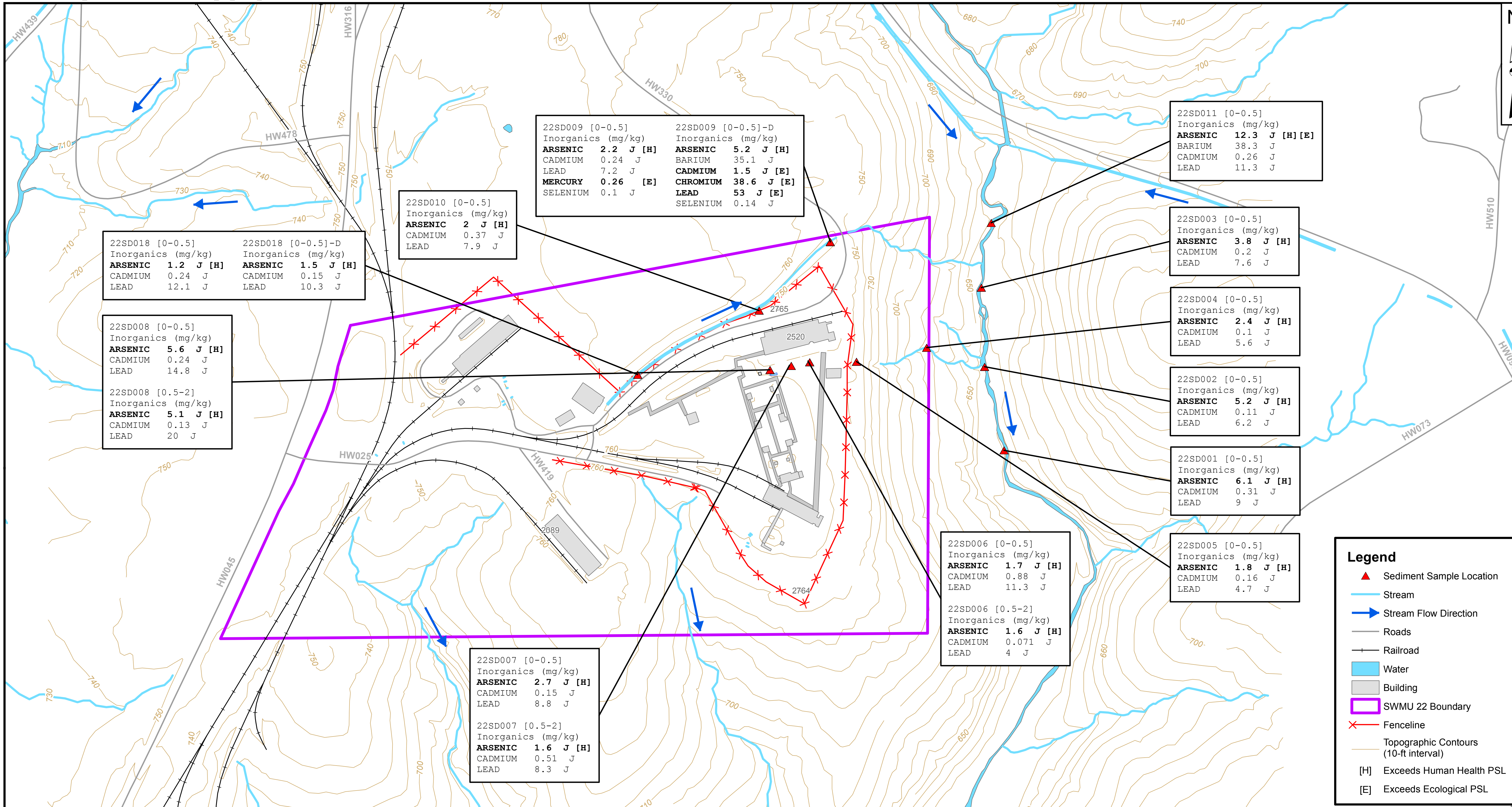

DRAWN BY J. ENGLISH DATE 10/10/11

CHECKED BY T. EVANS DATE 12/05/11

REVISED BY DATE

SCALE AS NOTED

NAVFAC

SEDIMENT SAMPLE RESULTS - JANUARY 2011
SWMU 22 - LEAD AZIDE POND
NSA CRANE
CRANE, INDIANA

CONTRACT NUMBER | CTO NUMBER

APPROVED BY | DATE

APPROVED BY | DATE

FIGURE NO. FIGURE 10-12 | REV 0

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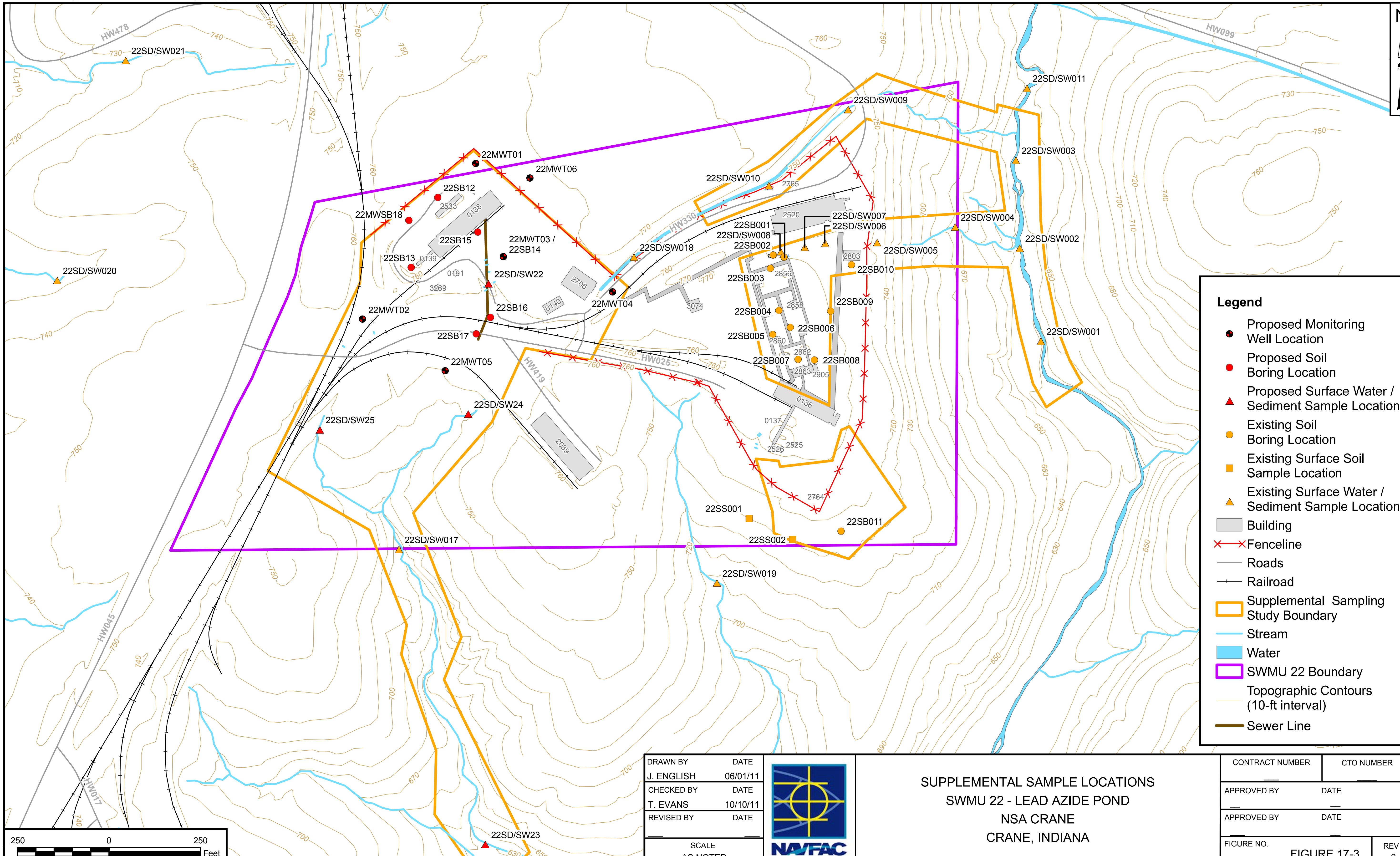

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J. ENGLISH	06/01/11
CHECKED BY	DATE
T. EVANS	10/10/11
REVISED BY	DATE
SCALE	AS NOTED

NAVFAC

SUPPLEMENTAL SAMPLE LOCATIONS
SWMU 22 - LEAD AZIDE POND
NSA CRANE
CRANE, INDIANA

CONTRACT NUMBER	CTO NUMBER
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO. FIGURE 17-3	REV 0

APPENDIX F

LIST OF MUNITIONS OPERATIONS (1964-1977)

Year	Item	Total	Compounds Identified in MIDAS[1]/Remarks
BUILDING 138			
1964	MFG COLOR BURST MK 2	21,416	Charcoal, graphite, chlorinated rubber, magnesium powder, paraffin wax, potassium nitrate, shellac, strontium nitrate, sulfur
	MFG PENOLITE PELLETS	40,000	--[2] / PETN, TNT
	EXPLOSIVE LD PARTS F/ MK 10700 ARM DEVICE	371	--
1965	MFG COLOR BIRST (*sic*) MK 2	20,000	Charcoal, graphite, chlorinated rubber, magnesium powder, paraffin wax, potassium nitrate, shellac, strontium nitrate, sulfur
1967	FAB & LOAD APF MK 89	22,622	--
	MFG PELLETS CH-6	3,400	-- / CH-6 (RDX)
	MFG PELLETS BLACK POWDER	8,000	--
	MFG COLOR BURST UNITS MK 2-0	110,138	Charcoal, graphite, chlorinated rubber, magnesium powder, paraffin wax, potassium nitrate, shellac, strontium nitrate, sulfur
	MFG TETRYL BOOS. F/5" R.H. MK 32	136,187	-- / Tetryl
1968	MFG BOOSTER & LEAD BLOCK ASSY MK 30	1,390	Iron, tetryl
	MFG TETRYL PELLETS	6,100	-- / Tetryl
	MFG COLOR BURST UNITS MK 2-0	9,497	Charcoal, graphite, chlorinated rubber, magnesium powder, paraffin wax, potassium nitrate, shellac, strontium nitrate, sulfur
	MFG COLOR BURST UNITS MK 2-0	9,497	Charcoal, graphite, chlorinated rubber, magnesium powder, paraffin wax, potassium nitrate, shellac, strontium nitrate, sulfur
	MFG TETRYL BOOSTER F/5 R.H. MK 32	134,439	-- / Tetryl
	MFG WARHEAD BOOSTER MK 3801 SPARROW	3,203	DATB, aluminum, iron, magnesium, polyamide
	CONVERT DEMO FIR DEVICE TO MK 23-1	175	Aluminum, iron, zinc
	MOD MK 5 S&A DEVICE TO MK 35-0	732	MK5: Chromium, iron, manganese, nickel, tetryl; MK35: Aluminum, chromium, copper, iron, nickel, RDX
	REPAIR MK 7 S7A DEVICE	101	--
	REPAIR & MOD TDD	867	--
	MFG EXPLOSIVE LEADS MK 11 TALOS	200	--
	MFG EXPLOSIVE LEADS MK 12 & 13	24,000	--
	MFG WARHEAD BOOSTER MK 38-1 SPARROW		DATB, aluminum, iron, magnesium, polyamide
1969	FABRICATE ADF MK 43-1 & 89-0	82,274	MK43-1: Aluminum, antimony sulfide, barium nitrate, lead azide, lead styphnate, tetryl
	MANUFACTURE BOOSTERS AND LEAD BLOCK ASSEMBLY MK 30	67,739	Iron, tetryl
	MANUFACTURE BOOSTER (TET) for 5" RH MK 32	105,838	-- / Tetryl
	LUBRICATE BURSTER SMALL CANNISTER M30	33,000	Nitrocellulose, nitroglycerin, potassium nitrate
	MANUFACTURE CH-6 EXPLOSIVE PELLETS AND BOOSTERS	4,400	CH-6 (RDX)
	MANUFACTURE WARHEAD BOOSTER MK 38-1	4,235	DATB, aluminum, iron, magnesium, polyamide
	MANUFACTURE BOOSTER FOR MK 4 EXPLOSIVE SECTION	1,000	--
	MANUFACTURE FUZE BOOSTER MK 53-0	1,890	Aluminum, copolymer, HMX, lead

Year	Item	Total	Compounds Identified in MIDAS[1]/Remarks
	MODIFY MK 5 S&A DEVICE to MK 35-0	576	MK5: Chromium, iron, manganese, nickel, tetryl; MK35: Aluminum, chromium, copper, iron, nickel, RDX
	REPAIR S&A DEVICE MK 5, 12, 14, and 17	270	MK5: Chromium, iron, manganese, nickel, tetryl; MK14: Aluminum, chromium, HMX, iron, lead, nickel
	MODIFY TDD 7 and 12	170	--
1970	MFG BOOSTERS & LEAD BLOCK ASSY. MK 30	7,529	Iron, tetryl
	MFG COLOR BURST MK 2-0 and MK 1-0	47,800	Charcoal, graphite, chlorinated rubber, magnesium powder, paraffin wax, potassium nitrate, shellac, strontium nitrate, sulfur
	MFG CH-6 PELLETS	200	-- / RDX
	MFG CH-6 BOOSTERS	15,150	-- / RDX
	MFG PENOLITE DONER CHG. 2" X 1"	7,355	-- / PETN, TNT
	MFG WARHEAD BOOSTER MK 38-1	2,044	DATB, aluminum, iron, magnesium, polyamide
	MFG FUZE BOOSTER MK 53-0 & 45-0	2,429	MK53: Aluminum, copolymer, HMX, lead
	REPAIR FUZE BOOSTER MK 45-0	24	--
	MFG DETONATORS MK 43-1, and MK 57	8,450	MK43-1: Aluminum, antimony sulfide, barium nitrate, lead azide, lead styphnate, tetryl; MK57: Copper, lead azide, lead styphnate, PETN, zinc
	MODIFY MK 5 S&A DEVICE MK 35-0	1,483	MK5: Chromium, iron, manganese, nickel, tetryl; MK35: Aluminum, chromium, copper, iron, nickel, RDX
	REPAIR S&A DEVICE MK 5,12, 14, and 17	150	MK5: Chromium, iron, manganese, nickel, tetryl; MK14: Aluminum, chromium, HMX, iron, lead, nickel
	MODIFY TDD MK 7 & 12	381	--
1971	MFG BOOSTERS & LEAD BLOCK ASSY MK 30	80,572	Iron, tetryl
	MFG COLOR BURST MK 1-0	326	Charcoal, graphite, chlorinated rubber, magnesium powder, paraffin wax, potassium nitrate, shellac, strontium nitrate, sulfur
	MFG PELLETS DWG. 1298259 ZUNI	15,150	--
	MFG PENOLITE DONER CHG. 2" X 1"	12,685	-- / PETN, TNT
	MFG FUZE BOOSTER MK 53-0	1,123	Aluminum, copolymer, HMX, lead
	REWORK ARM. DEVICES MK 2-3 INTO MK 2-4	2,808	--
	MFG DETONATORS	2,206,738	--
1972	MFG BOOSTERS & LEAD BLOCK ASSY MK 30	79,451	Iron, tetryl
	MFG BOOSTERS MK 39	22,242	Aluminum, copper, iron, lead, zinc, tetryl
	FAB ADF MK 54	96,127	--
	FAB ADF MK 89	625	--
	MFG BOOSTER FOR MK 36 DEMO CHG	625	Aluminum, coploymer,
	MFG COLOR BURST MK 2-0	15,800	Charcoal, graphite, chlorinated rubber, magnesium powder, paraffin wax, potassium nitrate, shellac, strontium nitrate, sulfur
	MFG PELLETS DWG 1298259 ZUNI	40,400	
	MFG PENOLITE DONER CHG	428	-- / PETN, TNT
	MFG FUZE BOOSTER MK 52-0	1,682	--

Year	Item	Total	Compounds Identified in MIDAS[1]/Remarks
	MFG RDX PELLETS	2,000	-- / RDX
	MFG DETONATORS MK 43-1, 57, 95-0	5,159,269	MK43-1: Aluminum, antimony sulfide, barium nitrate, lead azide, lead styphnate, tetryl; MK57: Copper, lead azide, lead styphnate, PETN, zinc; MK95-0: Aluminum, antimony sulfide, barium nitrate, lead zaide, lead styphnate, RDX, tetratzene
	ASSEMBLE AND PACK FIREBOMB INITIATOR MK 13	9,766	--
	MFG BOOSTERS AND LEAD BLOCK ASSY, MK 30	63,900	Iron, tetryl
	MFG BOOSTERS MK 39 & MK 53	131,999	MK39: Aluminum, copper, iron, lead, zinc, tetryl; MK53: Aluminum, copolymer, HMX, lead
	MFG W.H. BOOSTER MK 38-1	586	DATB, aluminum, iron, magnesium, polyamide
	MFG BOOSTER FOR MK 36 DEMO CHG	160	Aluminum, iron, polyethylene, RDX, TNT, wax
	MFG COLOR BURST MK 1-0 and 2-0	50,998	Charcoal, graphite, chlorinated rubber, magnesium powder, paraffin wax, potassium nitrate, shellac, strontium nitrate, sulfur
	MFG PELLETS BOOS. CH-6 for MK 63 W.H.	31,125	-- / CH-6 (RDX)
	MFG PENOLITE PELLETS	61	-- / PETN, TNT
	MFG DETONATORS MK 43-1, MK 57	155,662	MK43-1: Aluminum, antimony sulfide, barium nitrate, lead azide, lead styphnate, tetryl; MK57: Copper, lead azide, lead styphnate, PETN, zinc
	MFG DETONATORS MK 95-0	5,521,823	MK95-0: Aluminum, antimony sulfide, barium nitrate, lead zaide, lead styphnate, RDX, tetratzene
	MFG MK 8 EXP LEADS	13,140	--
	MFG M303A LEAD ASSYS	28,140	--

BOOSTER AREA

1966	MFG TRACER PELLETS	459,878	--
	MFG COLOR BURST MK 2-0	25,000	Charcoal, graphite, chlorinated rubber, magnesium powder, paraffin wax, potassium nitrate, shellac, strontium nitrate, sulfur
	PR BL PDR PELLET	9,450	--
	MFG CONVERSOIN KITS F/ADF MK 54 in 5/38	101,970	--
	LD DEMO CHG MK 8-3	1,528	--
	INSTALL BOOSTER IN PD-M51a5 FUZE	113,580	Aluminum, copper, iron, tetryl, zinc
	ASSY VTF MK 70 SERIES	8,028	--
	FAB ADF MK 89-0	11,605	--
	ASSY VTF MK 90 w/BOOSTER MK 39	200	MK39: Aluminum, copper, iron, lead, zinc, tetryl
	MFG BOOSTER MK 44 WALLEYE	820	--
	MFG DEMO CHG LINEAR MK 8-2	536	--
1967	REPAIR & MOD TDD	1,441	--
	REPAIR S&A DEVICE	287	--
1968	FAB BURSTER SM CANISTER M30	27,708	--

Year	Item	Total	Compounds Identified in MIDAS[1]/Remarks
1975	LOAD & PACK DETONATORS	3,552,074	--
	MFG PENOLITE PELLETS & CHARGE	100	-- / PETN, TNT
	MFG LEAD ASSY & BOOSTER	48,871	--
1976	LOAD & PACK DETONATORS	6,518,674	--
1977	LOAD & PACK DETONATORS	3,076,009	--
	MFG PENOLITE PELLETS & CHARGE	158	-- / PETN, TNT
	IMPULSE CTG	23,584	Nitrocellulose, nitroglycerin, triacetin, iron, aluminum

Notes

(1) Munition Item Disposition Action System (MIDAS), Accessed July 19-20, 2011. Compounds with calculated weight of =>1% listed.

(2) Item not located in or insufficient identification provided to locate in MIDAS.

APPENDIX G

JANUARY AND APRIL 2011 ANALYTICAL RESULTS

TABLE 10-1
SURFACE SOIL ANALYTICAL RESULTS
SWMU 22 - LEAD AZIDE POND
NAVAL SUPPORT ACTIVITY
CRANE, INDIANA

LOCATION	PSLs		BACKGROUND CONCENTRATIONS		22SB001	22SB002	22SB003	22SB004	22SB005	22SB006
SAMPLE ID	HH	ECO	RANGE	95% UTL	22SB0010002	22SB0020002	22SB0030002	22SB0040002	22SB0050002	22SB0060002
SAMPLE TYPE					NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
TOP DEPTH					0	0	0	0	0	0
BOTTOM DEPTH					2	2	2	2	2	2
METALS (MG/KG)										
ARSENIC	0.026	18	2.4 - 10.2	11.83	3.6 J	4.6 J	7.9 J	2.5 J	3.3 J	2.4 J
BARIUM	1500	330	46.1 - 153	211	30.9 J	44.6 J	32.1 J	17.6 J	12.8 J	38 J
CADMIUM	7	0.36	0.05 - 3.6	6.05	0.23 J	0.15 J	0.12 J	0.14 J	0.18 J	0.19 J
CHROMIUM	38	26	8.5 - 21.7	28.7	5.6 J	8 J	14.1 J	3.4 J	13.4 J	10.6 J
LEAD	81	11	9.4 - 21.5	27.0	8.9 J	10.2 J	10.8 J	2.8 J	6.1 J	4.6 J
SELENIUM	5.2	0.52	0.51 - 0.64	0.81	0.17 J	0.28 J	0.23 J	0.088 J	0.18 J	0.17 J
SILVER	31	4.2	0.05 - 0.11	0.130	0.04 UJ	0.04 UJ	0.04 UJ	0.04 UJ	0.04 UJ	0.04 UJ
MISCELLANEOUS PARAMETERS (S.U.)										
PH	NC	NC	NA	NA	7.3	NA	NA	NA	NA	NA

EXCEEDS HH PSL	
EXCEEDS ECO PSL	

HH - Human Health
ECO - Ecological
MG/KG - Milligrams per Kilogram
NC - No Criterion
NA - Not Applicable or Not Analyzed
PSL - Project Screening Level
S.U. - Standad Units
UTL - Upper Threshhold Limit

TABLE 10-1
SURFACE SOIL ANALYTICAL RESULTS
SWMU 22 - LEAD AZIDE POND
NAVAL SUPPORT ACTIVITY
CRANE, INDIANA

LOCATION	PSLs		BACKGROUND CONCENTRATIONS		22SB007	22SB008	22SB009	22SB010	22SB011	
SAMPLE ID	HH	ECO	RANGE	95% UTL	22SB0070002	22SB0080002	22SB0090002	22SB0100002	22SB0110002	22SS0010002
SAMPLE TYPE					NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
TOP DEPTH					0	0	0	0	0	0
BOTTOM DEPTH					2	2	2	2	2	2
METALS (MG/KG)										
ARSENIC	0.026	18	2.4 - 10.2	11.83	6	3.7 J	2.7 J	2.9 J	7 J	2.4
BARIUM	1500	330	46.1 - 153	211	89 J	34.3 J	15.4 J	55.3 J	65.8 J	27.1 J
CADMIUM	7	0.36	0.05 - 3.6	6.05	0.16	0.33 J	0.075 J	0.079 J	0.19 J	0.1
CHROMIUM	38	26	8.5 - 21.7	28.7	11	8.9 J	5.9 J	8 J	12.4 J	4.9
LEAD	81	11	9.4 - 21.5	27.0	11.8	11.2 J	4.1 J	4.7 J	11.5 J	6.5
SELENIUM	5.2	0.52	0.51 - 0.64	0.81	0.31	0.23 J	0.094 J	0.14 J	0.38 J	0.14 J
SILVER	31	4.2	0.05 - 0.11	0.130	0.04 U	0.035 J	0.04 UJ	0.04 UJ	0.038 J	0.04 U
MISCELLANEOUS PARAMETERS (S.U.)										
PH	NC	NC	NA	NA	NA	8.2	NA	NA	NA	NA

EXCEEDS HH PSL	
EXCEEDS ECO PSL	

HH - Human Health
ECO - Ecological
MG/KG - Milligrams per Kilogram
NC - No Criterion
NA - Not Applicable or Not Analyzed
PSL - Project Screening Level
S.U. - Standad Units
UTL - Upper Threshhold Limit

TABLE 10-1
SURFACE SOIL ANALYTICAL RESULTS
SWMU 22 - LEAD AZIDE POND
NAVAL SUPPORT ACTIVITY
CRANE, INDIANA

LOCATION	PSLs		BACKGROUND CONCENTRATIONS		22SS001		22SS002		
SAMPLE ID	HH	ECO	RANGE	95% UTL	22SS0010002-	22SS0010002-D	22SS0020002	22SS0020002-AVG	22SS0020002-D
SAMPLE TYPE					NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
TOP DEPTH					0	0	0	0	0
BOTTOM DEPTH					2	2	2	2	2
METALS (MG/KG)									
ARSENIC	0.026	18	2.4 - 10.2	11.83	2.75	3.1	2.4	2.4	NA
BARIUM	1500	330	46.1 - 153	211	38	48.9 J	22 J	22 J	NA
CADMIUM	7	0.36	0.05 - 3.6	6.05	0.0995	0.099 J	0.057 J	0.057 J	NA
CHROMIUM	38	26	8.5 - 21.7	28.7	6	7.1	4.9	4.9	NA
LEAD	81	11	9.4 - 21.5	27.0	6.9	7.3	5.1	5.1	NA
SELENIUM	5.2	0.52	0.51 - 0.64	0.81	0.16	0.18 J	0.086 J	0.086 J	NA
SILVER	31	4.2	0.05 - 0.11	0.130	0.04 U	0.04 U	0.04 U	0.04 U	NA
MISCELLANEOUS PARAMETERS (S.U.)									
PH	NC	NC	NA	NA	NA	NA	NA	NA	NA

EXCEEDS HH PSL	
EXCEEDS ECO PSL	

HH - Human Health
ECO - Ecological
MG/KG - Milligrams per Kilogram
NC - No Criterion
NA - Not Applicable or Not Analyzed
PSL - Project Screening Level
S.U. - Standad Units
UTL - Upper Threshhold Limit

TABLE 10-2
SUBSURFACE SOIL ANALYTICAL RESULTS
SWMU 22 - LEAD AZIDE POND
NAVAL SUPPORT ACTIVITY
CRANE, INDIANA

LOCATION	PSL	BACKGROUND CONCENTRATIONS		22SB001			22SB002	22SB003
SAMPLE ID	HH	RANGE	95% UTL	22SB0010305	22SB0010305-AVG	22SB0010305-D	22SB0020607	22SB0030305
SAMPLE DATE				20110119	20110119	20110119	20110119	20110119
TOP DEPTH				3	3	3	6	3
BOTTOM DEPTH				5	5	5	7	5
METALS (MG/KG)								
ARSENIC	0.026	1.4 - 8.5	12.5	4.1 J	4.4	4.7 J	3.8 J	3.4 J
BARIUM	1500	25.1 - 83.4	115	38.4 J	61.95	85.5 J	19.3 J	23.3 J
CADMIUM	7	0.05 - 0.64	0.8	0.16 J	0.21	0.26 J	0.1 J	0.11 J
CHROMIUM	38	14.2 - 27.1	33.0	6 J	10	14 J	8.7 J	10.7 J
LEAD	81	8.6 - 15.2	19.6	6.5 J	75.25	144 J	9 J	7 J
SELENIUM	5.2	0.37 - 0.88	1.07	0.16 J	0.275	0.39 J	0.29 J	0.13 J
SILVER	31	0.05 - 0.1	0.14	0.04 UJ	0.027 J	0.027 J	0.04 UJ	0.04 UJ
MISCELLANEOUS PARAMETERS (S.U.)								
PH	NC	NA	NA	7.9	7.8	7.7	NA	NA

EXCEEDS HH PSL
EXCEEDS HH PSL & BACKGROUND 95% UTL

HH - Human Health
MG/KG - Milligrams per Kilogram
NC - No Criterion
NA - Not Applicable or Not Analyzed
PSL - Project Screening Level
S.U. - Standad Units
UTL - Upper Threshhold Limit

TABLE 10-2
SUBSURFACE SOIL ANALYTICAL RESULTS
SWMU 22 - LEAD AZIDE POND
NAVAL SUPPORT ACTIVITY
CRANE, INDIANA

LOCATION	PSL	BACKGROUND CONCENTRATIONS		22SB004	22SB006	22SB007	22SB009	22SB010
SAMPLE ID	HH	RANGE	95% UTL	22SB0040305	22SB0060304	22SB0070304	22SB0090305	22SB0100305
SAMPLE DATE				20110119	20110119	20110121	20110119	20110119
TOP DEPTH				3	3	3	3	3
BOTTOM DEPTH				5	4	4	5	5
METALS (MG/KG)								
ARSENIC	0.026	1.4 - 8.5	12.5	2 J	1.1 J	2	4.9 J	3.1 J
BARIUM	1500	25.1 - 83.4	115	51.1 J	2.3 J	14.8 J	23.3 J	60.5 J
CADMIUM	7	0.05 - 0.64	0.8	0.16 J	0.092 J	0.1	0.14 J	0.1 J
CHROMIUM	38	14.2 - 27.1	33.0	12.1 J	7.4 J	5.3	9.2 J	7.6 J
LEAD	81	8.6 - 15.2	19.6	4.7 J	2.8 J	4.9	7 J	5.5 J
SELENIUM	5.2	0.37 - 0.88	1.07	0.15 J	0.06 J	0.11 J	0.14 J	0.16 J
SILVER	31	0.05 - 0.1	0.14	0.04 UJ	0.04 UJ	0.04 U	0.022 J	0.04 UJ
MISCELLANEOUS PARAMETERS (S.U.)								
PH	NC	NA	NA	NA	NA	NA	NA	NA

EXCEEDS HH PSL
EXCEEDS HH PSL & BACKGROUND 95% UTL

HH - Human Health
MG/KG - Milligrams per Kilogram
NC - No Criterion
NA - Not Applicable or Not Analyzed
PSL - Project Screening Level
S.U. - Standad Units
UTL - Upper Threshhold Limit

TABLE 10-2
SUBSURFACE SOIL ANALYTICAL RESULTS
SWMU 22 - LEAD AZIDE POND
NAVAL SUPPORT ACTIVITY
CRANE, INDIANA

LOCATION	PSL	BACKGROUND CONCENTRATIONS		22SB011
SAMPLE ID	HH	RANGE	95% UTL	22SB0110304
SAMPLE DATE				20110119
TOP DEPTH				3
BOTTOM DEPTH				4
METALS (MG/KG)				
ARSENIC	0.026	1.4 - 8.5	12.5	6.1 J
BARIUM	1500	25.1 - 83.4	115	40.6 J
CADMIUM	7	0.05 - 0.64	0.8	0.12 J
CHROMIUM	38	14.2 - 27.1	33.0	9 J
LEAD	81	8.6 - 15.2	19.6	8.9 J
SELENIUM	5.2	0.37 - 0.88	1.07	0.26 J
SILVER	31	0.05 - 0.1	0.14	0.023 J
MISCELLANEOUS PARAMETERS (S.U.)				
PH	NC	NA	NA	NA

EXCEEDS HH PSL
EXCEEDS HH PSL & BACKGROUND 95% UTL

HH - Human Health
MG/KG - Milligrams per Kilogram
NC - No Criterion
NA - Not Applicable or Not Analyzed
PSL - Project Screening Level
S.U. - Standad Units
UTL - Upper Threshhold Limit

TABLE 10-3
SURFACE WATER ANALYTICAL RESULTS
SWMU 22 - LEAD AZIDE POND
NAVAL SUPPORT ACTIVITY
CRANE, INDIANA
PAGE 1 of 6

LOCATION	PSLs		22SD/SW001	22SD/SW002	22SD/SW003	22SD/SW004
SAMPLE ID	HH	ECO	22SW001	22SW002	22SW003	22SW004
SAMPLE DATE			20110120	20110120	20110120	20110120
EXPLOSIVES (UG/L)						
HMX	180	150	0.82	0.79	0.87	0.23 U
RDX	0.61	360	**0.78**	**0.75**	**0.82**	0.246 U
METALS (UG/L)						
ARSENIC	0.045	148	0.18 U	0.18 U	0.18 U	**1.5**
BARIUM	730	220	69	69.2	74.8	57.7
CADMIUM	1.8	0.15	0.04 U	0.04 U	0.04 U	0.04 U
CHROMIUM	50	42	0.55	0.48 J	0.43 J	3
LEAD	15	1.17	0.22 U	0.22 U	0.11 J	**6.1**
MERCURY	0.057	0.0013	0.12 U	0.12 U	0.12 U	0.12 U
SELENIUM	10	5	0.2 U	0.2 U	0.2 U	0.2 U
SILVER	18	0.12	0.06 UJ	0.06 UJ	0.06 UJ	0.06 UJ
DISSOLVED METALS (UG/L)						
ARSENIC	0.045	148	0.18 U	0.18 U	0.18 U	0.18 U
BARIUM	730	220	68	68.4	73.9	26
CADMIUM	1.8	0.15	0.04 U	0.04 U	0.04 U	0.04 U
CHROMIUM	50	42	0.5	0.39 J	0.92	0.75
LEAD	15	1.17	0.22 U	0.22 U	**2.2**	0.22 U
MERCURY	0.057	0.0013	0.12 U	0.12 U	0.12 U	**0.068 J**
SELENIUM	10	5	0.2 U	0.2 U	0.2 U	0.2 U
SILVER	18	0.12	0.06 UJ	0.06 UJ	0.06 UJ	0.06 UJ
MISCELLANEOUS PARAMETERS (UG/L)						
PERCHLORATE	15	NC	0.4 U	0.4 J	0.4 U	0.4 U

EXCEEDS HH PSL
EXCEEDS ECO PSL
EXCEEDS HH AND ECO PSL

HH - Human Health
ECO - Ecological
NC - No Criterion
NA - Not Applicable or Not Analyzed
PSL - Project Screening Level
S.U. - Standad Units
UG/L - Microgram per Liter
UTL - Upper Threshhold Limit

LOCATION	PSLs		22SD/SW006	22SD/SW007		22SD/SW009
SAMPLE ID	HH	ECO	22SW006	22SW007	22SW009	22SW009-AVG
SAMPLE DATE			20110118	20110118	20110120	20110120
EXPLOSIVES (UG/L)						
HMX	180	150	0.48 U	0.48 U	0.15 J	0.15 J
RDX	0.61	360	0.48 U	0.48 U	0.39 J	0.385
METALS (UG/L)						
ARSENIC	0.045	148	**0.38**	0.18 U	**0.46 J**	**0.38**
BARIUM	730	220	45.9	54.3	36.9 J	36.6
CADMIUM	1.8	0.15	**0.5**	**0.24**	0.073 U	0.0685 U
CHROMIUM	50	42	1.5	0.47 J	0.4 J	0.445
LEAD	15	1.17	**9.6**	**1.8**	1 J	0.89
MERCURY	0.057	0.0013	**0.065 J**	0.12 U	**0.089 J**	**0.089 J**
SELENIUM	10	5	0.2 U	0.2 U	0.1 J	0.1 J
SILVER	18	0.12	0.06 UJ	0.06 UJ	0.032 J	0.032 J
DISSOLVED METALS (UG/L)						
ARSENIC	0.045	148	**0.19 J**	**0.23 J**	**0.23 J**	**0.205**
BARIUM	730	220	36 J	53.8 J	34.5 J	34.15
CADMIUM	1.8	0.15	**0.24 J**	**0.26 J**	0.04 U	0.04 U
CHROMIUM	50	42	0.29 J	0.28 J	0.31 J	0.31
LEAD	15	1.17	0.37 J	0.69 J	0.11 J	0.115
MERCURY	0.057	0.0013	0.12 U	**0.067 J**	0.12 U	0.12 U
SELENIUM	10	5	0.2 UJ	0.2 UJ	0.2 UJ	0.2 U
SILVER	18	0.12	0.067 J	0.057 J	0.06 UJ	0.06 U
MISCELLANEOUS PARAMETERS (UG/L)						
PERCHLORATE	15	NC	0.4 U	0.4 U	0.4 U	0.4 U

EXCEEDS HH PSL
EXCEEDS ECO PSL
EXCEEDS HH AND ECO PSL

HH - Human Health
ECO - Ecological
NC - No Criterion
NA - Not Applicable or Not Analyzed
PSL - Project Screening Level
S.U. - Standad Units
UG/L - Microgram per Liter
UTL - Upper Threshhold Limit

TABLE 10-3
SURFACE WATER ANALYTICAL RESULTS
SWMU 22 - LEAD AZIDE POND
NAVAL SUPPORT ACTIVITY
CRANE, INDIANA
PAGE 3 of 6

LOCATION	PSLs			22SD/SW010	22SD/SW011	22SD/SW012
SAMPLE ID	HH	ECO	22SW009-D	22SW010	22SW011	22SW012
SAMPLE DATE			20110120	20110120	20110120	20110409
EXPLOSIVES (UG/L)						
HMX	180	150	0.23 U	0.23 J	0.88	0.230 U
RDX	0.61	360	0.38 J	0.55	**0.79**	0.246 U
METALS (UG/L)						
ARSENIC	0.045	148	**0.3 J**	**0.49 J**	**0.41**	NA
BARIUM	730	220	36.3 J	36.1 J	76.5	NA
CADMIUM	1.8	0.15	0.064 U	0.083 U	0.04 U	NA
CHROMIUM	50	42	0.49 J	0.43 J	0.45 J	NA
LEAD	15	1.17	0.78 J	0.86 J	0.22 U	NA
MERCURY	0.057	0.0013	0.12 U	0.12 U	0.12 U	NA
SELENIUM	10	5	0.2 UJ	0.2 UJ	0.24 J	NA
SILVER	18	0.12	0.06 UJ	0.06 UJ	0.06 UJ	NA
DISSOLVED METALS (UG/L)						
ARSENIC	0.045	148	**0.18 J**	**0.2 J**	**0.44 J**	NA
BARIUM	730	220	33.8 J	34.4 J	77.4 J	NA
CADMIUM	1.8	0.15	0.04 U	0.043 U	0.04 UJ	NA
CHROMIUM	50	42	0.31 J	0.27 J	0.46 J	NA
LEAD	15	1.17	0.12 J	0.22 UJ	0.12 J	NA
MERCURY	0.057	0.0013	0.12 U	0.12 U	**0.084 J**	NA
SELENIUM	10	5	0.2 UJ	0.2 UJ	0.28 J	NA
SILVER	18	0.12	0.06 UJ	0.06 UJ	0.06 UJ	NA
MISCELLANEOUS PARAMETERS (UG/L)						
PERCHLORATE	15	NC	0.4 U	0.4 U	0.4 U	NA

EXCEEDS HH PSL
EXCEEDS ECO PSL
EXCEEDS HH AND ECO PSL

HH - Human Health
ECO - Ecological
NC - No Criterion
NA - Not Applicable or Not Analyzed
PSL - Project Screening Level
S.U. - Standad Units
UG/L - Microgram per Liter
UTL - Upper Threshhold Limit

TABLE 10-3
SURFACE WATER ANALYTICAL RESULTS
SWMU 22 - LEAD AZIDE POND
NAVAL SUPPORT ACTIVITY
CRANE, INDIANA
PAGE 4 of 6

LOCATION	PSLs		22SD/SW013	22SD/SW014	22SD/SW015	22SD/SW016
SAMPLE ID	HH	ECO	22SW013	22SW014	22SW015	22SW016
SAMPLE DATE			20110409	20110409	20110409	20110409
EXPLOSIVES (UG/L)						
HMX	180	150	11	0.230 U	0.230 U	0.230 U
RDX	0.61	360	**0.98**	0.246 U	0.246 U	0.246 U
METALS (UG/L)						
ARSENIC	0.045	148	NA	NA	NA	NA
BARIUM	730	220	NA	NA	NA	NA
CADMIUM	1.8	0.15	NA	NA	NA	NA
CHROMIUM	50	42	NA	NA	NA	NA
LEAD	15	1.17	NA	NA	NA	NA
MERCURY	0.057	0.0013	NA	NA	NA	NA
SELENIUM	10	5	NA	NA	NA	NA
SILVER	18	0.12	NA	NA	NA	NA
DISSOLVED METALS (UG/L)						
ARSENIC	0.045	148	NA	NA	NA	NA
BARIUM	730	220	NA	NA	NA	NA
CADMIUM	1.8	0.15	NA	NA	NA	NA
CHROMIUM	50	42	NA	NA	NA	NA
LEAD	15	1.17	NA	NA	NA	NA
MERCURY	0.057	0.0013	NA	NA	NA	NA
SELENIUM	10	5	NA	NA	NA	NA
SILVER	18	0.12	NA	NA	NA	NA
MISCELLANEOUS PARAMETERS (UG/L)						
PERCHLORATE	15	NC	NA	NA	NA	NA

EXCEEDS HH PSL
EXCEEDS ECO PSL
EXCEEDS HH AND ECO PSL

HH - Human Health
ECO - Ecological
NC - No Criterion
NA - Not Applicable or Not Analyzed
PSL - Project Screening Level
S.U. - Standad Units
UG/L - Microgram per Liter
UTL - Upper Threshhold Limit

TABLE 10-3
SURFACE WATER ANALYTICAL RESULTS
SWMU 22 - LEAD AZIDE POND
NAVAL SUPPORT ACTIVITY
CRANE, INDIANA
PAGE 5 of 6

LOCATION	PSLs		22SD/SW017	22SD/SW017		22SD/SW018
SAMPLE ID	HH	ECO	22SW017	22SW017	22SW018	22SW018
SAMPLE DATE			20110409	20110409	20110409	20110409
EXPLOSIVES (UG/L)						
HMX	180	150	0.61	0.61	0.63	0.53
RDX	0.61	360	**2.5**	**2.5**	**1.5**	**1.3**
METALS (UG/L)						
ARSENIC	0.045	148	NA	NA	**0.72**	**0.68**
BARIUM	730	220	NA	NA	26.4	25.4
CADMIUM	1.8	0.15	NA	NA	**0.25**	**0.22**
CHROMIUM	50	42	NA	NA	1.0	1.05
LEAD	15	1.17	NA	NA	**6.0**	**4.95**
MERCURY	0.057	0.0013	NA	NA	0.12 U	0.12 U
SELENIUM	10	5	NA	NA	0.17 J	0.17 J
SILVER	18	0.12	NA	NA	0.060 U	0.060 U
DISSOLVED METALS (UG/L)						
ARSENIC	0.045	148	NA	NA	**0.35**	**0.345**
BARIUM	730	220	NA	NA	27.1	23.6
CADMIUM	1.8	0.15	NA	NA	0.066 J	0.057 J
CHROMIUM	50	42	NA	NA	0.37 J	0.46 J
LEAD	15	1.17	NA	NA	0.220 U	0.220 U
MERCURY	0.057	0.0013	NA	NA	0.12 U	0.12 U
SELENIUM	10	5	NA	NA	0.20 U	0.60 U
SILVER	18	0.12	NA	NA	0.060 U	0.060 U
MISCELLANEOUS PARAMETERS (UG/L)						
PERCHLORATE	15	NC	NA	NA	NA	NA

EXCEEDS HH PSL
EXCEEDS ECO PSL
EXCEEDS HH AND ECO PSL

HH - Human Health
ECO - Ecological
NC - No Criterion
NA - Not Applicable or Not Analyzed
PSL - Project Screening Level
S.U. - Standad Units
UG/L - Microgram per Liter
UTL - Upper Threshhold Limit

TABLE 10-3
SURFACE WATER ANALYTICAL RESULTS
SWMU 22 - LEAD AZIDE POND
NAVAL SUPPORT ACTIVITY
CRANE, INDIANA

LOCATION	PSLs			22SD/SW019	22SD/SW020	22SD/SW021
SAMPLE ID	HH	ECO	22SW018-D	22SW019	22SW020	22SW021
SAMPLE DATE			20110409	20110409	20110409	20110409
EXPLOSIVES (UG/L)						
HMX	180	150	0.43 J	0.230 U	0.230 U	0.230 U
RDX	0.61	360	**1.1**	0.246 U	0.246 U	0.246 U
METALS (UG/L)						
ARSENIC	0.045	148	**0.64 J**	NA	NA	NA
BARIUM	730	220	24.4	NA	NA	NA
CADMIUM	1.8	0.15	**0.19 J**	NA	NA	NA
CHROMIUM	50	42	1.1 J	NA	NA	NA
LEAD	15	1.17	**3.9**	NA	NA	NA
MERCURY	0.057	0.0013	0.12 U	NA	NA	NA
SELENIUM	10	5	1 U	NA	NA	NA
SILVER	18	0.12	0.060 U	NA	NA	NA
DISSOLVED METALS (UG/L)						
ARSENIC	0.045	148	**0.34**	NA	NA	NA
BARIUM	730	220	20.1	NA	NA	NA
CADMIUM	1.8	0.15	0.048 J	NA	NA	NA
CHROMIUM	50	42	0.55 J	NA	NA	NA
LEAD	15	1.17	0.220 U	NA	NA	NA
MERCURY	0.057	0.0013	0.12 U	NA	NA	NA
SELENIUM	10	5	1.00 U	NA	NA	NA
SILVER	18	0.12	0.060 U	NA	NA	NA
MISCELLANEOUS PARAMETERS (UG/L)						
PERCHLORATE	15	NC	NA	NA	NA	NA

EXCEEDS HH PSL
EXCEEDS ECO PSL
EXCEEDS HH AND ECO PSL

HH - Human Health
ECO - Ecological
NC - No Criterion
NA - Not Applicable or Not Analyzed
PSL - Project Screening Level
S.U. - Standad Units
UG/L - Microgram per Liter
UTL - Upper Threshhold Limit

TABLE 10-4
SEDIMENT ANALYTICAL RESULTS
SWMU 22 - LEAD AZIDE POND
NAVAL SUPPORT ACTIVITY
CRANE, INDIANA

LOCATION	PSLs		22SD/SW001	22SD/SW002	22SD/SW003	22SD/SW004	22SD/SW005
SAMPLE ID	HH	ECO	22SD0010006	22SD0020006	22SD0030006	22SD0040006	22SD0050006
SAMPLE DATE			20110120	20110120	20110120	20110120	20110120
TOP DEPTH			0	0	0	0	0
BOTTOM DEPTH			0.5	0.5	0.5	0.5	0.5
METALS (MG/KG)							
ARSENIC	0.39	9.79	**6.1 J**	**5.2 J**	**3.8 J**	**2.4 J**	**1.8 J**
BARIUM	1500	NC	34.8 J	17 J	173 J	27.1 J	18.9 J
CADMIUM	7	0.99	0.31 J	0.11 J	0.2 J	0.1 J	0.16 J
CHROMIUM	430	26	12.4 J	13.2 J	13.9 J	4.5 J	3.2 J
LEAD	81	35.8	9 J	6.2 J	7.6 J	5.6 J	4.7 J
MERCURY	0.56	0.174	0.03 U	0.033 U	0.037 U	0.054 U	0.045 U
SELENIUM	39	2	0.21 J	0.11 J	0.11 J	0.14 J	0.083 J
SILVER	39	0.5	0.025 J	0.04 UJ	0.04 UJ	0.04 UJ	0.04 UJ
MISCELLANEOUS PARAMETERS (MG/KG)							
TOTAL ORGANIC CARBON	NC	NC	11000	1200	2900	13000	31000
MISCELLANEOUS PARAMETERS (S.U.)							
PH	NC	NC	NA	NA	NA	NA	NA

EXCEEDS HH PSL
EXCEEDS ECO PSL
EXCEEDS HH AND ECO PSL

HH - Human Health
ECO - Ecological
MG/KG - Milligrams per Kilogram
NC - No Criterion
NA - Not Applicable or Not Analyzed
PSL - Project Screening Level
S.U. - Standad Units
UTL - Upper Threshhold Limit

TABLE 10-4
SEDIMENT ANALYTICAL RESULTS
SWMU 22 - LEAD AZIDE POND
NAVAL SUPPORT ACTIVITY
CRANE, INDIANA

LOCATION	PSLs		22SD/SW006		22SD/SW007	
SAMPLE ID	HH	ECO	22SD0060006	22SD0060624	22SD0070006	22SD0070624
SAMPLE DATE			20110118	20110118	20110118	20110118
TOP DEPTH			0	0.5	0	0.5
BOTTOM DEPTH			0.5	2	0.5	2
METALS (MG/KG)						
ARSENIC	0.39	9.79	**1.7 J**	**1.6 J**	**2.7 J**	**1.6 J**
BARIUM	1500	NC	25 J	17.9 J	23.2 J	19.6 J
CADMIUM	7	0.99	0.88 J	0.071 J	0.15 J	0.51 J
CHROMIUM	430	26	4.7 J	4 J	3.7 J	2.9 J
LEAD	81	35.8	11.3 J	4 J	8.8 J	8.3 J
MERCURY	0.56	0.174	0.041 U	0.04 U	0.034 U	0.039 U
SELENIUM	39	2	0.1 J	0.061 J	0.11 J	0.12 J
SILVER	39	0.5	0.02 J	0.04 UJ	0.04 UJ	0.04 UJ
MISCELLANEOUS PARAMETERS (MG/KG)						
TOTAL ORGANIC CARBON	NC	NC	10000	2000	8300	5500
MISCELLANEOUS PARAMETERS (S.U.)						
PH	NC	NC	6.6	7.3	NA	NA

EXCEEDS HH PSL
EXCEEDS ECO PSL
EXCEEDS HH AND ECO PSL

HH - Human Health
ECO - Ecological
MG/KG - Milligrams per Kilogram
NC - No Criterion
NA - Not Applicable or Not Analyzed
PSL - Project Screening Level
S.U. - Standad Units
UTL - Upper Threshhold Limit

TABLE 10-4
SEDIMENT ANALYTICAL RESULTS
SWMU 22 - LEAD AZIDE POND
NAVAL SUPPORT ACTIVITY
CRANE, INDIANA

LOCATION	PSLs		22SD/SW008		22SD/SW009		
SAMPLE ID	HH	ECO	22SD0080006	22SD0080624	22SD0090006	22SD0090006-AVG	22SD0090006-D
SAMPLE DATE			20110118	20110118	20110120	20110120	20110120
TOP DEPTH			0	0.5	0	0	0
BOTTOM DEPTH			0.5	2	0.5	0.5	0.5
METALS (MG/KG)							
ARSENIC	0.39	9.79	**5.6 J**	**5.1 J**	**2.2 J**	**3.7**	**5.2 J**
BARIUM	1500	NC	41.1 J	46.1 J	16.7 J	25.9	35.1 J
CADMIUM	7	0.99	0.24 J	0.13 J	0.24 J	0.87	**1.5 J**
CHROMIUM	430	26	10.4 J	11.4 J	3.8 J	21.2	**38.6 J**
LEAD	81	35.8	14.8 J	20 J	7.2 J	30.1	**53 J**
MERCURY	0.56	0.174	0.045 U	0.056 U	**0.26**	0.143	0.052 U
SELENIUM	39	2	0.22 J	0.19 J	0.1 J	0.12	0.14 J
SILVER	39	0.5	0.02 J	0.04 UJ	0.04 UJ	0.0565 U	0.073 U
MISCELLANEOUS PARAMETERS (MG/KG)							
TOTAL ORGANIC CARBON	NC	NC	18000	2100	18000	20000	22000
MISCELLANEOUS PARAMETERS (S.U.)							
PH	NC	NC	NA	NA	NA	NA	NA

EXCEEDS HH PSL
EXCEEDS ECO PSL
EXCEEDS HH AND ECO PSL

HH - Human Health
ECO - Ecological
MG/KG - Milligrams per Kilogram
NC - No Criterion
NA - Not Applicable or Not Analyzed
PSL - Project Screening Level
S.U. - Standad Units
UTL - Upper Threshhold Limit

TABLE 10-4
SEDIMENT ANALYTICAL RESULTS
SWMU 22 - LEAD AZIDE POND
NAVAL SUPPORT ACTIVITY
CRANE, INDIANA

LOCATION	PSLs		22SD/SW010	22SD/SW011	22SD/SW018		
SAMPLE ID	HH	ECO	22SD0100006	22SD0110006	22SD0180006	22SD0180006-AVG	22SD0180006-D
SAMPLE DATE			20110120	20110120	20110409	20110409	20110409
TOP DEPTH			0	0	0	0	0
BOTTOM DEPTH			0.5	0.5	0.5	0.5	0.5
METALS (MG/KG)							
ARSENIC	0.39	9.79	2 J	12.3 J	1.2	1.4	1.5
BARIUM	1500	NC	8.6 J	38.3 J	12.8	15.7	18.5
CADMIUM	7	0.99	0.37 J	0.26 J	0.24	0.20	0.15
CHROMIUM	430	26	2.5 J	16.2 J	2.8	3.9	5.0
LEAD	81	35.8	7.9 J	11.3 J	12.1	11.2	10.3
MERCURY	0.56	0.174	0.051 U	0.049 U	0.038 J	0.038 J	0.04 U
SELENIUM	39	2	0.044 J	0.19 J	0.17 J	0.16 J	0.15 J
SILVER	39	0.5	0.04 UJ	0.04 UJ	0.04 U	0.04 U	0.04 U
MISCELLANEOUS PARAMETERS (MG/KG)							
TOTAL ORGANIC CARBON	NC	NC	8800	2800	6900	9950	13000
MISCELLANEOUS PARAMETERS (S.U.)							
PH	NC	NC	NA	NA	NA	NA	NA

EXCEEDS HH PSL
EXCEEDS ECO PSL
EXCEEDS HH AND ECO PSL

HH - Human Health
ECO - Ecological
MG/KG - Milligrams per Kilogram
NC - No Criterion
NA - Not Applicable or Not Analyzed
PSL - Project Screening Level
S.U. - Standad Units
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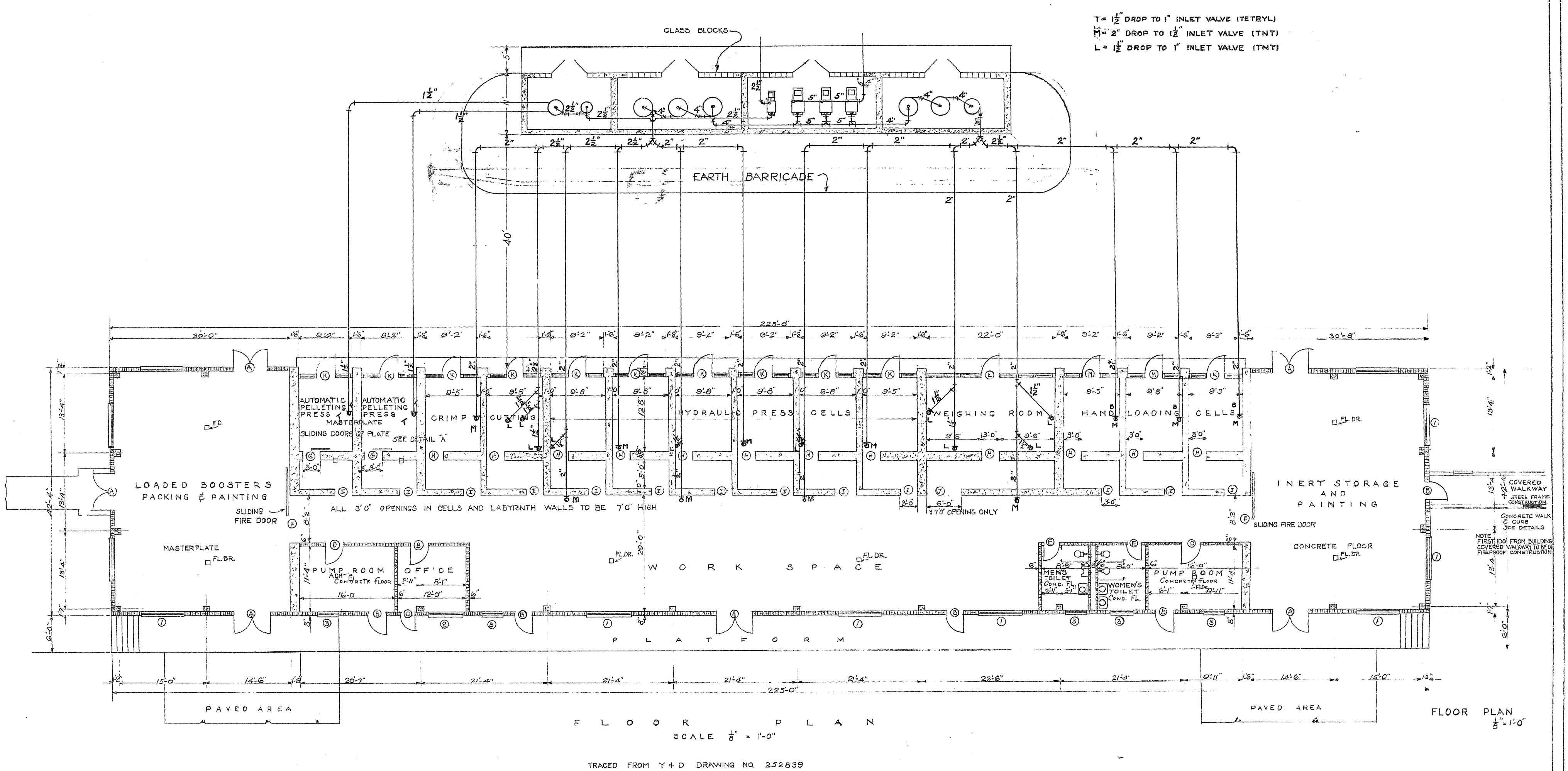
APPENDIX H

NSA CRANE PUBLIC WORKS DRAWINGS



FLOOR PLAN
SCALE 1/8" = 1'-0"

TRACED FROM Y & D DRAWING NO. 252839

FLOOR PLAN
1/8" = 1'-0"

PRELIMINARY VACUUM SYSTEM PIPING LAYOUT FOR BOOSTER LOADING BUILDING

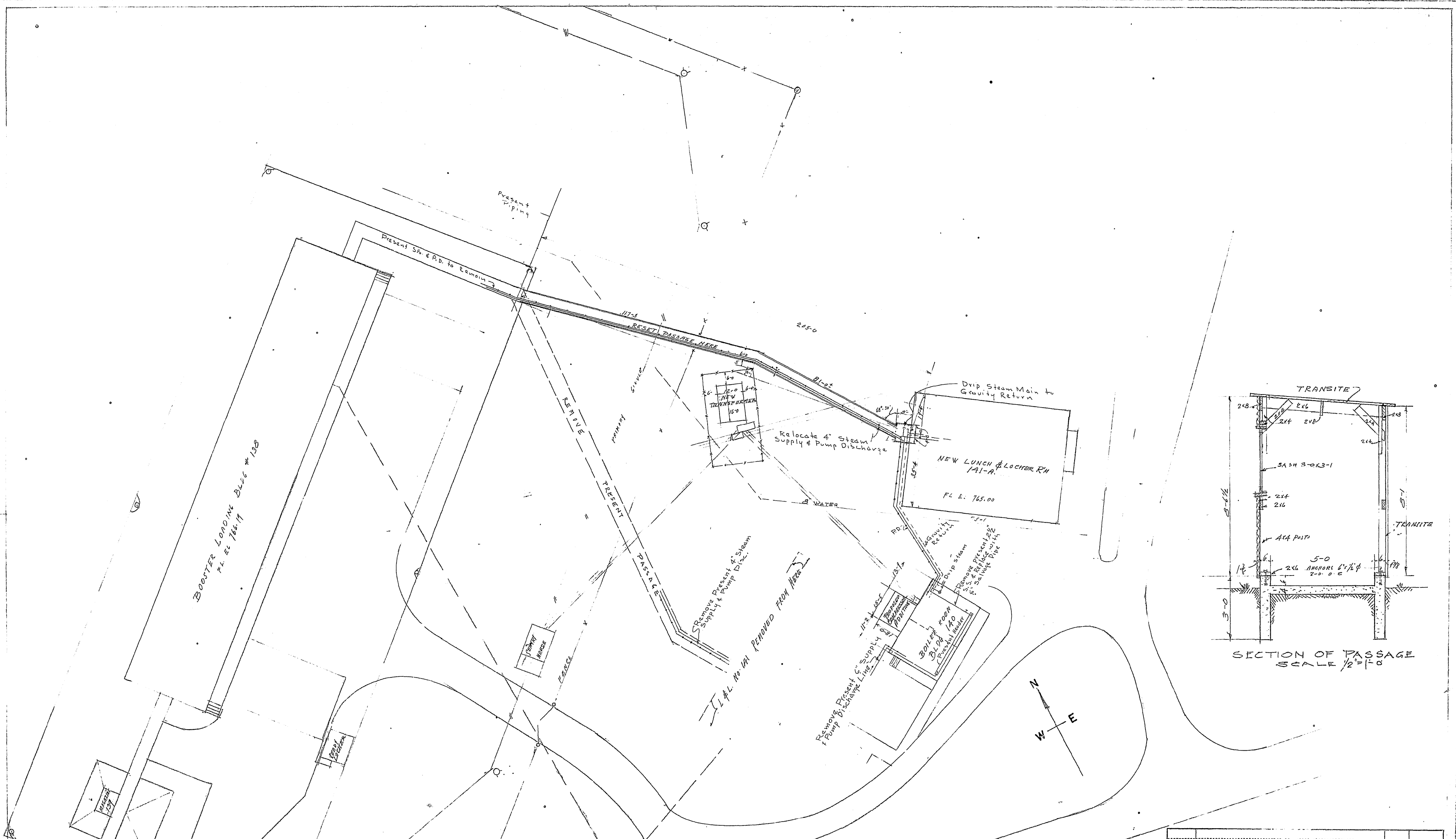
U.S. NAVAL AMMUNITION DEPOT, ENGINEERING DEPT. CRANE, INDIANA

REVISIONS	PRINTS	ISSUED	REMARKS
	5	7-19-44	

APPROVED
DATE
PROJ. NO.
DEPOT DRAWING NO.
CHECKED
DRAFTSMAN G. W. Steele
DATE 7-19-44
SCALE 1/8" = 1'-0"
SHEET NO.
ORD. 260

C-5

C-7



SYMBOL	DESCRIPTION	DATE	APPROVAL
"A"	Relocated Steam & Pump Disc. Lines	7-15-52	

REVISIONS

PWO DRAWING NO. 607

DEPARTMENT OF THE NAVY — BUREAU OF YARDS & DOCKS
NINTH NAVAL DISTRICT — CHICAGO, ILLINOIS
U. S. NAVAL AMMUNITION DEPOT — CRANE, INDIANA

DRAWN BY J.J.G.
TRACED BY
CHECKED BY
DES. ENGR. RSW
P.W. ENGR.

BOOSTER AREA PASSAGE REMOVAL AND RESETTING AND RELOCATING TRANSFORMER

APPROVED ________ PUBLIC WORKS OFFICER DATE 6/25/52

APPROVED FOR BUREAU OF YARDS & DOCKS
DPWO FOR CHIEF OF BUREAU
DATE

SCALE — SPEC.
SHEET 1 OF 2 — NOY
Y&D DRAWING NO.

APPENDIX I

SITE-SPECIFIC FIELD STANDARD OPERATING PROCEDURES

STANDARD OPERATING PROCEDURE
SOP-14

MONITORING WELL INSTALLATION

1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper design and installation of ground water monitoring wells for the collection of groundwater samples in the upper water-bearing zone. The methods described herein are specific for monitoring well construction at the NSA Crane facility. Guidelines by South Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM, 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

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of performing all phases of proper monitoring well installation and construction. The drilling contractor personnel must have all the health and safety training required to perform the work, as specified in the health and safety plan. The driller is also responsible for obtaining, in advance, any required permits for drilling and monitoring well installation and construction.

Field Geologist - The field geologist supervises and documents well installation and construction performed by the driller and ensures that the screen interval for each monitoring well is properly placed to provide representative groundwater data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

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 drilling and installation equipment with associated materials (typically supplied by the driller).

Hydrogeologic equipment (weighted engineer's tape, water-level indicator, retractable engineer's rule, electronic calculator, clipboard, mirror and flashlight for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, boring logs, soil sample log forms, chain-of-custody records, sample coolers with ice, and a field notebook).

4.0 WELL DESIGN AND CONSTRUCTION

Overburden well borings will be drilled using minimum 4-inch inside diameter hollow-stem augers to the desired depth of each well boring. Rotary drilling with a roller bit and water wash or air rotary drilling can be used to extend the shallow well borings to allow well installation in the upper water-bearing zone. In no cases will the Mississippian Elwren Shale Formation be completely penetrated unless a steel casing is installed and grouted in place at the top of the Elwren Formation.

Bedrock monitoring well borings will be drilled using hollow-stem auger or rotary drilling techniques until the bedrock is reached. For shallow bedrock wells (i.e., those monitoring the upper water-bearing zone in bedrock) where no overburden soil contamination is present, a temporary 6-inch, steel casing will be installed to isolate the overburden while the upper bedrock is drilled. For wells to be installed in the upper water-bearing zone where soil contamination is known to be present, a 6-inch-diameter steel casing will be installed 3- to 5-into to the top of competent bedrock and will be grouted with cement-bentonite slurry in a manner to ensure that the entire annulus between the casing and borehole is sealed. Diamond coring (NX) or air rotary drilling will be initiated after the grout is allowed to cure for a minimum of 24 hours.

For wells using diamond coring, the coring will proceed from the bottom of the casing to the full depth of the boring. Once the coring has been completed and the core has been logged (see SOP-13), then the hole will be reamed out with a minimum 5-inch-diameter air rotary bit.

For wells using air rotary drilling in those cases where coring is not anticipated, the drilling will be performed through the casing after the grout has sufficiently set. These borings will be logged using the rock chips and dust blown up the boring by the return air of the drill bit (see SOP-13). The borehole will then be cleaned out using compressed air from the drill bit. The air rotary equipment must have a filter on the compressed air line going to the borehole to prevent oil and other organics from being introduced.

All monitoring wells will be constructed of Schedule 40, flush-joint-threaded, 2-inch inside diameter polyvinyl chloride (PVC) riser pipe and flush joint threaded, factory slotted well screen with a threaded end cap. The well screens will be factory slotted to 0.010-inch size. Each section of well casing and screen will be National Sanitation Foundation (NSF) approved. Well screens will be 10 feet long but may be longer or shorter based on the subsurface conditions that are encountered. A PVC cap will be placed on the bottom and will also be flush threaded. Other means of joining casings using glue, gaskets, pop rivets, or screws are not allowed. The screen will pass no more than 10 percent of the pack material or in-situ aquifer material.

Monitoring wells will be installed immediately upon completion of drilling or packer testing, if performed. A well screen section with bottom cap and the proper amount of riser pipe will be assembled and lowered down the borehole. Centralizers will be used as necessary to ensure that the casing and screen are centered and are aligned straight. The sand pack will be extended from 0.5 foot below the well screen to 2.0 feet above the top of the well screen. Clean silica sand of U.S. Standard Sieve Size No. 20 to 40 will be used.

A minimum 3-foot-thick bentonite pellet seal will be installed above the filter pack and allowed to hydrate for a minimum of 3 hours before grout is added above the seal. Only 100 percent, certified pure sodium bentonite will be used for well construction. The depths of backfill materials will be constantly monitored during well installation using a weighted stainless-steel or fiberglass tape measure.

The remaining annulus above the hydrated bentonite seal will be backfilled to the surface using a tremie pipe, with a 20:1 cement/bentonite grout. A maximum of 10 gallons of water per 94-pound bag of Type 1 cement will be used. The grout mixture should be blended in an above-ground rigid container or mixer to produce a thick lump-free mixture. This grout mixture will also be used for placement of steel casings in deep wells.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets extending to the surface. The grout effectively seals the well and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom of the hole upward to prevent bridging and to provide a better seal. However, in shallow boreholes that do not collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

When the well is completed and grouted to the surface, a protective steel surface casing is placed over the top of the riser pipe. The finished well casing will extend at least 2 feet above the ground level. This casing will have a cap that can be locked to prevent vandalism. A vent hole will be provided in the cap to allow venting of gases and maintain atmospheric pressure as water levels rise or fall in the well. The protective casing has a larger diameter than the riser pipe and is set into the wet cement grout over the well upon completion or can be placed between the steel casing and the riser pipe in the case of deep monitoring well borings. In addition, one hole is drilled just above the cement collar through the protective casing, which acts as a weep hole for the flow of water that may enter the annulus during well development, purging, or sampling. In traffic areas or high visibility areas, a flush-to-grade protective may be installed over the top of the riser pipe.

5.0 DOCUMENTATION OF FIELD ACTIVITIES

A critical part of monitoring well installation is recording of significant details and events in the site logbook, on field forms, and in a field logbook. Details of borehole logging are contained in SOP-09.

6.0 ATTACHMENTS

1. Bedrock Monitoring Well Sheet
2. Overburden Monitoring Well Sheet

ATTACHMENT 1

BEDROCK MONITORING WELL SHEET

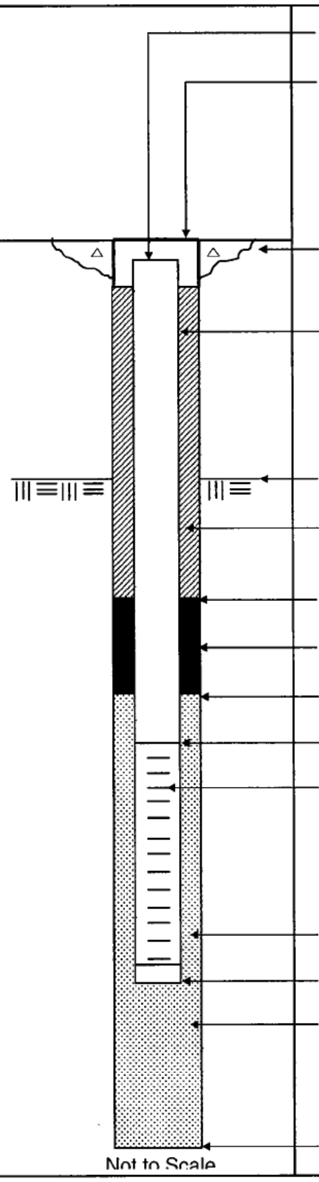
Tetra Tech NUS, Inc.

MONITORING WELL SHEET

WELL No.: ____________

PROJECT:	________	DRILLING Co.:	________	BORING No.:	________
PROJECT No.:	________	DRILLER:	________	DATE COMPLETED:	________
SITE:	________	DRILLING METHOD:	________	NORTHING:	________
GEOLOGIST:	________	DEV. METHOD:	________	EASTING:	________

Ground Elevation =
Datum:



Elevation / Depth of Top of Riser: ______ / ______

Elevation / Height of Top of Surface Casing: ______ / ______

I.D. of Surface Casing: ____________

Type of Surface Casing: ____________

Type of Surface Seal: ____________

____

I.D. of Riser: ____________

Type of Riser: ____________

Borehole Diameter: ____________

Elevation / Depth Top of Rock: ______ / ______

Type of Backfill: ____________

____

Elevation / Depth of Seal: ______ / ______

Type of Seal: ____________

Elevation / Depth of Top of Filter Pack: ______ / ______

Elevation / Depth of Top of Screen: ______ / ______

Type of Screen: ____________

Slot Size x Length: ____________

I.D. of Screen: ____________

Type of Filter Pack: ____________

Elevation / Depth of Bottom of Screen: ______ / ______

Elevation / Depth of Bottom of Filter Pack: ______ / ______

Type of Backfill Below Well:

____

Elevation / Total Depth of Borehole: ______ / ______

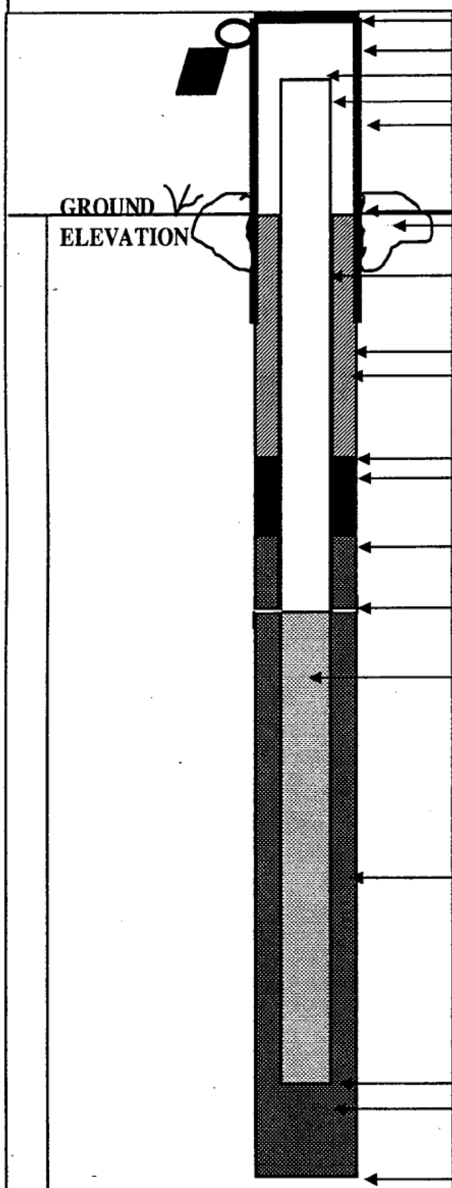
ATTACHMENT 2

OVERBURDEN MONITORING WELL SHEET

BORING NO.: ________

Tetra Tech NUS, Inc. **OVERBURDEN MONITORING WELL SHEET**

PROJECT:	NIROP FRIDLEY	DRILLING Co.:		BORING No.:	
PROJECT No.:	7842 CTO 0057	DRILLER:		DATE COMPLETED:	
SITE:	ANOKA PARK	DRILLING METHOD:		NORTHING:	
GEOLOGIST:		DEV. METHOD:		EASTING:	



ELEVATION OF TOP OF SURFACE CASING: ________
STICK -UP TOP OF SURFACE CASING: ________
ELEVATION OF TOP OF RISER PIPE: ________
RISER STICK-UP ABOVE GROUND SURFACE: ________
I.D. OF SURFACE CASING: ________
TYPE OF SURFACE CASING: ________

GROUND ELEVATION: ________
TYPE OF SURFACE SEAL: ________

RISER PIPE I.D.: 2"
TYPE OF RISER PIPE: CARBON STEEL

BOREHOLE DIAMETER: ________
TYPE OF SEAL: ________

ELEVATION / DEPTH OF SEAL: ____ / ____
TYPE OF SEAL: BENTONITE CHIPS

ELEVATION / DEPTH TOP OF FILTER PACK: ____ / ____

ELEVATION / DEPTH TOP OF SCREEN: ____ / ____

TYPE OF SCREEN: CARBON STEEL

SLOT SIZE X LENGTH: 10 SLOT x

I.D. OF SCREEN: 2"

TYPE OF FILTER PACK: SILICA SAND
(No. 10-20 U.S. STANDARD SEIVE SIZE)

ELEVATION / DEPTH BOTTOM OF SCREEN: ____ / ____
ELEVATION / DEPTH BOTTOM OF FILTER PACK: ____ / ____
TYPE OF BACKFILL BELOW WELL: ________
ELEVATION / DEPTH OF BOREHOLE: ____ / ____

STANDARD OPERATING PROCEDURE
SOP-15

DRILLING AND GEOLOGIC LOGGING OF BOREHOLES IN BEDROCK

1.0 PURPOSE

This procedure describes the methods and equipment necessary to drill bedrock borings and identify the equipment, sequence of events, and appropriate methods necessary to obtain rock cores and prepare boring logs during drilling activities. Up to four types of drilling activities and equipment will be used to drill holes and install monitoring wells at the NSA Crane facility:

- Auger drilling with continuous split-spoon sampling will be used to drill through the overburden material.

- Diamond coring equipment will be used to core through the bedrock. NX or similar size diamond core barrels will be used to collect 2- to 3-inch-diameter continuous rock core. These cores will be used to describe the lithologic characteristics and fracture distributions in the bedrock. Diamond coring is relatively slow and more expensive compared to the air rotary method of drilling, so one hole per subarea is proposed to be cored.

- Air-rotary or rotosonic drilling will be used to advance the boreholes not cored. The holes need to be a minimum of 5 inches in diameter in order to install a 2-inch-diameter monitoring well. Air rotary may also be used to deepen well borings in the event bedrock is encountered before the desired well boring depth is reached.

- Rotary drilling with a roller bit and water wash may be used to complete well borings in the event that bedrock is encountered before the desired well boring depth is reached.

2.0 RESPONSIBILITIES

<u>Field Operations Leader (FOL)</u> - The FOL is responsible for coordinating all on-site personnel and for providing technical assistance, when required. The FOL, or designee, will coordinate and lead all activities and will ensure the availability and maintenance of all materials and equipment. The FOL is responsible for the completion of all field activities and field and chain-of-custody documentation. The

FOL will assume custody of all samples and will ensure the proper handling and shipping of samples. The FOL is a highly experienced environmental professional who will report directly to the TtNUS Task Order Manager (TOM). Specific FOL responsibilities include the following:

- Function as a communications link among field staff members, the site quality assurance/quality control advisor, site safety officer, the site manager, and the TOM.
- Oversee the mobilization and demobilization of all field equipment and subcontractors.
- Coordinate and manage the field technical staff.
- Adhere to the work schedules provided by the TOM.
- Maintain the site logbook and field recordkeeping.
- Initiate field task modification requests, when necessary.
- Identify and resolve problems in the field, resolve difficulties in consultation with the NSA Crane Site Manager, implement and document corrective action procedures, and provide communication between the field team and upper management.

<u>Field Geologist</u> - The field geologist is responsible for ensuring that standard and approved drilling procedures are followed. The field geologist will generate a detailed boring log for each borehole. This log will include a description of geologic materials, samples (if any), method of sampling, and other pertinent information and observations that may be obtained during drilling.

Determination of the exact location for borings is the responsibility of the field geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the QAPP.

<u>Drilling Subcontractor</u> - The subcontractor operates under the supervision of the FOL. He or she is responsible for obtaining all drilling permits and clearances and supplying all services (including labor), equipment, and material required to perform the drilling, testing, and well installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical problems encountered in the field to the FOL within 24 hours of determination and must provide advance written notification of any changes in field procedures, describing and justifying such changes. No such changes will be made unless requested and authorized in writing by the FOL (with the concurrence of the project manager). Depending on the subcontract, the project manager may need to obtain written authorization from appropriate administrative personnel before approving any changes.

The drilling subcontractor is responsible for following decontamination procedures specified for drilling and coring equipment specified in the project plan documents. The FOL will oversee the in-field equipment decontamination procedures to confirm compliance with the appropriate SOP and specific requirements of the NSA Crane Environmental Department. Upon completion of the work, the driller is responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

3.0 PROCEDURES

3.1 General

The purpose of drilling boreholes is

- To determine the type, thickness, and certain physical and chemical properties of the soil, water, and rock strata that underlie the site.
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned between samples and borings using appropriate decontamination procedures as outlined in SOP-12. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first and at the most contaminated locations last to reduce the risk of spreading contamination between locations. All borings must be logged by the site geologist as they proceed.

3.2 Rock Coring

Drilling is done by rotating and applying downward pressure to the drill rods and drill bit. The drill bit is a circular, hollow, diamond-studded bit attached to the outer core barrel in a double-tube core barrel. The use of single-tube core barrels is not recommended because the rotation of the barrel erodes the sample and limits its use for detailed geological evaluation. Water or air is circulated down through the drill rods and annular space between the core barrel tubes to cool the bit and remove the cuttings. The bit cuts a core out of the rock that rises into an inner barrel mounted inside the outer barrel. The inner core barrel and rock core are removed by lowering a wire line with a coupling into the drill rods, latching onto the inner barrel, and withdrawing the inner barrel. A less efficient variation of this method utilizes a core barrel that cannot be removed without pulling all the drill rods. This variation is practical only if fewer than 50 feet of core is required. When coring rock, the speed of the drill and the drilling pressure, amount and pressure of water, and length of run can be varied to give the maximum recovery from the rock being drilled.

Advantages of core drilling include

- Undisturbed rock cores can be recovered for examination and/or testing.
- In formations in which the cored hole will remain open without casing, water from the rock fractures may be recovered from the well without the installation of a well screen and gravel pack.
- Formation logging is extremely accurate.
- Drill rigs are relatively small and mobile.

Disadvantages include

- Water or air is needed for drilling.
- Coring is slower than rotary drilling (and more expensive).
- Depth to water cannot accurately be determined if water is used for drilling.
- The size of the borehole is limited.

This drilling method is useful if accurate determinations of rock lithology are desired or if open wells are to be installed into bedrock. To install monitoring wells in coreholes, the hole will be reamed out to the proper size after boring, using air rotary drilling methods. Rock coring enables a detailed assessment of borehole conditions to be made, showing precisely all lithologic changes and characteristics. Because coring is an expensive drilling method, it is commonly used for shallow studies of 500 feet or less or for specific intervals in the drill hole that require detailed logging and/or analyzing. Rock coring can, however, proceed for thousands of feet continuously, depending on the size of the drill rig, and can yield better quality data than air-rotary drilling, although at a substantially reduced drilling rate.

Borehole diameter can be drilled to various sizes, depending on the information needed. NX, or a similar size (2- to 3-inch-diameter core recovery), may be used.

Begin the core drilling using a double-tube swivel-core barrel of the desired size. After drilling no more than 10-feet (3-meters), remove the core barrel from the hole and take out the core. If the core blocks the flow of the drilling fluid during drilling, remove the core barrel immediately.

Since rock structures and the occurrence of bedding planes, porosity type and distribution, and fracture patterns are among the most important items to be detected and described, take special care to obtain and record these features. If such broken zones or cavities prevent further advance of the boring, one of the following three steps shall be taken: cement the hole, ream and case, or case and advance with the next smaller size core barrel, as conditions warrant.

3.3 Rock Core Management and Labeling

When the core barrel has been recovered, the rock core will be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). Each core will be described, classified, and logged using a uniform system (Sections 4.0 and 5.0 of this SOP).

Rock cores will be placed in the sequence of recovery in well-constructed wooden or cardboard boxes provided by the drilling contractor. Rock cores from two different borings will not be placed in the same core box. The core boxes will be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each. Wood partitions will be placed at the end of each core run. The depth from the surface of the boring to the top and bottom of the drill run and run number will be marked on the wooden partitions with indelible ink. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores will be the same in all core boxes. Rock core will be placed in the box so that, when the box is open, with the inside of the lid facing the observer, the top of the cored interval contained within the box is in the upper left corner of the box and the bottom of the cored interval is in the lower right corner of the box. The top and bottom of each core obtained and their true depths will be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, an empty space in a row will be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

The inside and outside of the core-box lid will be marked by indelible ink to show all pertinent data about the box's contents. At a minimum, the following information will be included:

- Project name
- Project number
- Boring number
- Run numbers
- Footage (depths)
- Recovery
- RQD (%)
- Box number and total number of boxes for that boring (Example: Box 5 of 7)
- Contact person's name and telephone number

For easy retrieval when core boxes are stacked, the sides and ends of the box will also be labeled and will include project number, boring number, top and bottom depths of core, and box number.

Before final closing of the core box, a photograph will be taken of the recovered core and the labeling on the inside cover will be taken. If moisture content is not critical, the core shall be wetted and wiped clean for the photograph. (This will help to show true colors and bedding features in the cores.)

3.4 Air Rotary Drilling

Air-rotary drilling is a method of drilling where the drill rig simultaneously turns and exerts a downward pressure on the drilling rods and bit while circulating compressed air down the inside of the drill rods, around the bit, and out the annulus of the borehole. Air circulation serves to both cool the bit and remove the cuttings from the borehole.

Advantages of this method include

- The drilling rate is high (even in rock).
- The cost per foot of drilling is relatively low.
- Air-rotary rigs are common in most areas.
- No drilling fluid is required (except when water is injected to keep down dust).
- The borehole diameter is large to allow room for proper well installation procedures.

Disadvantages to using this method include

- Formations must be logged from the cuttings that are blown to the surface and thus the depths of materials logged are approximate.

- Air blown into the formation during drilling may "bind" the formation and impede well development and natural groundwater flow.

- In-situ samples cannot be taken, unless the hole is cased.

- Air-rotary drill rigs are large and heavy.

- Large amounts of investigation-derived waste (IDW) may be generated that may require containerization, sampling, and off-site disposal.

3.5 Rotosonic Drilling

The rotosonic drilling method employs a high frequency vibrational and low speed rotational motion coupled with down pressure to advance the cutting edge of a drill string. This produces a uniform borehole while providing a continuous, undisturbed core sample of both unconsolidated and most bedrock formations. Rotosonic drilling advances a 4-inch diameter to 12-inch diameter core barrel for sampling and can advance up to a 12-inch diameter outer casing for the construction of standard and telescoped monitoring wells. During drilling, the core barrel is advanced ahead of the outer barrel in increments as determined by the site geologist and depending upon type of material, degree of subsurface contamination and sampling objectives. The outer casing can be advanced at the same time as the inner drill string and core barrel, or advanced down over the inner drill rods and core barrel, or after the core barrel has moved ahead to collect the undisturbed sample and has been pulled out of the borehole. The outer casing can be advanced dry in most cases, or can be advanced with water or air depending upon the formations being drilled, the depth and diameter of the hole, or requirements of the project.

Advantages of this method include:

- Sampling and well installation are faster as compared to other drilling methods.

- Continuous sampling, with larger sample volume as compared to split-spoon sampling.

- The ability to drill through difficult formations such as cobbles or boulders, hard till and bedrock.

- Reduction of IDW by an average of 70 to 80 percent.

- Well installations are quick and controlled by elimination of potential bridging of annular materials during well installation, due to the ability to vibrate the outer casing during removal.

Disadvantages include:

- The cost for rotosonic drilling as compared to other methods are generally higher. However, the net result can be a significant savings considering reduced IDW and shortened project duration.

- Rotosonic drill rigs are large and need ample room to drill, however, rotosonic units can be placed on the ground or placed on an A TV.

- There are a limited number of rotosonic drilling contractors at the present time.

4.0 GEOLOGIC DESCRIPTION OF BOREHOLES IN ROCK

These procedures provide descriptions of the standard techniques for borehole and sample logging. These logging techniques will be used for each boring to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist or engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

The classification of soil and rocks is one of the most important jobs of the field geologist or engineer. To maintain a consistent flow of information, it is imperative that the field geologist or engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

4.1 Required Field Forms and Equipment

When logging soil and rock samples, the geologist or engineer should be equipped with the following:

Rock hammer
Knife
Camera
10% Dilute hydrochloric acid (HCl)
Ruler (marked in tenths and hundredths of feet)

Hand lens

Writing utensil with indelible ink

Field logbook

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

Soil/rock classification sheets

4.2 Classification of Rocks

Sedimentary rocks are by far the predominant type exposed at the earth's surface and are the only type present at NSA Crane. In classifying a sedimentary rock, the following hierarchy will be noted: Rocks are grouped into three main divisions: sedimentary, igneous, and metamorphic. The following basic names are applied to the types of rocks found in sedimentary sequences:

Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.

Siltstone - Made up of granular materials between 1/16 to 1/256 mm in diameter. Fractures irregularly. Medium thick to thick bedded.

Claystone - Very fine-grained rock made up of particle less than 1/256 mm in diameter. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.

Shale - A fissile, very fine-grained rock with particles less than 1/256 mm in diameter. Fractures along bedding planes.

Limestone - Rock made up predominantly of calcite ($CaCO_3$, which is mainly fossilized animal and plant debris). Effervesces strongly upon the application of dilute hydrochloric acid.

Coal – A very dark colored rock consisting mainly of organic (mainly fossilized plant debris) remains.

Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record.

The local abundance of any of these rock types is dependent upon the depositional history of the area. Conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

4.2.1 Rock Type

As described above, there are numerous types of sedimentary rocks. In most cases, a rock will be a combination of several grain types; therefore, a modifier such as "sandy siltstone" or a "silty sandstone" can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifying descriptions can include carbonaceous, calcareous, siliceous, fossiliferous, etc.

Grain size is the basis for the classification of clastic (sandstones, siltstones, and shales) sedimentary rocks. The Udden-Wentworth classification will be assigned to sedimentary rocks (shown below). The individual boundaries are slightly different than the USGS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse-grained rocks. Alternatively, the division between siltstone and shale may be measurable in the field by the use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a hand lens, the rock is a siltstone. If the grains are not distinguishable with a hand lens, the rock is a shale.

GRAIN SIZE CLASSIFICATION FOR ROCKS

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4 - 64 mm
Granules	2 - 4 mm
Very Coarse Sand	1 - 2 mm
Coarse Sand	0.5 - 1 mm
Medium Sand	0.25 - 0.5 mm
Fine Sand	0.125 - 0.25 mm
Very Fine Sand	0.0625 - 0.125 mm
Silt	0.0039 - 0.0625 mm
After Wentworth, 1922	

4.2.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples will be classified while wet, when possible, and air-cored samples will be scraped clean of cuttings prior to color classifications. Soil colors will be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

4.2.3 Bedding Thickness

The bedding thickness designations listed below will also be used for rock classification.

BEDDING THICKNESS CLASSIFICATION

Thickness (metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3'	Massive
30 cm - 1 meter	1.0' - 3.3'	Thick bedded
10 cm - 30 cm	4" - 1.0'	Medium bedded
3 cm - 10 cm	1" - 4"	Thin bedded
1 cm - 3 cm	2/5" - 1"	Very thin bedded
3 mm - 1 cm	1/8" - 2/5"	Laminated
1 mm - 3 mm	1/32" - 1/8"	Thinly laminated
< 1 mm	<1/32"	Micro laminated

(Ingram, 1954)

4.2.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock that occupies the zone between the lowest soil horizon and firm bedrock).

Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.

Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.

Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage of the words "scratch" and "gouge." A scratch will be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), and a gouge is much deeper.

4.2.5 Fracturing

Method of Calculating RQD
(After Deere, 1966)

Fractures should also be noted.

$$RQD\ \% = r/l \times 100$$

r = Total length of all pieces of the lithologic unit being measured that are greater than 4 inches in length and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.

l = Total length of the coring run.

4.2.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

Fresh - The rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.

Slight - The rock has some staining that may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration. Oxidation and weathering may affect the degree of fracturing or brokenness of a rock. After eliminating drilling breaks, the average spacing of natural breaks is calculated and the fracturing is described by the following terms:

Very broken (V. BR.) - Less than 2-inch spacing between fractures
Broken (BR.) - 2-inch to 1-foot spacing between fractures
Blocky (BL.) - 1- to 3-foot spacing between fractures

Massive (M.) - 3- to 10-foot spacing between fractures

The structural integrity of the rock can be approximated by calculating the rock quality designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run to obtain a percentage.

Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with a hammer.

Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

4.2.7 Other Characteristics

The following items will be included in the rock description:

Description of contact between two rock units. These can be sharp or gradational.

- Stratification (parallel, cross stratified).
- Description of any filled cavities or vugs.
- Cementation (calcareous, siliceous, hematitic).
- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs will be neat so it can be reproduced on a copy machine for report presentation. The data will be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

4.2.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

Seam - Thin (12 inches or less), probably continuous layer.

Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."

Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."

Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."

Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

4.2.9 Abbreviations

Abbreviations may be used in the description of a rock. However, they will be kept at a minimum. Following are some of the abbreviations that may be used:

C - Coarse	Lt - Light	Yl - Yellow
Med - Medium	BR - Broken	Or - Orange
F - Fine	BL - Blocky	SS - Sandstone
V - Very	M - Massive	Sh - Shale
Sl - Slight	Br - Brown	LS - Limestone
Occ - Occasional	Bl - Black	Fgr - Fine-grained
Tr - Trace		

5.0 BORING LOGS AND DOCUMENTATION

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceding sections will be used to complete the logs. A sample boring log is attached at the end of this SOP.

The field geologist or engineer will use this example as a guide in completing each boring log. Each boring log will be fully described by the geologist or engineer as the boring is being drilled. Every sheet contains space for 25 feet of log. Information regarding classification details is provided either on the back of the boring log or on a separate sheet, for field use. All data will be written directly on the boring log. Additional notes may be entered in a field notebook if more space is needed.

5.1 Remarks Column

The following information will be entered under the "Remarks" column and will include, but is not limited to, the following:

- Moisture - Estimate moisture content using the following terms: dry, moist, wet, and saturated. These terms are determined by the individual. Whatever method is used to determine moisture should be consistent throughout the log.

- Angularity - Describe angularity of coarse-grained particles using the terms angular, subangular, subrounded, or rounded. Refer to ASTM D 2488 or the Earth Manual for criteria for these terms.

- Particle shape - flat, elongated, or flat and elongated.

- Maximum particle size or dimension.

- Water-level observations.

- Reaction with HCl - none, weak, or strong.

Additional comments:

- Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.

- Indicate odor and photoionization detector (PID) readings.

- Indicate any change in lithology by drawing a line through the lithology change column and indicate the depth. This will help when cross-sections are subsequently constructed.

- At the bottom of the page, indicate type of rig, drilling method, hammer size and drop, and any other useful information (i.e., borehole size, casing set, changes in drilling method).

- Vertical lines shall be drawn in the Material Description column from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines will be drawn if there is a change in lithology, then vertical lines will be drawn to that point.

- Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.2 Rock Classification

Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate core run number, RQD percent, and core recovery under the appropriate columns.

Indicate lithology change by drawing a line at the appropriate depth, as explained above.

Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.

Enter color as determined while the core sample is wet; if the sample is cored by air, the core is to be scraped clean before the color is described.

Enter rock type. For sedimentary rocks, use terms as described in Section 4.2. Again, be consistent in classification. Use modifiers and additional terms as needed.

Enter brokenness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M, as explained in Section 4.2.6 and as noted on the back of the boring log.

The following information will be entered under the remarks column. Items will include but are not limited to the following:

- Indicate depths of joints, fractures, and breaks and also approximate to horizontal angle (such as high, low) (i.e., 70^{o} angle from horizontal, high angle).
- Indicate calcareous zones, description of any cavities or vugs.
- Indicate any loss or gain of drill water.

- Indicate drop of drill tools or change in color of drill water.

Remarks at the bottom of boring log will include

- Type and size of core obtained
- Depth casing was set
- Type of rig used

As a final check, the boring log will include the following:

- Vertical lines will be drawn as explained for soil classification to indicate consistency of bedrock material.

- If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole logging based on identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that will be followed when logging cuttings are as follows:

- Obtain cutting samples at approximately 5-foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or ziplock bag for future reference, and label the jar or bag (i.e., hole number, depth, date, etc.). Cuttings will be closely examined to determine general lithology.

- Note any change in color of drilling fluid or cuttings to estimate changes in lithology.

- Note drop or chattering of drilling tools or a change in the rate of drilling to determine fracture locations or lithologic changes.

- Observe loss or gain of drilling fluids or air (if air rotary methods are used) to identify potential fracture zones.

- Record this and any other useful information onto the boring log.

This logging provides a general description of subsurface lithology, and adequate information can be obtained through careful observation of the drilling process. It is recommended that split-barrel and rock core sampling methods be used at selected boring locations during the field investigation to provide detailed information to supplement the less-detailed data generated through borings drilled using air and mud rotary methods.

5.4 Review

Upon completion of the borings logs, copies will be made and reviewed. Items to be reviewed include

- Checking for consistency of all logs
- Checking for conformance to the guideline
- Checking to see that all information is entered in their respective columns and spaces

Originals of the boring logs will be retained in the project files.

7.0 ATTACHMENTS

1. Boring Log

ATTACHMENT 1

BORING LOG

Tetra Tech NUS, Inc.

BORING LOG

Page ___ of ___

PROJECT NAME: ____________________
PROJECT NUMBER: ____________________
DRILLING COMPANY: ____________________
DRILLING RIG: ____________________

BORING No.: ____________________
DATE: ____________________
GEOLOGIST: ____________________
DRILLER: ____________________

					MATERIAL DESCRIPTION					PID/FID Reading (ppm)			
Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	U S C S *	Remarks	Sample	Sampler BZ	Borehole**	Driller BZ**

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): [ ]

Remarks: ____________________

Converted to Well: Yes ______ No ______ Well I.D. #: ____________________

References

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Ingram, R.L., 1954. Terminology for the Thickness of Stratification and Parting Units in Sedimentary Rocks: Geological Society of America Bulletin, v. 65. p. 937-938.

STANDARD OPERATING PROCEDURE
SOP-16

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 NSA 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 developing monitoring wells. The drilling contractor personnel must have all the health and safety training required to perform the work, as specified in the health and safety plan (HASP).

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 will 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 that 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 because 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.

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 percent for at least three consecutive readings. Turbidity should also show stabilization and ideally be below 10 nephelometric turbidity units (NTUs).

If for any reason the above criteria cannot be met, the site geologist should document the event in writing and consult with the Project Manager 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.

5.0 ATTACHMENTS

1. Monitoring Well Development Record

ATTACHMENT 1

MONITORING WELL DEVELOPMENT RECORD

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Page ___ of _____

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

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

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

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

STANDARD OPERATING PROCEDURE
SOP-17

MEASUREMENT OF WATER LEVELS IN MONITORING WELLS

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes procedures for determining water levels in monitoring wells.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following equipment and field forms are required for determining water levels in monitoring wells.

Groundwater Level Measurement Form: A copy of the Groundwater Level Measurement Form is attached.
Bound field logbook
Photoionization detector (PID):
Well key
Writing utensil
Electronic water-level indicator: The water-level indicator must have a cable of sufficient length to reach the water surface and be capable of measurements of 0.01-foot.
Decontamination supplies: SOP-12 describes decontamination procedures including decontamination supplies.

3.0 WATER-LEVEL MEASUREMENT PROCEDURES

3.1 Check the operation of the electronic water-level indicator or interface meter.

3.2 Record the well identification (ID), date, and time (using military time) on the Groundwater-Level Measurement Form.

3.3 Unlock the well and remove the well cap.

3.4 Place the well cap on a clean piece of plastic.

3.5 Check the well for the presence of organic vapors in the 2-inch polyvinyl chloride (PVC) riser pipe as follows:

1. Calibration of the PID shall be done in accordance with the calibration procedures described in the owner's manual. Calibration of the PID shall be done at the field office prior to entering the field.

2 Insert the PID sample inlet straw approximately 3 inches into the riser pipe.

3 Record the PID reading on the Groundwater Level Measurement Form. If the reading is less than concentrations specified in the site-specific HASP, proceed to step 3.6. If the reading is greater than the concentration specified in the HASP, measure the concentration in the breathing zone. If the concentration in the breathing zone is less than the concentration specified in the HASP, proceed to Step 3.6. If the reading is greater than the specified concentration, allow the riser pipe to ventilate for 10 minutes and repeat the measurement of breathing zone concentrations until the concentrations fall below the level specified in the HASP before proceeding to step 3.6.

3.6 Ensure that the water-level indicator probe has been decontaminated before use, in accordance with the procedures outlined in SOP-12.

3.7 Slowly lower the probe into the well riser pipe until an audible and/or visible signal is produced, indicating contact with the water surface.

3.8 Read the ground water-level measurement from the top of the inner casing at the surveyed reference point to the nearest 0.01 foot.

3.9 Record the water-level measurement on the Groundwater Level Measurement Form.

3.10 Wind the meter cable measuring tape back onto the spool.

3.11 Replace the well cap and lock.

3.12 Decontaminate the meter's probe and cable following the procedures outlined in SOP-12.

3.13 Containerize any decontamination fluids and PPE in accordance with the procedures described in SOP-11.

4.0 ATTACHMENTS

1. Groundwater Level Measurement Sheet

ATTACHMENT 1

GROUNDWATER LEVEL MEASUREMENT SHEET

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: ____________________ **Project No.:** ____________
Location: ____________________ **Personnel:** ____________
Weather Conditions: ____________ **Measuring Device:** ____________
Tidally Influenced: Yes ___ No ___ **Remarks:** ____________

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Total Well Depth From TOC (feet)*	Water Level Indicator Reading (feet)*	Groundwater Elevation (feet)*	Comments

* All measurements to the nearest 0.01 foot

Page ____ of ____

STANDARD OPERATING PROCEDURE
SOP-18

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.

Groundwater Sample Log Sheet: A copy of this form and instructions for its completion are included in SOP-19.

Bound field logbook

Writing utensil

Photoionization detector (PID): The procedures for the operation of the PID are found in the health and safety plan.

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 foot (see SOP-17).

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-06).

Flow-through cell adapter for water-quality meter

LaMotte Turbidity Meter: Used to measure turbidity (see SOP-06).

Purge water containers

Graduated cylinder and stopwatch: Used to calculate flow rate.

Decontamination supplies: SOP-12 describes required decontamination supplies.

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

3.0 PROCEDURES FOR WELL PURGING

3.1 Prior to mobilizing to the site, clean, check for proper operation, and calibrate above equipment in accordance with manufacturer requirements as necessary.

3.2 Follow the steps outlined in SOP-17 to obtain a static water-level measurement of the well to be purged. Record the information on the Groundwater 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 by measurement.

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:

$$\mathbf{V = (0.163)(T)(r^2)}$$

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 that 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 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 it is being connected.

3.5 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 it is being connected.

3.6 Following the instructions found in the water-quality meter manual, connect the flow-through cell to the pump discharge line (at the well cap).

3.7 Place the discharge tubing from the flow-through cell to direct the purge water discharge into the graduated cylinder or purge water container.

3.8 Following the instructions in the pump controller manual, start pumping water from the well.

3.9 Start with the initial pump rate set at approximately 0.1 liters per minute. Use the graduated cylinder and stopwatch to measure the pumping rate. Adjust pumping rates as necessary to prevent drawdown from exceeding 0.3 foot during purging. If no drawdown is noted, the pump rate may be increased (to a max of 0.4 liters per minute) to expedite the purging and sampling event. The pump rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If groundwater is drawn down below the top of the well screen, purging 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:

- Stabilization of parameters
- Possible drawdown
- 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.

3.10 Measure the well water level using the water-level meter every 5 minutes. Record the well water level on the Low-Flow Purge Data Form (attached at the end of this SOP).

3.11 Every 5 to 10 minutes, record on the Low-Flow Purge Data Form 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.

3.12 Measure the flow rate using a graduated cylinder. Remeasure the flow rate any time the pump rate is adjusted.

3.13 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.

3.14 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 4 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 Groundwater 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 from a distance until he or she 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 the sampler departs.

In both cases, the time purging was stopped and restarted will be noted on the Low-Flow Purge Data Form.

3.15 Rinse the flow-through cell, the water-quality meter probes, and the turbidity cell with analyte-free water and pack the cell and meters for transport.

4.0 ATTACHMENTS

1. Low-Flow Purge Data Sheet

ATTACHMENT 1
LOW-FLOW PURGE DATA SHEET

Tetra Tech NUS, Inc.

LOW FLOW PURGE DATA SHEET

PROJECT : ____________
PROJECT NUMBER: ____________
PROJECT SITE NAME: ____________

WELL ID.: ____________
DATE: ____________
WEATHER: ____________

Time (Hrs.)	Water Level (Ft. below TOC)	Volume (gal/L)	Flowrate (mL/min)	pH (S.U.)	Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celsius)	ORP (mV)	Comments

Water Quality Meter (S/N) ____________
Control Box Type (S/N) ____________
Turbidity Meter (S/N) ____________

Pump Intake Depth ____________

SIGNATURE(S): ____________

PAGE___OF___

STANDARD OPERATING PROCEDURE
SOP-19

GROUNDWATER SAMPLING

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedure for collecting groundwater samples from permanent and temporary monitoring wells. Low-flow sampling techniques will be used for groundwater sampling at the NSA Crane facility.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following field forms and equipment are required for low-flow sampling of monitoring wells:

Writing utensil (preferably black ink)
Stainless steel Geoprobe Screen Point Groundwater Sampler (or equivalent)
Groundwater Sample Log Form: A copy of this form is attached at the end of this SOP
Low Flow Purge Data Sheet: A copy of this form is attached at the end of this SOP
Bound field log book
Chain-of-Custody Form
Bladder pump
Photoionization Detector (PID)
Peristaltic pump
Silicon tubing
Teflon tubing
Required sample containers with appropriate preservative: All sample containers for analysis by fixed-base laboratories will be supplied and deemed certified clean by the laboratory.
Surgical gloves
Water-level indicator
0.45-micron filter cartridge
Bucket: to collect development/purge water
Calculator, wristwatch, and timer
Stainless steel clamps
Plastic storage bags

Shipping containers with ice

3.0 SAMPLING PROCEDURES FOR PERMANENT MONITORING WELLS

3.1 Groundwater sampling may be initiated when the monitoring well has been purged and stabilized in accordance with SOP-18.

3.2 Record the sample start time (using military time) on the Groundwater Sample Log Sheet. Record the field measurements for pH, oxidation-reduction potential (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 will 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 Groundwater Sample Log Form, the sample label, and the sample label.

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

3.8 Enter the proper information on the Chain-of-Custody Form for each sample container (see SOP-03).

3.9 Repeat steps 3.3 through 3.8 for each sample container collected.

3.10 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 Groundwater Sample Log Form.

3.11 All samples will be collected into pre-preserved bottles (if required) supplied by an approved laboratory. All samples will be collected in the following sequence (where applicable):

- Volatile organic compounds (VOCs)
- Other organics
- Metals
- Other Inorganics
- Filtered Metals (only if turbidity reading > 10 NTU, see section 3.12 below)

3.12 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 groundwater 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.

3.13 After completion of sample collection, remove the bladder pump (if bladder pump is used for sampling) from the well and decontaminate the pump following the procedures in SOP-12. Leave dedicated tubing inside the well for possible future sampling events.

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

3.15 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-11).

4.0 SAMPLING PROCEDURES FOR TEMPORARY WELL POINTS

4.1 Groundwater samples may be collected from temporary well screens inserted into auger holes or DPT soil borings. The temporary well screens can be constructed of PVC or stainless steel.

4.2 Once the water table has been encountered, and the Geoprobe hole or auger hole has been completed, insert a 0.75- to 1.0-inch diameter slotted PVC well screen and riser to the bottom of the hole.

4.3 Field screening of volatile organic vapors (VOCs) in the borehole shall be done using a PID.

4.4 The temporary well screen will be allowed to equilibrate for at least 15 minutes. Measure water level in well every 5 minutes and record on the Low Flow Purge Data Sheet.

4.5 Development of the screen point will be accomplished using a peristaltic pump and Teflon tubing.

4.6 Insert the intake end of a length of Teflon tubing to the bottom of the screen point and attach a length of silicon tubing (approximately 1 foot) to the discharge end of the Teflon tubing. The silicon tubing will be threaded around the rotor of the pump and out of the pump.

4.7 The Teflon tubing will be lifted and lowered slightly while the pump is operating. The maximum pump rate will be approximately 2 liters per minute during development. However, the yield of the formation will dictate the pumping rate. Measure water level in well every 5 minutes and record on the Low Flow Purge Data Sheet.

4.8 Measurement of pH, specific conductance, turbidity, dissolved oxygen, ORP, and temperature shall be recorded every 5 to 10 minutes during the development process using a water quality meter and flow-through cell.

4.9 The screen point will be pumped until discharge water is visibly clear, the turbidity readings do not improve over time, or the well screen goes dry.

4.10 Once the water has cleared or will clear no further, the pumping rate will be lowered to 50 to 100 mL per minute. Stabilization is achieved after two consecutive readings taken at 5 to 10 minutes intervals of the following field parameters has occurred:

- pH +/- 0.1 standard units
- Turbidity +/- 10% for values greater than 1 NTU
- Specific conductance +/- 3%
- Temperature +/- 3%
- ORP +/- 10 millivolts

- Dissolved oxygen +/- 10%

If the above condition(s) have not been met after three well point volumes have been removed, this will be recorded on the field sample form and the groundwater sample collection can commence.

4.11 Samples will be collected using the peristaltic pump set at a flow rate of 100 mL per minute or less, depending on the yield of the formation. Samples will be collected directly from the pump discharge tubing. The pump shall operate continuously between development, purging, and sampling.

4.12 Record the sample date and time (using military time) on a Tetra Tech Groundwater Sample Log Sheet and on a chain of custody form.

4.13 Record the sample date and time (using military time) on an adhesive-backed sample label and affix the sample label securely to the sample container.

4.14 With the pump continuing to run, allow the pump discharge to flow gently down the inside of the sample container with minimal turbulence when filling sample containers. Avoid immersing the discharge tube into the sample as the sample container is being filled.

4.15 Cap each container immediately after filling.

4.16 Place the sample container into a ziplock bag and then into a cooler containing ice.

4.17 Repeat steps 4.14 through 4.16 for each sample container collected.

4.18 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 Tetra Tech Groundwater Sample Log Sheet.

4.19 All samples will be collected into pre-preserved bottles (if required) supplied by an approved laboratory. Worksheet No. 19 of the UFP-SAP includes information on preservation requirements and types of sample containers. The hierarchy of filling sample containers is as follows:

- Volatile organics

- Other Organics
- Total metals
- Other Inorganics
- Filtered metals (only if turbidity reading > 10 NTU, see section 4.20 below)

This hierarchy takes into consideration the volatilization sensitivity of groundwater samples.

4.20 If the turbidity of a groundwater sample is greater than 10 NTU and a total metals sample aliquot is collected, then a dissolved metals aliquot will also be collected. A single-use, disposable, in-line 0.45-micron filter cartridge shall be used to collect dissolved metals samples. Attach the filter cartridge to the discharge end of the pump tubing. Prior to filling containers with filtered sample, rinse the filter cartridge with approximately 100-ml of water from the boring to be sampled. Direct the discharge from the filter cartridge into the sample bottle and collect the filtered sample. Types of sample containers, sample volume, preservation requirements, and holding times are summarized in Worksheet No. 19 of the UFP-SAP The laboratory will supply all sample containers, and the laboratory will pre-preserve sample containers where appropriate.

4.21 Once all of the sample containers have been filled, the pump shall be shut off. Record the sample date and time (in military time) on an adhesive-backed sample label and affix the sample label securely to the sample container. Record the end time for sampling on a Tetra Tech Groundwater Sample Log Sheet.

4.22 Once collection of samples is complete, remove tubing from temporary well screen and discard as investigation-derived waste (IDW, see SOP-11). The screen point shall be removed from the boring and decontaminated in accordance with the procedures outlined in SOP-12.

4.23 Proceed to abandon the borehole with bentonite chips and excess soil core material.

5.0 ATTACHMENTS

1. Groundwater Sample Log Sheet
2. Low Flow Purge Data Sheet

ATTACHMENT 1

GROUNDWATER SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: ____________
Project No.: ____________

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

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

SAMPLING DATA:

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

PURGE DATA:

Date:	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Method:								
Monitor Reading (ppm):								
Well Casing Diameter & Material								
Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

STANDARD OPERATING PROCEDURE
SOP-20

CALIBRATION AND CARE OF WATER QUALITY METERS

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedures for the calibration and maintenance of field instruments used to measure water quality and for the proper documentation of calibration and maintenance. The YSI 600-Series Environmental Monitoring System or the Horiba U20–Series multi-parameter water quality monitoring system will be used to measure pH, temperature, oxidation-reduction potential (ORP), specific conductance (SC), and dissolved oxygen (DO) in water. A LaMotte turbidity meter will be used in conjunction with the water quality meter to measure turbidity. The multi-parameter water quality meter will have a multiprobe sensor that can be used in conjunction with a flow-through cell attached to a pump discharge tube to measure water-quality parameters in a groundwater discharge or can be immersed in a surface water body such as a stream, pond, or drainage ditch. The LaMotte is a hand held meter that uses a multi-detector optical configuration to assure long term stability and minimize stray light and color interferences. All comparable equipment used in place of the equipment items identified in Section 2.0 below must be comparable in terms of sensitivity, accuracy, and precision.

2.0 FIELD FORMS AND EQUIPMENT LIST

The following logbooks, forms, equipment, and supplies are required:

Site logbook
Equipment calibration log sheet
YSI Model 600 Series and Sonde or Horiba U20 Series, or comparable
LaMotte Turbidity Meter, or comparable
Equipment manual
Calibration kit
Deionized water, paper towels, spray bottle, etc.
Disposable medical-grade gloves (e.g., latex, nitrile)

3.0 PROCEDURES

This section describes the calibration procedures for the YSI Model 600 series and Horiba U20 series multi-parameter water quality meters and the LaMotte turbidity meter. Each meter is supplied with an instruction manual and will be on-site and used as the calibration guidance documents. These procedures will list requirements for frequency of calibration and checks to be performed on the meter.

3.1 YSI Model 600 Series and Horiba U20 Series

The YSI Model 600 series and Sonde and the Horiba U20 series are multi-parameter water quality meters that may be used to measure open water bodies (streams, ponds, springs, etc.) with the probe guard installed. With the flow-through cell attached, the meters have the ability to measure water-quality parameters in groundwater via a pump discharge line. By performing the measurements in the discharge line coming directly from the well, the parameters are measured before the groundwater comes in contact with the atmosphere. The parameters measured by the YSI or Horiba meters for this field effort may include as follows:

- DO
- Specific conductivity
- Temperature
- pH
- Oxidation-reduction potential (ORP)
- Turbidity

3.1.1 Documentation

The Equipment Calibration Log is used to document calibration of measuring equipment used in the field. The Equipment Calibration Log documents that the manufacturer’s instructions were followed for calibration of the equipment, including the frequency of calibration, type of standards used, and checks performed on calibration during the course of using the equipment. An Equipment Calibration Log must be maintained for each measuring device that requires calibration. Entries must be made for each day the equipment is used. A blank Equipment Calibration Log form is attached at the end of this SOP.

3.1.2 Calibration

The parameters listed in Section 3.1 (except temperature which is factory calibrated) must be calibrated prior to the start of each field effort. After this initial calibration, the meter will be checked each day that it is used. If the check shows any out-of-specification readings, the specific probe will be recalibrated. Meter specifications can be found in the equipment manual, starting on page 5-1 (YSI) or page 93 (Horiba). Calibration and calibration checks will be documented in the field logbook and on the Equipment Calibration Log. The name, lot number, and expiration date for all calibration buffers and standards used will be recorded on the Equipment Calibration Log. The meter's model, serial number, and name of the rental company will also be recorded on the equipment calibration form.

3.1.3 Tips for Good Calibration

- The DO calibration is a water-saturated air calibration. Make certain to loosen the calibration cup seal to allow pressure to equilibrate before calibrating.

- For all other parameters, make certain that the applicable sensor is completely submersed in solution, and the parameter readings are stable when calibration values are entered.

- Use a small amount of calibration solution (previously used solution may be used, then discarded for this purpose) to pre-rinse the sonde.

- Fill a bucket with ambient temperature water to rinse the sonde between calibration solutions.

- Make sure to rinse and dry the probe between calibration solutions. This will reduce carry-over contamination and increase the accuracy of the calibration.

3.2 Lamotte Turbidity Meter

The Lamotte turbidity meter is a hand held meter that measures the amount of suspended matter in water using the nephelometric method.

3.2.1 Documentation

The Equipment Calibration Log is used to document calibration of measuring equipment used in the field. The Equipment Calibration Log documents that the manufacturer's instructions were followed for calibration of the equipment, including the frequency of calibration, type of standards used, and checks performed on calibration during the course of using the equipment. An Equipment Calibration Log must be maintained for each measuring device that requires calibration. Entries must be made for each day the equipment is used. A blank Equipment Calibration Log form is attached at the end of this SOP.

3.2.2 Calibration

Turbidity must be calibrated prior to the start of each field effort. After this initial calibration, the LaMotte will be calibrated each day that it is used. If the check shows any out-of-specification readings, the meter will be recalibrated. Meter specifications can be found in the equipment manual. Calibration and calibration checks will be documented in the field logbook and on the Equipment Calibration Log. The name, lot number, and expiration date for all calibration standards used will be recorded on the Equipment Calibration Log. The meter's model, serial number, and name of the rental company will also be recorded on the equipment calibration form.

3.2.3 Tips for Good Calibration

- Thoroughly clean the standard vial with a chem wipe to remove finger prints.
- Make sure that the vial is properly aligned in the meter according the manual recommendations.

4.0 MAINTENANCE

The YSI and/or Horiba Meter and LaMotte will be rented for the duration of each brief field effort. Therefore, little field maintenance will be required. For any maintenance other than the routine cleaning, calibrating, or battery charging, the instrument should be returned to the vendor and a replacement sent immediately to the job site.

4.1 Meter Storage for the YSI and Horiba Meters

For this field effort, the meter storage will be short term, [i.e. overnight or between work shifts (4-day break)]. During these breaks, the meter will be charged. One-half inch of tap water will be placed in the meter calibration cup, and the cup will be threaded onto the sonde. The key for short-term storage of probes is to use a minimal amount of water so the calibration cup will remain at 100 percent humidity. The water level must be low enough so that none of the probes are actually immersed. Proper storage of the sonde between usage will extend its life and will also ensure that the unit is ready for use as quickly as possible for the next application.

Multi-parameter short term storage key points:

- Use enough water to provide humidity but not enough to cover the probe surfaces.
- Make sure the storage vessel is sealed to minimize evaporation.
- Check periodically to make certain that water is still present.

4.2 Probe Cleaning for the YSI and Horiba Meters

- Rinse the probe thoroughly with potable water.
- Wash the probe in a mild solution of Liquinox and water and wipe with paper towels and/or cotton swabs.
- Rinse and soak the probe in deionized water.
- If stronger cleaning is required, consult Section 2.10 on page 89 (YSI) or Section 7.1 on page 86 (Horiba) of the equipment manual.

Note: Reagents that are used to calibrate and check the water quality meter may be hazardous. Review the health and safety plan and Material Safety Data Sheets (MSDSs), all of which are on file in the field trailer.

4.3 Meter Storage for the LaMotte Turbidity Meter

For this field effort, the meter storage will be short term, [i.e. overnight or between work shifts (4-day break)]. Proper storage of the meter between usages will extend its life and will also ensure that the unit is ready for use as quickly as possible for the next application.

Short term storage key points:

- Make sure the storage vessel is moisture free and sealed.

4.4 Sample Vial Cleaning

- Rinse the vial thoroughly with potable water to remove sediments.
- Wipe with chem-wipes or cotton swabs.

5.0 ATTACHMENTS

1. Equipment Calibration Log

ATTACHMENT 1
EQUIPMENT CALIBRATION LOG

EQUIPMENT CALIBRATION LOG

PROJECT NAME : ____________________ INSTRUMENT NAME/MODEL: ____________________

SITE NAME: ____________________ MANUFACTURER: ____________________

PROJECT No.: ____________________ SERIAL NUMBER: ____________________

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration	Post-calibration	Pre-calibration	Post-calibration		

STANDARD OPERATING PROCEDURE
SOP-21

HYDRAULIC CONDUCTIVITY TESTING

1.0 PURPOSE

This Standard Operating Procedure (SOP) provides technical guidance for the performance and evaluation of in-situ hydraulic conductivity tests (i.e., slug tests) in monitoring wells at the NSA Crane facility.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Solid slug
Pressure transducers and data recorder, including instruction manual
Manual water-level indicator
Hydraulic Conductivity Testing Data Sheet
Watch
Decontamination equipment and supplies
Field logbook
Measuring tape

3.0 PROCEDURES

Slug tests are short-term tests designed to provide approximate hydraulic conductivity values for the portion of a formation immediately surrounding the screened/open interval of a well or boring. These tests are much less accurate than pumping tests, because a much more localized area is involved. Therefore, a number of slug tests are typically performed and averaged to determine a representative hydraulic conductivity value for the formation tested. Performance of slug tests may be preferable to pumping tests in situations where handling of large volumes of contaminated water is a concern or when time or budget constraints preclude the more expensive and time-consuming setup and performance of a pumping test.

The procedure is summarized below:

3.1 Determine the total depth of the well using a weighted tape or other measuring device. A pressure transducer attached to a data logger will be placed in the well approximately 1 foot from the bottom of the well. The transducer will be positioned so that it is about 5 to 10 feet lower than the slug.

3.2 Record the well number, the transducer probe identification number being used, the PSI rating for each probe, the depth below top of casing where each probe is positioned, the static water level in the well, and any other information relative to the setup and performance of the slug test. Data and information should be recorded in a bound field notebook and on the Hydraulic Conductivity Testing Data Sheet.

3.3 A falling-head test can be performed where the slug is lowered into the well and the rate of water-level fall with respect to time is recorded until equilibrium is reached. A rising-head test can be performed where a slug is lowered into the well and the water is allowed to equilibrate, then the slug is removed and the rate of water-level rise is measured with respect to time. Falling head slug tests should only be performed in wells with fully submerged screens, and rising head slug tests can be performed in wells with either partially or fully submerged screens or open intervals.

3.4 Remove or insert the slug and immediately start the data logger. Record the starting time for the data logger on the form sheet.

3.5 Manually measure the depth to water with a water depth indicator to estimate the rate of recovery while the data logger is in the sleep mode. Enter the reading onto the form sheet, along with the corresponding transducer reading from the same time.

3.6 Observe the water-level readings when the data logger can be read. Record the times and the readings on the form sheet.

3.7 Rate of recovery measurements shall be obtained from time zero (maximum change in water level) until water-level recovery exceeds 90 percent of the initial change in water level. In low-permeability formations, the test may be cut-off short of 90 percent recovery due to time constraints. Time intervals between water level readings will vary according to the rate of recovery of the well. For a moderately fast recovering well, water-level readings at 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.75, 1.0, 1.25, 1.5, 2.0, 2.5, 3.0, 4.0, . . . minutes may be required. With practice, readings at down to 0.05-minute (3 seconds) time intervals can be obtained with reasonable accuracy, using a pressure transducer and hand-held readout. For wells that recover very fast, the pressure transducer and data logger can be set on a logarithmic recording interval. Time intervals between measurements can be extended for slow recovering wells. A typical schedule for measurements for a slow recovering well would be 0, 0.25, 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0, 8.0, 10.0, 15.0, 20.0, 30.0, . . . minutes from the beginning the test. Measurements will be taken from the top of the well casing.

3.8 Stop the test when equilibrium is reached and repeat as necessary to ensure reproducibility.

3.9 Remove the pressure transducer, the slug, and the cables from the well and thoroughly decontaminate, in accordance SOP-12 (Decontamination of Field Equipment).

3.10 Check all field notes, copy, and place into one file for each test. Download the data recorder as soon as possible and check data. Make an electronic file and paper file of all data and place with the file for evaluation later. Confirm that the data are usable for the intended analysis prior to leaving the field. Time and recovery should be field plotted on semilog graph paper to determine the data quality. The data set should plot along a sloped, straight line. If excessive data scatter is observed, the test should be rerun until acceptable results are obtained.

4.0 PERSONNEL

A qualified geologist or hydrogeologist, with experience with these test procedures and equipment, will be needed for each sampling team to carry out the hydraulic conductivity tests.

5.0 ATTACHMENTS

1. Hydraulic Conductivity Testing Data Sheet

ATTACHMENT 1

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET

Tetra Tech NUS, Inc.

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET

ACAD:FORM_HYDCONTST.dwg 07/06/99 INL

PROJECT NAME: .... WELL/BORING NO.: ....

PROJECT NO.: .... GEOLOGIST: ....

WELL DIAMETER: .... SCREEN LENGTH/DEPTH: .... TEST NO.: ....

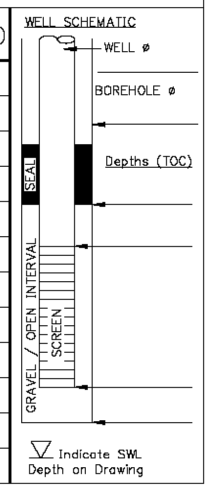
STATIC WATER LEVEL (Depth/Elevation): .... DATE: ....

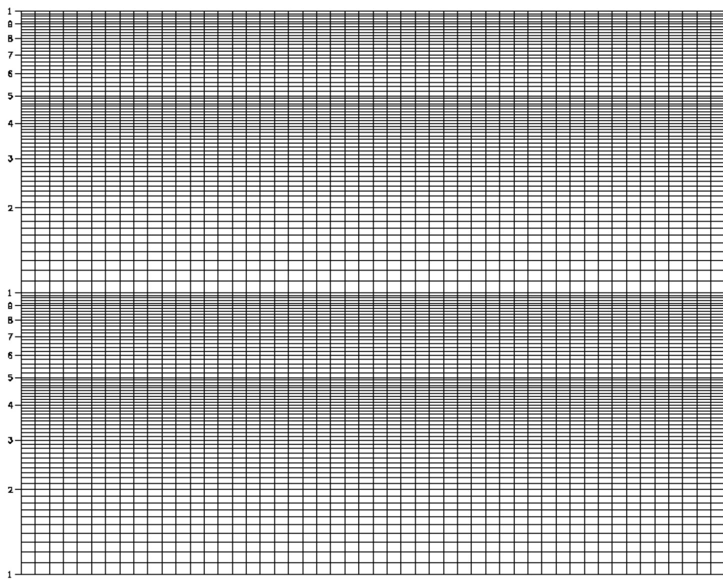
TEST TYPE (Rising/Falling/Constant Head): .... CHECKED: ....

METHOD OF INDUCING WATER LEVEL CHANGE: .... PAGE ...... OF ....

REFERENCE PT. FOR WL MEAS. (Top of Casing, Transducer, etc.): ....

ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)	ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)





REMARKS:

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CALCS, SKETCH MAPS, ETC.: