

FINAL

**SAMPLING AND ANALYSIS PLAN
ADDENDUM NO. 2**

FOR THE

**PHASE II REMEDIAL INVESTIGATION OF
LOAD LINE 1 AT THE RAVENNA ARMY
AMMUNITION PLANT, RAVENNA, OHIO**

PREPARED FOR



LOUISVILLE DISTRICT

**CONTRACT No. DACA27-97-D-0025
DELIVERY ORDER 0003**

September 2000



SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

contributed to the preparation of this document and should not be considered
an eligible contractor for its review.

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Prepared for
U.S. Army Corps of Engineers
Louisville District
Under Contract Number DACA27-97-D-0025
Delivery Order No. 003

Prepared by
Science Applications International Corporation
P.O. Box 2502
800 Oak Ridge Turnpike
Oak Ridge, Tennessee 37831

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ACRONYMS

AOCs	areas of concern
Bgs	below ground surface
BRA	baseline risk assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	chemical of concern
COPCs	chemicals of potential concern
CRREL	Cold Regions Research and Engineering Laboratory
CSF	cancer slope factor
DNT	dinitrotoluene
DQO	Data Quality Objective
EDQL	ecological data quality level
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
FS	Feasibility Study
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HI	Hazard Index
HQ	Hazard Quotient
IDW	investigation-derived waste
ILCR	incremental lifetime cancer risk
IR	Industrial Readiness
LOAEL	lowest observed adverse effect level
MCL	maximum contaminant level
NOAEL	no observed adverse effects level
OE	ordnance and explosive
Ohio EPA	Ohio Environmental Protection Agency
ONG	Ohio National Guard
OSC	Operations Support Command
OVA	organic vapor analyzer
PAH	polyaromatic hydrocarbon
PCB	polychlorinated biphenyl
PID	photo-ionization detector
PRG	preliminary remediation goal
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RAGS	Risk Assessment Guidance for Superfund
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RfD	reference dose
RGO	remedial goal option
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RVAAP	Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan
SCM	site conceptual model
SRC	site-related contaminant
SVOC	semivolatile organic compound
T&E	threatened and endangered

TAL	Target Analyte List
TCLP	Toxicity Characteristic Leaching Procedure
TNB	trinitrobenzene
TNT	trinitrotoluene
UCL ₉₅	95 percent Upper Confidence Limit
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
UXO	unexploded ordnance
VOCs	volatile organic compound
XRF	X-ray fluorescence

1.0 PROJECT DESCRIPTION

1.1 INTRODUCTION

The Phase II Remedial Investigation (RI) for Load Line 1 at the Ravenna Army Ammunition Plant (RVAAP), Ohio ([Figure 1-1](#)) will evaluate the nature and extent of contamination, and identify the risks to human health and the environment posed by contamination in soil, surface water, sediment, and groundwater. This Sampling and Analysis Plan (SAP) addendum has been prepared for RVAAP by Science Applications International Corporation (SAIC) for the U.S. Army Corps of Engineers (USACE) Louisville District, under contract number DACA27-94-D-0025, Delivery Order No. 0003. The SAP Addendum No. 1 (USACE 1999a) addressed the characterization of groundwater through the drilling, installation, and sampling of monitoring wells at Load Line 1. Sampling activities in November 1999 addressed the suitability of soils beneath the load line's change houses for disposal of clean hard fill, and consisted of analysis of 23 soil samples. This SAP Addendum (No. 2) addresses the characterization of contaminants in soil, sediment, surface water, and existing subsurface infrastructure. It also provides for additional sampling of the groundwater monitoring wells. Planned activities described in this Addendum are as follows:

- Collection of surface and subsurface soil samples;
- Characterization of soils in the railroad beds and the area between buildings CB-4 and CB-4A;
- Collection of sediment and surface water samples from surface drainage channels;
- Collection of sediment samples from catch basins, pipes, and sumps;
- Collection of groundwater samples from the 14 monitoring wells; and
- Characterization of sanitary and storm sewer lines by video survey.

This SAP Addendum has been developed to tier under and supplement the *Facility-Wide Sampling and Analysis Plan for the Ravenna Army Ammunition Plant, Ravenna, Ohio* [USACE 2000a(under review)]. The Facility-Wide SAP provides the base documentation (i.e., technical and investigative protocols) for conducting investigations under the standards of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) at RVAAP; whereas this and the previous SAP Addendum (USACE 1999a) include all of the investigation-specific sampling and analysis objectives, rationales, planned activities, and criteria specific to the Phase II RI at Load Line 1. Consequently, both documents are necessary in order to implement the Phase II RI. Where appropriate, this SAP Addendum contains references to the Facility-Wide SAP for base procedures and protocols.

The Facility-Wide SAP and SAP Addendum have been developed following the USACE guidance document, *Requirements for the Preparation of Sampling and Analysis Plans, EM 200-1-3* (USACE 1994a), to collectively meet the requirements established by the Ohio Environmental Protection Agency (Ohio EPA), Northeast District, and the U.S. Environmental Protection Agency (EPA) Region 5 for conducting CERCLA investigations.

1.2 LOAD LINE 1 HISTORY AND CONTAMINANTS

RVAAP is located in northeastern Ohio in Portage and Trumbull Counties and lies about 16 km (10 miles) east of Ravenna, Ohio ([Figure 1-1](#)). Operations at the facility date to 1940 and include the storage, handling, and packing of military ammunition and explosives. The facility encompasses 8,668 hectares (21,419 acres) and is jointly operated by the Operations Support Command (OSC) of the

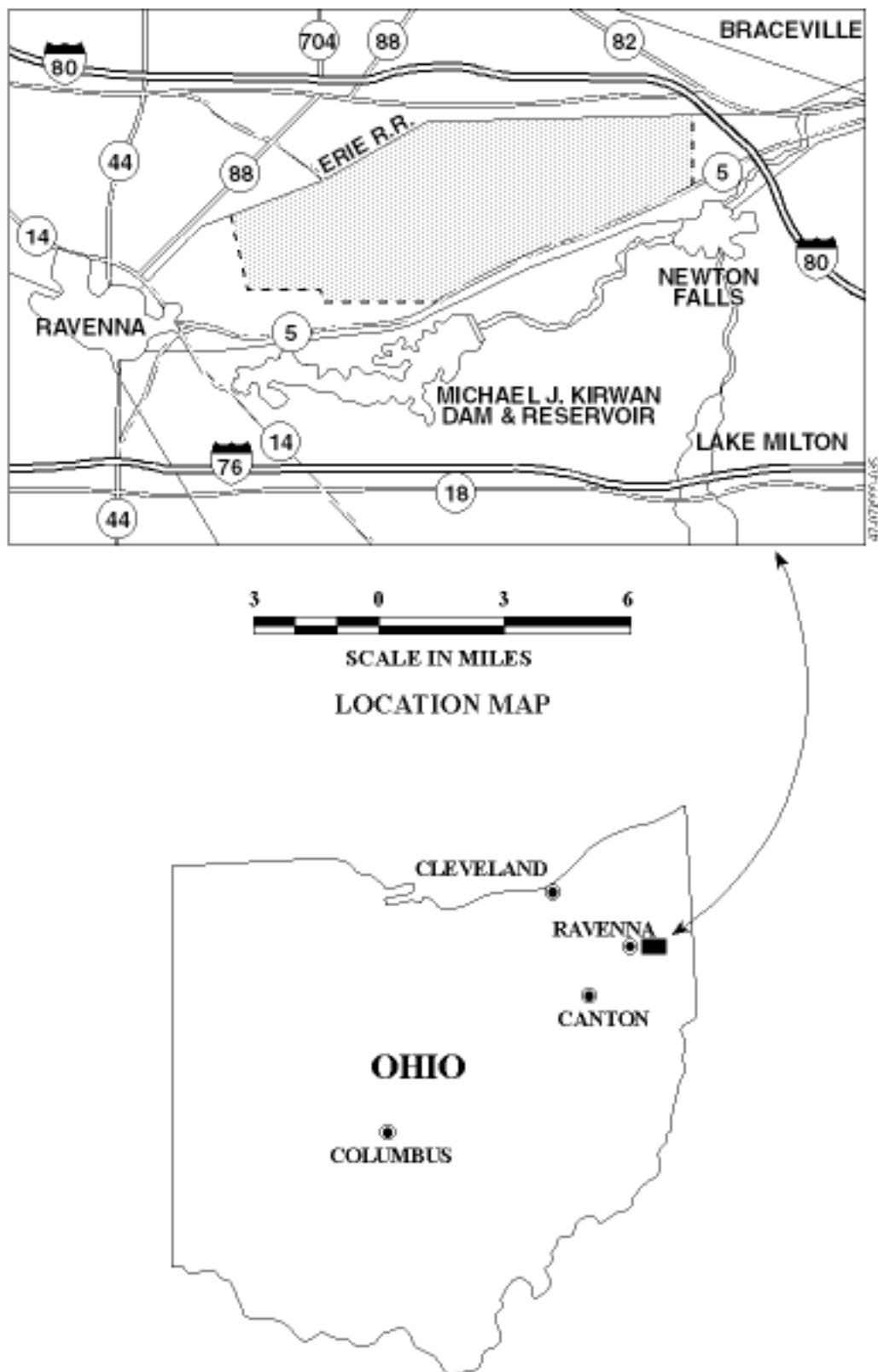


Figure 1-1. Ravenna Location Map

U.S. Army and the National Guard Bureau. The OSC controls environmental areas of concern (AOCs) and bulk explosives storage areas. A detailed history of process operations and waste processes for each AOC at RVAAP is presented in the *Preliminary Assessment for the Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 1996b). The following is a summary of the history and related contaminants for Load Line 1.

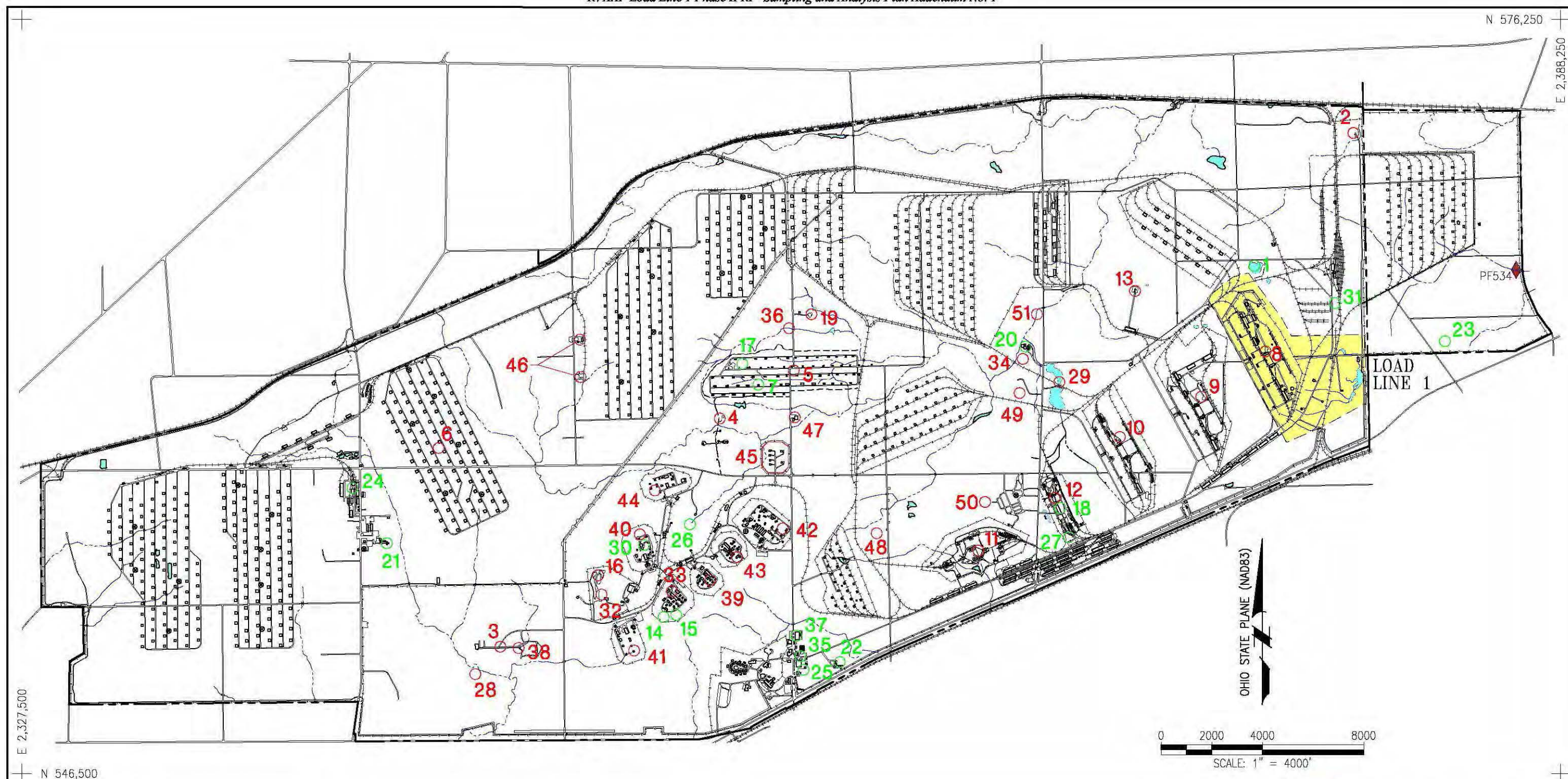
Load Line 1 (RVAAP-08) is located in the southeastern portion of RVAAP (Figure 1-2), began operation in 1941, and was used until 1971. A detailed site map of Load Line 1 is presented in Figure 1-3. All load lines operated at full capacity from 1941 through 1945. During World War II and the Korean War, Load Line 1 was used to melt and load trinitrotoluene (TNT) and Composition B explosives into large-caliber shells. Composition B is a mixture of TNT and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX). Cadmium was applied to various components of the shells as a rust deterrent. The operation on the load line produced explosive dust, spills, and vapors that collected on the floors and walls of several buildings. These residues were periodically washed from walls and floors with water and steam. The majority of the wastewater, known as “pink water,” was collected in concrete sumps located throughout the load line area. The pink water was then pumped to a sawdust filtration unit for chlorification and removal of nitro-compounds prior to discharge. Sawdust filtration units consisted of a set of three parallel 3- × 9.1- × 0.9-m (10- × 30- × 3-feet) concrete settling tanks and a set of three 1.5- × 4.6- × 0.9-m (5- × 15- × 3-feet) filter blocks in the bottom of the filtration tanks. Settling tank effluent via Outlet A (Figure 1-3). Effluent from the main production area exited through Outlets A, C, D, and E. Thus, a portion of the surface drainage from Load Line 1 drains through an unnamed tributary that flows beneath State Route 534, while another portion flows to Griggy’s Pond. The distances between the production area and these exit points at the RVAAP boundary are approximately 12,000 to 13,000 ft. Sawdust from the filtration unit was disposed by open burning at Winklepeck Burning Grounds. During building washdown, pink water or loose explosive flakes or dust were occasionally swept out of doorways onto the ground.

Various industrial operations associated with the munitions loading process were also active during the operation of Load Line 1. These operations included painting, machining, munitions truck and equipment maintenance, and paint, oil, solvent, and equipment storage. The load lines were rehabilitated in 1951 (USATHAMA 1978), to remove and replace soils contaminated with accumulated explosives, and to remove and replace contaminated overhead storm drains, particularly at buildings CB-4 and CB-4A. However, many contaminated storm drain lines remained in each load line after 1951.

More recently, Load Line 1 was the site of munitions rehabilitation activities following the Vietnam War. These activities primarily involved the dismantling, replacement of components, and repainting of mines. Much of this work was conducted in Building CB-10.

Load Line 1 was the subject of a Phase I RI in 1996 (USACE 1997a). The purpose of the investigation was to confirm whether contamination was present at the site and to determine the nature of the chemicals of potential concern (COPCs). The results of this investigation are summarized in Section 1.3.

Load Line 1 buildings were recently demolished and removed. All buildings with residual explosive dust were swept prior to and immediately after demolition, and the free-standing equipment was removed from the buildings, before the load line was declared inactive in 1971. Salvaging contractors removed telephone lines and major rail spurs across the site from 1996 to 1998. Similarly, the overhead steam lines have been removed for metal recycling following the removal of friable asbestos. Inside the buildings, removal of friable asbestos shielding began in 1997, as did removal of the steel piping, trim, overhead lighting [with polychlorinated biphenyl (PCB) ballasts], and some structural steel. All salvage/scrap operations have been overseen by the U.S. Army Industrial Readiness (IR) Command. Transite (asbestos



LEGEND OF SITES:

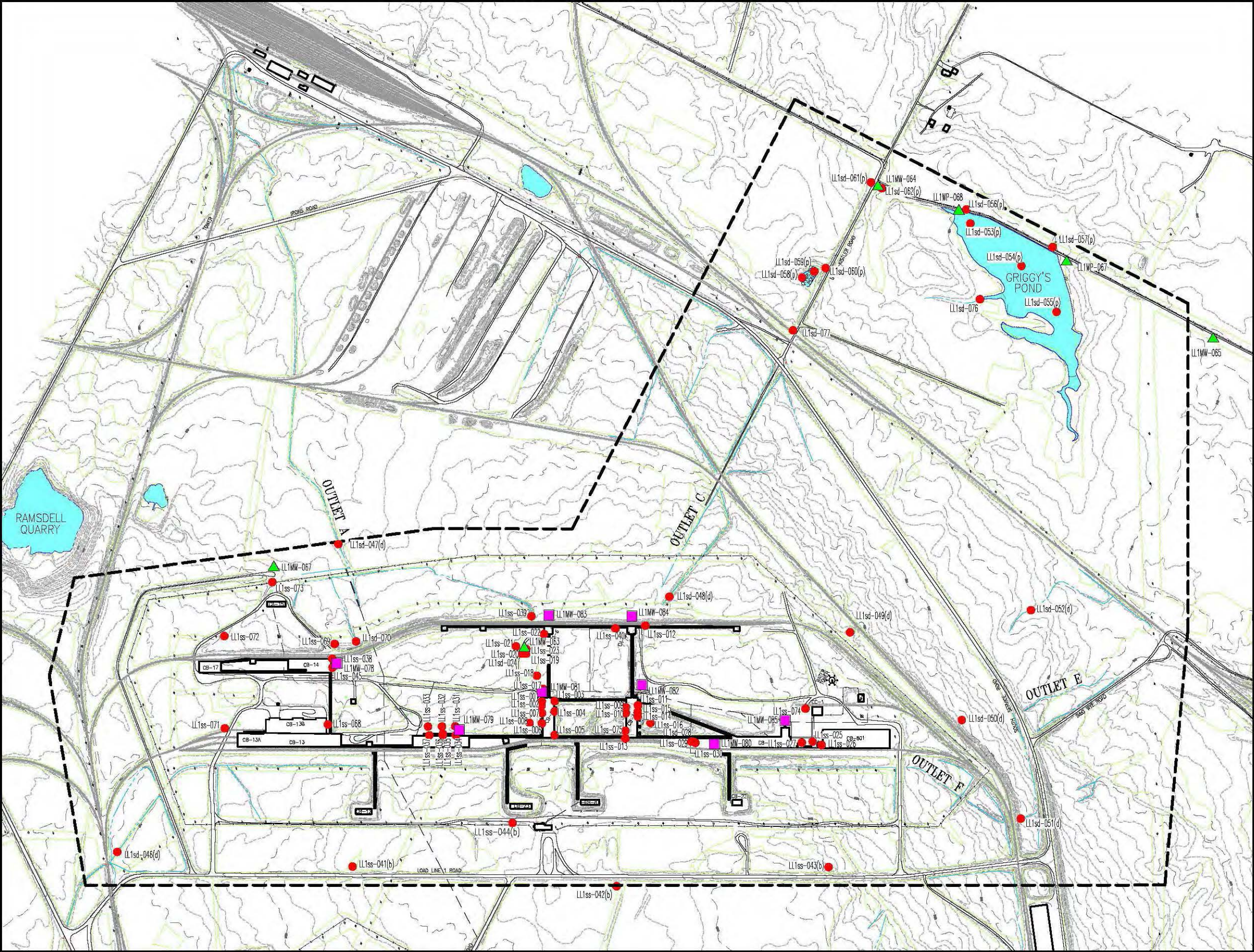
1.....RAMSDALL QUARRY LANDFILL	13.....BLDG 1200 AND DILUTION/SETTLING POND	25.....BLDG 1034 MOTOR POOL WASTE OIL TANK	37.....PESTICIDE STORAGE BUILDING T-4452	49.....CENTRAL BURN PITS
2.....ERIE BURNING GROUNDS	14.....LOAD LINE 6, EVAPORATION UNIT	26.....FUZE BOOSTER AREA SETTLING TANKS	38.....NACA TEST AREA	50.....ATLAS SCRAP YARD
3.....DEMOLITIONS AREA #1	15.....LOAD LINE 6, TREATMENT PLANT	27.....BLDG 854-PCB STORAGE	39.....LOAD LINE 5 / FUZE LINE 1	51.....DUMP ALONG PARIS-WINDHAM ROAD
4.....DEMOLITIONS AREA #2	16.....QUARRY LANDFILL/FORMER FUZE & BOOSTER BURNING PITS	28.....MUSTARD AGENT BURIAL SITE	40.....LOAD LINE 7 / BOOSTER LINE 1	○.....CERCLA
5.....WINKLEPECK BURNING GROUNDS	17.....DEACTIVATION FURNACE	29.....UPPER AND LOWER COBBS POND COMPLEX	41.....LOAD LINE 8 / BOOSTER LINE 2	○.....RCRA
6.....C BLOCK QUARRY	18.....LOAD LINE 12 PINK WASTE WATER TREATMENT	30.....LOAD LINE 7 PINK WASTEWATER TREATMENT PLANT	42.....LOAD LINE 9 / DETONATOR LINE	○.....OTHER REGULATORY
7.....BLDG 1601 HAZARDOUS WASTE STORAGE	19.....LANDFILL NORTH OF WINKLEPECK BURNING GROUND	31.....ORE PILE RETENTION POND	43.....LOAD LINE 10 / PERCUSSION ELEMENT	◆.....SURFACE WATER QUALITY MONITORING STATION PF534
8.....LOAD LINE 1 AND DILUTION/SETTLING POND	20.....SAND CREEK SEWAGE TREATMENT PLANT	32.....40- AND 60-MM FIRING RANGE	44.....LOAD LINE 11 / ARTILLERY PRIMER	
9.....LOAD LINE 2 AND DILUTION/SETTLING POND	21.....DEPOT SEWAGE TREATMENT PLANT	33.....FIRESTONE TEST FACILITY	45.....WET STORAGE AREA	
10.....LOAD LINE 3 AND DILUTION/SETTLING POND	22.....GEORGE ROAD SEWAGE TREATMENT PLANT	34.....SAND CREEK DISPOSAL ROAD LANDFILL	46.....BUILDINGS F-15 AND F-16	
11.....LOAD LINE 4 AND DILUTION/SETTLING POND	23.....UNIT TRAINING SITE WASTE OIL TANK	35.....1037 BUILDING-LAUNDRY WASTEWATER SUMP	47.....BUILDING T-5301 DECONTAMINATION	
12.....LOAD LINE 12 AND DILUTION/SETTLING POND	24.....RESERVE UNIT MAINTENANCE AREA WASTE OIL TANK	36.....PISTOL RANGE	48.....ANCHOR TEST AREA	

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RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO
FACILITY MAP

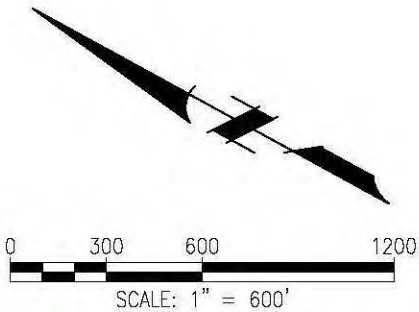
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Figure 1-2. RVAAP Installation Map



LEGEND:

- BUILDING
- ASPHALT ROAD
- GRAVEL ROAD
- RAILROAD TRACKS
- FENCE LINE
- POND
- STREAM
- CONTOUR (2-FT. INTERVAL)
- CONTOUR (10-FT. INTERVAL)
- DITCH LINE W/FLOW ARROW
- PHASE I RI MONITORING WELL LOCATION
- PHASE I RI SEDIMENT SAMPLE (SEE TABLE 3-1)
- LL1 PHASE II RI MONITORING WELL



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RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO
LOAD LINE 1

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Figure 1-3. Existing Phase I RI Sampling Locations and Phase II RI Monitoring Wells at Load Line 1.

and concrete) siding and roofing, and any remaining recyclable steel, were removed as part of the demolition. There was a concern that removal of the transite panels would introduce new contamination to the soil around the buildings. To minimize the spread of these contaminants, the following measures were taken during the demolition work:

- vacuuming and sweeping all dust and debris before transite removal/demolition, during removal activities as significant quantities of dust and debris accumulated, and at the completion of demolition activities;
- disposing dust and debris according to state and federal rules, laws, and regulations;
- removing loose paint on all surfaces;
- removing and collecting all lead bolts as well as explosives-contaminated plugs of cement; and
- removing structural steel members with high levels of paint-related contamination by mechanical cutting where feasible, with minimal use of cutting torches.

Salvage and demolition activities at Load Line 1 were complete as of June 2000. All buildings (except for CB-13 and CB-801) have been demolished and the debris either removed from the site or placed in clean hard fill areas at the locations of the former change houses (CB-12, CB-8, and CB-23). Floor slabs and most below-grade infrastructure remain in place.

Based on the site operational history, waste constituents and potential contaminants at Load Line 1 include TNT; RDX; octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX); Composition B; propellants; lead; cadmium; chromium; mercury; and arsenic from the handling and processing of materials used to assemble ammunition. Contaminants associated with support activities include petroleum products, solvents, pesticides, PCBs, and heavy metals. Additional information regarding site-related contamination identified in environmental investigations is presented in Section 1.3.

1.3 SUMMARY OF EXISTING DATA

Three previous investigations relevant to this SAP Addendum have been conducted wholly or in part at or in the vicinity of Load Line 1. These are (1) the Water Quality Surveillance Program (USATHAMA 1980-92); (2) the Cold Regions Research and Engineering Laboratory (CRREL) study of explosives contamination in surface soils (USACE 1997a); and (3) the Phase I RI of High-Priority Areas of Concern at RVAAP (USACE 1997b). The sampling locations, dates, and analyses are documented for these studies. Other studies conducted are missing some or all documentation and are not discussed in this SAP Addendum. Previous groundwater and surface water data relevant to Load Line 1 are summarized in the SAP Addendum No. 1 for this Phase II RI (USACE 1999), and will not be repeated here.

The Phase I RI performed in 1996 included sampling and analysis of groundwater, surface soils, ditch sediment, and sediment from Griggy's and Charlie's Ponds. The Phase I RI identified elevated concentrations of explosives, inorganics, and organic compounds in soils in the central portion of the complex. Explosives such as TNT, TNB, and RDX were most plentiful around the doorways, drains, and vacuum pump houses associated with the melt/pour buildings (CB-4 and CB-4A), and near the main concrete settling tank adjacent to monitoring well LL1mw-063. During Phase I RI field activities, residual propellant pellets were found on the ground beside buildings CB-13, CB-13B, and CB-14.

Aluminum, arsenic, barium, cadmium, chromium, iron, lead, manganese, magnesium, mercury, selenium, and zinc were all found at concentrations above background criteria in Phase I surface soils. The 1996 background values were established only for the 11 process-related metals, and differ from the facility-wide background criteria generated during the 1998 sampling efforts. Maximum concentrations of inorganics in the soils are higher at Load Line 1 than at any of the remaining AOCs investigated in that study. Chromium and lead were both detected at levels that exceeded residential and industrial screening values.

Sediments in drainage ditches did not contain significant concentrations of explosives or convey them to the ponds. The ponds were found to contain no explosives. Samples from the concrete settling tank contained the highest concentrations of explosives. Metals are concentrated near building CB-3A and the ditch along Outlet D just upstream at Former Track 23 (see [Figure 1-3](#)). PCBs were identified in the southern third of the plant, and are associated with CB-3A and the drainage ditch along Outlet D.

Eight Phase II RI monitoring wells were installed in 1999 and sampled for explosives, propellants, Target Analyte List (TAL) metals, and cyanide. The Phase I wells (four in Load Line 1 and two in Load Line 2) were also sampled during the 1999 sampling event. Two samples were also analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and PCB/pesticides. No explosives were detected during the Phase I sampling (LL1mw-063, -064, -065, and -067). TNT and trinitrobenzene (TNB) were detected in five of the wells during Phase II (LL1mw-078, -079, -080, -081, and -083). The maximum concentration of any explosive in groundwater was 15 µg/L. Given that the Phase II wells were installed at the sites of Phase I maximum soil contamination with explosives, these results suggest a very low vertical mobility of explosives from soils to groundwater.

Inorganics such as arsenic, cyanide, lead, barium, and selenium were all detected in the Phase II monitoring wells, but none were present at concentrations above maximum contaminant levels (MCLs). No comparisons have been made to the facility-wide background criteria.

VOCs and SVOCs were analyzed in samples from LL1mw-079 and -085. There were detections of bis(2-ethylhexyl)phthalate, chloroform, and methylene chloride in LL1mw-079, and methylene chloride in LL1mw-085, both below 0.01 mg/L. PCBs and pesticides were not detected.

1.4 SPECIFIC SAMPLING AND ANALYSIS PROBLEMS

Many of the features where the most contaminated surface soils were identified in Phase I are cut into sandstone bedrock. Opportunities for collection of subsurface soil samples are very limited in areas where surface soils are known to be contaminated. In some cases, the presence of soils deeper than 1 foot may be the result of earthmoving activities during the demolition phase.

It is not known whether the demolition and removal operations that took place in August 1999 through June 2000 may have altered the occurrences of contamination in surface soils as documented in the Phase I RI.

Survey and sampling of sanitary and storm sewers for potential contamination can only be accomplished from a limited number of access points. In order to clear specific catch basins for use of the video monitoring system, some minor excavation of soil will be required. Under no circumstances will confined spaces be entered in order to obtain samples.

Efforts were made to avoid disturbing the monitoring wells installed at Load Line 1 in 1999 during demolition activities. However, a brief site visit on June 20, 2000 identified minor damage to the

protective posts and well pads at some wells. The integrity of monitoring wells will be fully evaluated and documented per the Facility-wide SAP prior to attempting to sample them.

Unexploded ordnance (UXO) technicians performed surface clearance of Load Line 1 during demolition activities. Aside from the previously identified propellants, no UXO or ordnance and explosive (OE) were identified. Additional UXO/OE support is planned for the remaining soil sampling activities at Load Line 1. Furthermore, because sanitary and storm sewer lines may harbor potentially dangerous quantities of bulk explosives, UXO support will be necessary for the camera survey and sampling of sanitary sewer lines.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The responsibilities for the Load Line 1 Phase II RI soil, sediment, surface water, and groundwater sampling activities are organized according to [Figure 2-1](#). The functional responsibilities of key personnel are described in Chapter 2.0 of the Facility-Wide SAP and, therefore, are not presented here. [Figure 2-1](#) shows the Project Organization Chart for the remaining sampling effort. [Table 2-1](#) presents the planned project schedule for the remaining components of the Phase II RI.

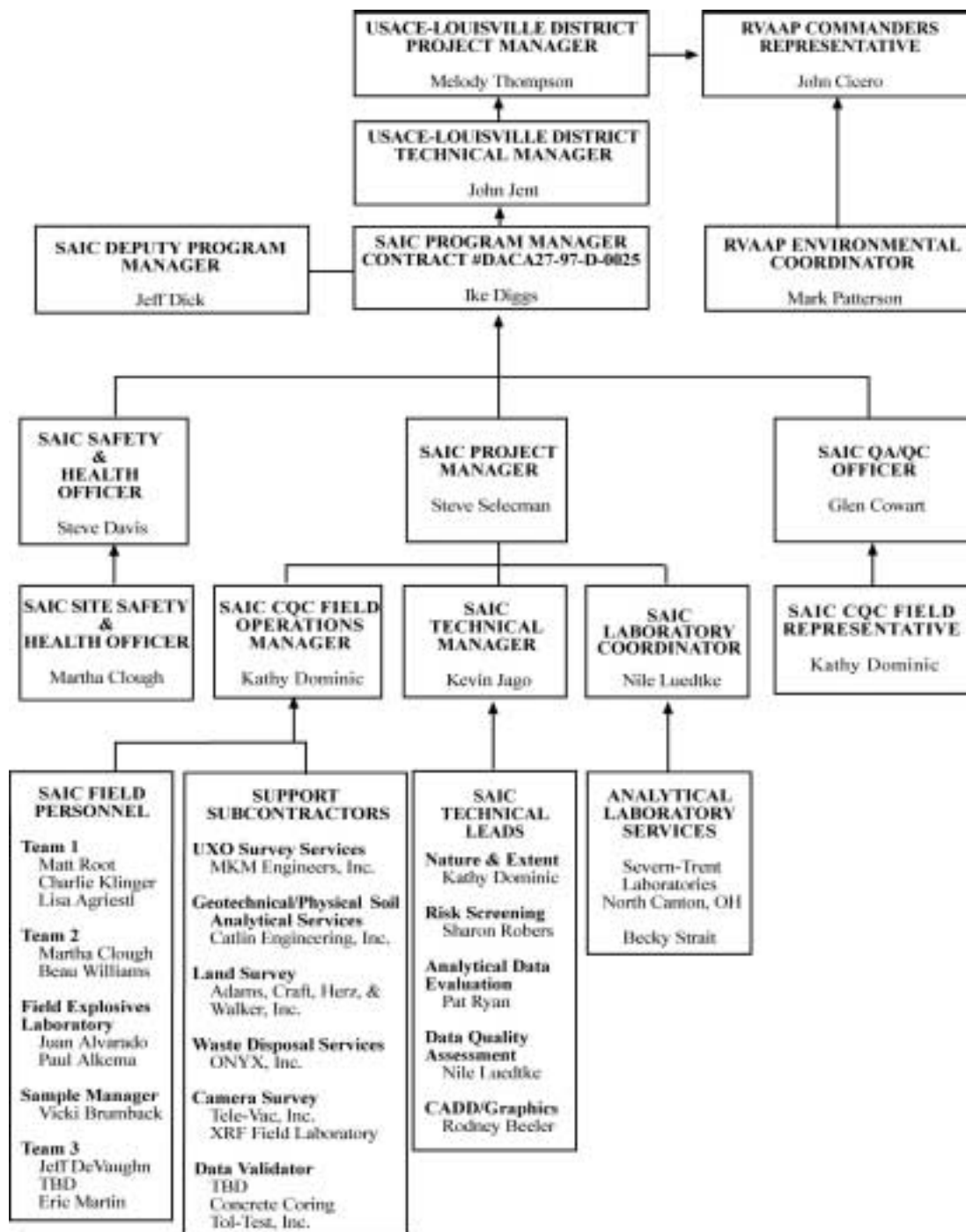


Figure 2-1. Project Organization Chart for Phase II RI



Table 2-1. Planned Project Schedule for the Remaining Components of the Load Line Phase II RI

3.0 SCOPE AND OBJECTIVES

3.1 PHASE II RI SOIL, SEDIMENT, SURFACE WATER, GROUNDWATER SCOPE AND OBJECTIVES

The scope of the Load Line 1 Phase II RI is to determine the extent of contamination in soils, sediment, surface water, and groundwater based on the Phase I results. The primary technical objectives of the Phase II RI are as follows:

- Characterize the physical environment of Load Line 1 and its surroundings to the extent necessary to define potential transport pathways and receptor populations.
- Characterize sources, types, chemical properties, and quantities of contaminants, potential contaminant release mechanisms, and contaminant fate and transport; obtain sufficient engineering data to develop a site conceptual model (SCM) suitable for use in a baseline risk assessment, and to evaluate remedial action alternatives.
- Conduct baseline human health and ecological risk assessments using characterization data and the SCM to evaluate the potential threats, and develop preliminary remediation goals (PRGs) for use in determining areas that may require remediation and evaluating remedial action alternatives.
- Assess the suitability of field-portable X-ray fluorescence (XRF) spectrometry for performing in situ and ex situ analyses of metals in soil and sediment samples. Results of these tests will determine the suitability of metals field determinations for future environmental investigations and remedial activities.

This SAP Addendum No. 2 includes all of the components of the Phase II RI field investigation except for the groundwater component, which was described in the SAP Addendum No. 1 (USACE 1999b). The Phase II RI technical objectives have been developed using the data quality objective (DQO) approach presented in the Facility-Wide SAP. The sampling rationale and objectives specific to this Phase II RI field investigation are presented in Section 4.0 of this SAP Addendum No. 2.

3.2 PHASE II DATA QUALITY OBJECTIVES

Specific DQOs for the Phase II RI at Load Line 1 address remaining data gaps, which are stated below:

- No subsurface soil samples were collected in the Phase I RI at Load Line 1.
- No samples were analyzed for propellants.
- Surface water in ditches and ponds was not characterized.
- Surface water drainage on the east side of the load line was not fully characterized.
- Groundwater was not fully characterized
- Storm and sanitary sewers were not evaluated.
- Surface water conveyances that were outside the AOC boundary were not characterized.
- Lateral extent of contamination was not an objective of the Phase I RI.
- Some of the service buildings were later understood to have had multiple uses throughout the active life of the load line. The analytical suite for most of the Phase I RI surface soil samples did not account for this.

In addition, facility-wide background criteria for metals were not determined until after the Phase I RI was completed. No data collected to date at Load Line 1 have been compared to background values to fully characterize nature and extent. A complete discussion of the facility-wide background data is presented in the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds at Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 1999a).

The project DQO is to provide sufficient high-quality data to address the primary objectives stated in Section 3.1.

3.2.1 Conceptual Site Model

Based on current knowledge, the SCM model presented in the Facility-Wide SAP is applicable to this element of the Phase II RI for Load Line 1. Operational information and analytical data collected during the Phase I RI of High-Priority Areas of Concern (USACE 1998) and other historical environmental investigations have also been used to refine the SCM for Load Line 1 as follows:

Soils. During the Phase I RI, 48 surface soil samples were collected from 0 to 0.6 m (0 to 2 feet) and analyzed for explosives. Thirty-eight of these samples were also analyzed for process-related metals, and 12 samples received additional analysis for cyanide, VOCs, SVOCs, and PCBs/pesticides. Relevant components of the SCM for soils derived from the Phase I RI and historical studies include:

- The soil cover at Load Line 1 is thin (< 0.5 foot) or absent in many locations, and sandstone bedrock crops out or has been excavated at the sites of the former change houses and melt/pour buildings CB-4 and CB-4A. Consequently, contaminant leaching pathways from soil to bedrock are short or nonexistent in many areas.
- TNT was detected in 28 Phase I RI soil samples and TNB in 10 samples. Dinitrotoluene (DNT) was detected in five samples. Explosives were most concentrated in areas surrounding the former melt/pour and washout buildings, the vacuum pump houses at Building CB-10, a settling tank, and east of building CA-6. Building CB-3A also exhibits explosives contamination. High concentrations of explosives are localized around doorways, drains, and vacuum pumps.
- Inorganics were identified at concentrations above the Phase I RI background criteria for soils in many locations. Lead, cadmium, and zinc were the most frequently detected metals exceeding the background criteria. The highest concentrations for arsenic, cobalt, chromium, lead, vanadium, and selenium found in the Phase I RI were found at Load Line 1, but do not correlate with the highest concentrations of explosives.
- Organic compounds were present in 9 out of 12 Phase I RI surface soil samples. VOCs acetone, chloroform, and toluene were present in eight samples, at concentrations of 0.017 mg/kg or less. SVOCs, including several polycyclic aromatic hydrocarbons (PAHs) and phthalates, were encountered in seven sampling locations, with the maximum concentrations for the PAHs centering on building CB-10's pump houses. PCBs or pesticides were also encountered in seven samples.

Sediment. Twenty-two Phase I RI sediment samples were collected from the ditches and settling ponds and analyzed for explosives and process-related inorganic compounds. Three of these samples also received analyses for VOCs, SVOCs, and PCBs/pesticides. Relevant aspects of the site conceptual model for sediments include:

- Load Line 1 surface water drainage pathways convey sediment eastward and southeastward off the installation. Drainage from the production area exits the installation beneath State Route 534 to the east, and at Griggy's Pond to the southeast. These drainages do not appear to be connected to Eagle Creek or the other streams that comprise the tributary system at RVAAP. All drainages are unlined, man-made extensions of natural drainage trends. These ditches are generally dry except immediately following storm events.
- Explosives were not detected in Phase I RI sediment samples from three of the four main drainage ditches that exit Load Line 1 from the south, or from a ditch that exits the load line at its northern end. Pond sediments from Griggy's and Charlie's Ponds exhibit no detectable contamination with explosives. Explosives were detected in sediments in concrete settling tanks and in one ditch at the south end of the load line. However, some drainages at the load line were not sampled during Phase I.
- All 11 site-related metals were detected at concentrations exceeding the Phase I background criteria. The highest concentrations of metals occurred predominantly in locations where no detectable quantities of explosives were present. Maximum concentrations of many analytes occurred in Griggy's or Charlie's Ponds, including the maximum value of chromium in any RVAAP sediment.
- Three Phase I RI samples were analyzed for organic compounds. Acetone and chloroform were detected once. PAHs were present in all three samples. Pesticides and PCBs were found in two samples in the southern third of the load line and in one ditch that discharges to Griggy's Pond.

Groundwater. Groundwater samples were collected from four monitoring wells and three temporary well points installed for the Phase I RI. Following installation of eight new wells as part of the Phase II field activities, all wells were sampled. The samples were analyzed for inorganic and explosive compounds, VOCs, SVOCs, and pesticides/PCBs. Known aspects of the site conceptual model for groundwater include:

- Groundwater occurs in the highly permeable sandstones of the Pottsville Formation and in unconsolidated sands overlying the Pottsville south of Load Line 1. Groundwater flow is presumed to be north–northeastward, toward the facility boundary.
- No explosives were detected in either the monitoring wells or well points during the Phase I RI. Occurrences of explosives during the first round of Phase II RI groundwater sampling indicated very low concentrations of TNT and other explosives only in wells interior to Load Line 1.
- All metals present in groundwater, with the exception of essential nutrients, are considered to be site related. Comparison of detected constituents to facility-wide background levels was not performed because facility-wide background criteria were not developed at the time of the Phase I RI.
- Organic compounds are generally not found in groundwater at the perimeter locations sampled. Heptachlor and phthalates were present in minor concentrations in a single well point sample.
- The storm and sanitary sewers still in place beneath Load Line 1 are suspected to represent a significant source of explosives contamination with a potential to migrate to groundwater and surface water. Data from similar, heavily used load lines at other army ammunition plants (AAPs) indicate that bulk explosives commonly clog sewer lines, even many years after their use was discontinued.

3.2.2 Problem Definition

Wastewater effluent from steam cleaning of explosives-handling buildings and residuals from various support activities have potentially contaminated surface and subsurface soils. The potential exists for contaminant migration to groundwater via infiltration and leaching through soils. The potential for surface water runoff to drainage ditches and surface water bodies exists. The Phase I RI demonstrated that contamination is present in surface soils, with the highest concentrations occurring near the melt-pour buildings. Also, contamination of storm and sanitary sewers throughout Load Line 1 has possibly occurred. Migration of contaminants to surface water (by flushing during storm events) or groundwater (through leaking sewers) from the sewer systems is a pathway of concern. Groundwater contamination is most likely in the vicinity of primary operational facilities (i.e., melt/pour buildings) or heavily contaminated secondary sources (i.e., soil or storm sewers); thus, Phase II RI monitoring well locations are biased to these areas.

3.2.3 Remedial Action Objectives

See Section 3.2.3 of the Facility-Wide SAP.

3.2.4 Identify Decisions

The key decisions for all investigations at RVAAP have been identified in Section 3.2.4 and [Table 3-1](#) of the Facility-Wide SAP. Phase II RI data, inclusive of the baseline risk assessment results, are necessary for refinement of the SCM, development of PRGs, and initiation of the Feasibility Study (FS) process.

3.2.5 Define the Study Area Boundaries

The investigation area boundary for Load Line 1 is that presented in [Figure 1-3](#). The AOC includes both Griggy's and Charlie's Ponds. The boundary was established to encompass all known or reported historical activities and potential surface water exit pathways.

3.2.6 Identify the Decision Rules

Decision rules used to guide remediation decisions are provided in Section 3.0 of the Facility-Wide SAP. Phase I RI data were not sufficient to define nature and extent of contamination; therefore, these data were insufficient to fully evaluate risk due to exposure to these contaminants.

3.2.7 Identify Inputs to the Decisions

Inputs to the decisions are the analytical results that can be used to estimate risk.

3.2.8 Specify Limits on Decision Error

Limits on decision errors are addressed in Section 3.2.8 of the Facility-wide SAP.

3.2.9 Optimize Sample Design

The sample design for the Phase II RI at Load Line 1 is described in detail in Section 4.0 of this SAP Addendum No. 2.

Table 3-1. Surface Soil (0 to 1 ft) Facility-wide Background Criteria

Analyte	Results > Detection Limit ^a	Minimum Detect	Maximum Detect	Average Result ^b	Std. Dev.	Distr. ^c	Parametric 95% UTL	Nonparametric 95% UTL	Background Criteria ^d
<i>Metals (mg/kg)</i>									
Aluminum	11/ 11	4920.00	17700.00	1070.00	4914.00	N	22100.00	17700.00	17700.00
Antimony	0/ 11			0.32	6.21	O		0.78	0.96 ^e
Arsenic	11/ 11	7.00	15.40	10.50	3.72	L	20.20	15.40	15.40
Barium	11/ 11	47.90	88.40	65.20	1202.00	L	112.00	88.40	88.40
Beryllium	0/ 11			0.25	0.54	O		0.82	0.88 ^e
Cadmium	0/ 11			0.32	74.8	O		0.78	0.00
Calcium	11/ 11	238.00	15800.00	4300.00	18276.00	L	97300.00	15800.00	15800.00
Chromium	11/ 11	6.30	17.40	12.10	18.1	N	24.20	17.40	17.40
Cobalt	11/ 11	4.10	10.40	7.53	2.07	N	14.20	10.40	10.40
Copper	11/ 11	9.10	17.70	11.50	1980.00	X		17.70	17.70
Cyanide	0/ 11			0.32	0.15	O		0.78	0.00
Iron	11/ 11	10000.00	23100.00	17200.00	5336.00	N	27600.00	23100.00	23100.00
Lead	11/ 11	12.80	26.10	18.40	373.6	L	32.80	26.10	26.10
Magnesium	11/ 11	1140.00	3030.00	1970.00	2287.00	L	4410.00	3030.00	3030.00
Manganese	11/ 11	147.00	1450.00	638.00	499.9	L	3050.00	1450.00	1450.00
Mercury	7/ 11	0.03	0.04	0.04	0.15	X		0.16	0.04
Nickel	10/ 11	9.00	21.10	13.60	14.85	L	29.40	21.10	21.10
Potassium	11/ 11	303.00	927.00	621.00	518.3	N	1120.00	927.00	927.00
Selenium	2/ 11	0.69	1.40	0.45	0.69	D		1.40	1.40
Silver	0/ 11			0.65	2.92	O		1.60	0.00
Sodium	1/ 11	123.00	123.00	42.80	195.7	D		123.00	123.00
Thallium	0/ 11			0.32	0.54	O		0.78	0.00
Vanadium	11/ 11	9.10	31.10	19.00	4.98	N	40.80	31.10	31.10
Zinc	11/ 11	38.40	61.80	51.20	2066.00	N	74.80	61.80	61.80
<i>Organics (mg/kg)</i>									
Total organic carbon	11/ 11	7000.00	24000.00	14400.00		L	41700.00	24000.00	24000.00
<i>SVOCs (µg/kg)</i>									
Benzo(a)anthracene	6/ 11	44.00	110.00	142.00	250.00	X		520.00	110.00
Benzo(a)pyrene	4/ 11	58.00	100.00	167.00	193.00	D		520.00	100.00
Benzo(b)fluoranthene	6/ 11	62.00	140.00	159.00	275.00	N	351.00	520.00	140.00
Benzo(g,h,i)perylene	2/ 11	46.00	51.00	185.00	74.9	D		520.00	51.00
Benzo(k)fluoranthene	2/ 11	53.00	54.00	186.00	106.00	D		520.00	54.00
Bis(2-ethylhexyl)phthalate	1/ 11	47.00	47.00	198.00	63.0	D		520.00	47.00

Table 3-1 (continued)

Analyte	Results > Detection Limit ^a	Minimum Detect	Maximum Detect	Average Result	Std. Dev. ^c	Distr.	Parametric 95% UTL	Nonparametric 95% UTL	Background Criteria ^{d,e}
Chrysene	6/ 11	57.00	120.00	147.00	248.00	N	369.00	520.00	120.00
Fluoranthene	6/ 11	53.00	290.00	179.00	801.00	N	409.00	520.00	290.00
Indeno(1,2,3- <i>cd</i>)pyrene	1/ 11	54.00	54.00	198.00	91.7	D		520.00	54.00
Phenanthrene	2/ 11	110.00	150.00	197.00	661.00	D		520.00	150.00
Pyrene	6/ 11	48.00	230.00	169.00	577.00	L	2390.00	520.00	230.00

^aResults for 4 samples with outlier results were excluded [(BKGSS-011(b)-0794-SO, BKGss-012(b)-0795-SO, BKGss-015(b)-0798-SO, and BKGss-005(b)-0788-SO)]

^bResults less than the detection limit were set to one-half the reported detection limit.

^cDistribution codes: L = Distribution most similar to lognormal.
N = Distribution significantly different from normal.
X = Distribution significantly different from normal and lognormal.
D = Non-parametric distribution – frequency of detection <50%.
0 = Zero detects – background criteria are set to zero.

^dIf 95% UTL > max. detect then background criteria = max. detect.

^eSubsurface antimony and beryllium background used

If distribution determined not normal or lognormal or fewer than 3 results then background criteria = max. detect.

Background criteria was set to zero if there were no detects.

In order to accomplish the sampling objectives listed above, biased sampling will be used. That is, process history, topography, geology, and the data from the Phase I RI will be used to identify locations where residual contamination would most probably remain.

Given the non-uniform horizontal distributions of contaminated areas on ammunition plants such as RVAAP (e.g., former burning pads separated by apparently unused, uncontaminated land), the investigation of Load Line 1 requires characterization of the spaces between contaminated areas as well. For this purpose, non-biased, or random grid, sampling will be used to acquire representative information on areas between known or suspected sources within and beyond the operational area of the load line.

Random grid sampling will be conducted as follows:

- Select a representative area or exposure unit that most reflects the future land use (e.g., a 300 × 300-foot plot);
- Use the Gilbert (1987) statistical approach to determine an appropriate triangular grid spacing (e.g., 60-ft spacing);
- Lay out exposure units outside or beyond the areas of biased sampling, and label each grid sampling location with a grid sampling number;
- At each exposure unit, randomly select a grid sampling number;
- Field screen for explosives on composited soil samples and for metals, and allow 911 of those samples to have corresponding laboratory analyses for metals performed. Fifteen percent of the environmental sampling locations will be subject to the full suite of chemical analyses. All samples showing field detections of explosives will receive laboratory analysis of explosives, according to Section 4.3.1.4 of this SAP.

3.3 DATA EVALUATION METHODS

The methods for identifying AOC-related contaminants are consistent with those established for the Phase II RI for Winklepeck Burning Ground (USACE 1999a) at RVAAP. The general process involves initial data reduction; definition of aggregates; data quality assessment; and screening of data against statistical, background, and weight-of-evidence criteria. Analytical results will be reported by the laboratory in electronic form and loaded into an established data base. Site data are extracted from the database so that only one result is used for each station and depth sampled. Quality control (QC) data such as sample splits, duplicates, laboratory re-analyses, and dilutions will not be included in the determination of contaminant nature and extent, or in the risk assessment. Samples rejected in the validation process will also be excluded. If it is found that a significant number of samples are rejected, the entire data set will be evaluated to determine if a representative data set exists without the rejected data. The percentage of rejected data will be presented in the data quality assessment section of the Phase II RI Report.

3.3.1 Determination of AOC Chemical Background

The Phase II RI will not require determination of separate AOC-specific chemical background. Analytical results from the Phase I RI will be screened against the final facility-wide background values for RVAAP, published in the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds at Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 1999a). The background criteria were established for

inorganics. This screening step, which applies only to the inorganics, will be used to determine if detected inorganics are site related or naturally occurring.

3.3.2 Definition of Aggregates

Data collected from the Phase II RI at Load Line 1 will be aggregated by environmental medium (i.e., surface water, soil, sediment, and groundwater). Soil data will be aggregated by depth interval—surface soils from 0 to 1 foot below ground surface (bgs), and subsurface soil from 1 to 3 or 3 to 5 feet bgs. Data will be evaluated on an AOC-wide basis. Summary statistics [i.e., minimum detect, maximum detect, frequency of detection, mean detect, and 95 percent upper confidence limit (UCL₉₅)] will be developed for the entire Load Line 1 data set. Source areas will be identified spatially from the soil and sediment data. Evaluation of the spatial distribution of surface water contaminants will remain on an AOC-wide scale and include factors such as proximity to sources and flow patterns. Focused discussions of any identified source areas and contamination at surface water exit points will be developed in the nature and extent characterization and risk assessment.

3.3.3 Data Screening

Data screening prior to the risk assessment will consist of four steps: (1) a data quality assessment, (2) frequency-of-detection screening, (3) background screening, and (4) screening of essential human nutrients. These screens will be used to identify site-related contaminants (SRCs). Those constituents identified as SRCs will then be carried through the risk assessment. The application of these screens to the risk assessment is described in Section 3.4.

- A detailed assessment of the quality of the Phase II analytical results will take place. Data that are rejected as a result of the data quality assessment will not be evaluated further in the screening process.
- Each chemical for each environmental medium (aggregate) will be evaluated to determine its frequency of detection. Chemicals that are never detected will be eliminated as SRCs. For sample aggregations with greater than 20 samples and a frequency of detection of less than 5 percent, a weight-of-evidence approach will be used to determine if the chemical is AOC-related. The magnitudes and locations (clustering) of the detections will be evaluated. If the detected results show no clustering, the chemical is not an SRC in another medium, and the concentrations are not substantially elevated relative to the detection limit, they will be considered spurious and the chemical will be eliminated from further consideration.
- For each inorganic constituent passing the frequency-of-detection screening, concentrations will be screened against available naturally occurring background levels. If the maximum concentration of a constituent exceeds the background value, the constituent will be considered AOC-related. These background levels are presented in [Tables 3-1](#), [3-2](#), [3-3](#), [3-4](#), [3-5](#), and [3-6](#) for surface soils, subsurface soils, sediment, surface water, and groundwater, respectively. Note that in the event a constituent was never detected in the background data set, its background level is assigned as zero. This approach ensures that any detected concentrations at Load Line 1 for a particular constituent in a particular medium cannot be eliminated simply because the chemical was never detected in the background data set. All detected organic compounds will be considered SRCs, evaluated in nature and extent, and screened in the risk assessment.

Table 3-2. Subsurface Soil (>1 ft) Facility-wide Background Criteria

Analyte	Results > Detection Limit	Minimum Detect	Maximum Detect	Average Result ^a	Std. Dev. ^a	Distr. ^b	Parametric 95% UTL	Nonparametric 95% UTL	Background Criteria ^c
<i>Metals (mg/kg)</i>									
Aluminum	27/ 27	1380.00	19500.00	11600.00	2862.00	N	22900.00	19500.00	19500.00
Antimony	8/ 27	0.27	0.96	0.34	0.42	D		0.96	0.96
Arsenic	27/ 27	3.50	19.80	12.10	2.86	N	21.40	19.80	19.80
Barium	27/ 27	10.70	134.00	58.60	90.62	N	124.00	134.00	124.00
Beryllium	12/ 27	0.26	0.88	0.37	0.25	D		0.88	0.88
Cadmium	0/ 27			0.29	2.23	O		0.62	0.00
Calcium	22/ 27	416.00	35500.00	4880.00	5325.00	L	44800.00	35500.00	35500.00
Chromium	27/ 27	4.10	27.20	16.90	3.92	N	31.30	27.20	27.20
Cobalt	27/ 27	2.30	23.20	9.94	3.96	L	31.00	23.20	23.20
Copper	27/ 27	2.90	32.30	19.50	8.16	N	34.10	32.30	32.30
Cyanide	0/ 27			0.29	0.01	O		0.62	0.00
Iron	27/ 27	3690.00	35200.00	23200.00	5561.00	N	39900.00	35200.00	35200.00
Lead	27/ 27	2.50	19.10	11.60	17.31	X		19.10	19.10
Magnesium	27/ 27	216.00	8790.00	3350.00	1344.00	X		8790.00	8790.00
Manganese	27/ 27	107.00	3030.00	400.00	584.00	X		3030.00	3030.00
Mercury	4/ 27	0.03	0.04	0.04	0.02	D		0.12	0.04
Nickel	27/ 27	3.80	60.70	23.60	8.30	L	76.10	60.70	60.70
Potassium	27/ 27	333.00	3560.00	1520.00	664.9	N	3350.00	3560.00	3350.00
Selenium	8/ 27	0.61	1.50	0.49	0.15	D		1.50	1.50
Silver	0/ 27			0.58	0.16	O		1.20	0.00
Sodium	7/ 23	29.90	145.00	59.50	55.96	D		524.00	145.00
Thallium	3/ 27	0.77	0.91	0.35	0.18	D		0.91	0.91
Vanadium	27/ 27	5.20	37.60	19.70	5.38	N	37.80	37.60	37.60
Zinc	27/ 27	7.60	93.30	60.50	25.26	N	99.90	93.30	93.30
<i>SVOCs (µg/kg)</i>									
Fluoranthene	1/ 12	76.00	76.00	188.00	339.35	D		410.00	NA
Pyrene	1/ 12	60.00	60.00	186.00	245.49	D		410.00	NA
<i>VOCs (µg/kg)</i>									
Toluene	2/ 2	0.94	3.40	2.17	1.10	N	3.40	3.40	NA

^aResults less than the detection limit were set to one-half the reported detection limit.

^bDist. Codes: L = Distribution most similar to lognormal.
 N = Distribution most similar to normal.
 X = Distribution significantly different from normal and lognormal.
 D = Non-parametric distribution – frequency of detection <50%.
 0 = Zero detects – background criteria set to 0.00.

^cIf 95% UTL >max. detect then background criteria = max. detect.

If distribution determined not normal or lognormal or fewer than 3 results then background criteria = max. detect.

Background criteria were set to zero if there were not detects.

NA - Not applicable. Background criteria were determined for metals only.

Table 3-3. Sediment Facility-wide Background Criteria

Analyte	Results > Detection Limit	Minimum Detect	Maximum Detect	Average ^a Result	Std. Dev. ^a	Distr. ^b	Parametric 95% UTL	Nonparametric 95% UTL	Background Criteria ^c
<i>Metals (mg/kg)</i>									
Aluminum	7/ 7	1710.00	13900.00	6430.00	4801.00	L	75900.00	13900.00	13900.00
Antimony	0/ 7			0.48	0.18	O		1.50	0.00
Arsenic	7/ 7	3.70	19.50	9.34	5.32	L	54.40	19.50	19.50
Barium	7/ 7	15.20	123.00	62.00	46.05	N	219.00	123.00	123.00
Beryllium	2/ 7	0.15	0.38	0.24	0.12	D		0.64	0.38
Cadmium	0/ 7			0.48	0.18	O		1.50	0.00
Calcium	5/ 7	920.00	5510.00	2320.00	2118.00	L	50300.00	5510.00	5510.00
Chromium	7/ 7	2.60	18.10	8.99	6.19	L	91.50	18.10	18.10
Cobalt	7/ 7	2.10	9.10	5.61	2.84	L	34.20	9.10	9.10
Copper	7/ 7	2.50	27.60	12.40	9.27	L	198.00	27.60	27.60
Cyanide	0/ 7			0.48	0.18	O		1.50	0.00
Iron	7/ 7	5170.00	28200.00	15500.00	9329.00	L	123000.00	28200.00	28200.00
Lead	7/ 7	3.40	27.40	13.00	9.13	N	44.00	27.40	27.40
Magnesium	7/ 7	434.00	2760.00	1450.00	854.4	L	11200.00	2760.00	2760.00
Manganese	7/ 7	154.00	1950.00	694.00	636.3	L	12100.00	1950.00	1950.00
Mercury	2/ 7	0.04	0.06	0.07	0.03	D		0.28	0.06
Nickel	5/ 7	4.00	17.70	9.00	5.48	L	68.20	17.70	17.70
Potassium	7/ 7	195.00	1950.00	745.00	607.2	L	8070.00	1950.00	1950.00
Selenium	1/ 7	1.70	1.70	0.62	0.50	D		1.70	1.70
Silver	0/ 7			0.96	0.37	O		3.00	0.00
Sodium	4/ 7	22.40	112.00	56.80	34.01	L	923.00	174.00	112.00
Thallium	1/ 7	0.89	0.89	0.56	0.23	D		1.50	0.89
Vanadium	7/ 7	3.30	26.10	12.50	8.85	L	139.00	26.10	26.10
Zinc	7/ 7	16.20	532.00	123.00	183.06	L	3090.00	532.00	532.00
<i>SVOCs (µg/kg)</i>									
Benzo(a)anthracene	2/ 6	73.00	100.00	256.00	178.7	D		980.00	NA
Benzo(b)fluoranthene	1/ 6	120.00	120.00	303.00	150.69	D		980.00	NA
Chrysene	1/ 6	95.00	95.00	298.00	156.96	D		980.00	NA
Fluoranthene	4/ 6	47.00	190.00	194.00	144.63	L	10000.00	920.00	NA
Pyrene	3/ 6	86.00	170.00	206.00	133.89	L	7340.00	920.00	NA

Table 3-3 (continued)

Analyte	Results > Detection Limit	Minimum Detect	Maximum Detect	Average Result ^a	Std. Dev. ^a	Distr. ^b	Parametric 95% UTL	Nonparametric 95% UTL	Background Criteria ^c
<i>VOCs (µg/kg)</i>									
Acetone	1/ 3	540.00	540.00	184.00	308.16	D		540.00	NA
Chloromethane	1/ 3	3.00	3.00	5.17	1.89	D		13.00	NA
Toluene	1/ 3	1.10	1.10	2.45	1.18	D		6.50	NA

^aResults less than the detection limit were set to one-half the reported detection limit.

^bDist. Codes: L = Distribution most similar to lognormal.
N = Distribution most similar to normal.
X = Distribution significantly different from normal and lognormal.
D = Non-parametric distribution – frequency of detection <50%.
0 = Zero detects – background criteria set to 0.00.

^cIf 95% UTL >max. detect then background criteria = max. detect.

If distribution determined not normal or lognormal or fewer than 3 samples then background criteria = max. detect.

Background criteria were set to zero if there were no detects.

NA - Not applicable. Background criteria were determined for metals only.

Table 3-4. Surface Water Facility-wide Background Criteria

Analyte	Results > Detection Limit	Minimum Detect	Maximum Detect	Average ^a Result	Std. Dev. ^a	Distr. ^b	Parametric 95% UTL	Nonparametric 95% UTL	Background Criteria ^c
<i>Metals (µg/L)</i>									
Aluminum	5/ 6	661.00	3370.00	1450.00	1138.00	N	5670.00	3370.00	3370.00
Antimony	0/ 7			2.50	0.0	O		5.00	0.00
Arsenic	1/ 7	3.20	3.20	2.70	0.42	D		6.80	3.20
Barium	7/ 7	12.50	47.50	28.50	10.69	N	64.90	47.50	47.50
Beryllium	0/ 7			2.00	0.0	O		4.00	0.00
Cadmium	0/ 7			2.50	0.0	O		5.00	0.00
Calcium	7/ 7	13500.00	41400.00	23100.00	10554.00	L	92700.00	41400.00	41400.00
Chromium	0/ 7			5.00	0.0	O		10.00	0.00
Cobalt	0/ 7			25.00	0.0	O		50.00	0.00
Copper	4/ 7	3.50	7.90	5.94	3.56	L	62.40	25.00	7.90
Cyanide	0/ 7			0.01	0.0	O		0.01	0.00
Iron	7/ 7	440.00	2560.00	1370.00	715.4	L	8420.00	2560.00	2560.00
Lead	0/ 7			1.50	0.0	O		3.00	0.00
Magnesium	7/ 7	3240.00	10800.00	5520.00	2704.00	L	22300.00	10800.00	10800.00
Manganese	7/ 7	33.60	391.00	153.00	125.3	L	1820.00	391.00	391.00
Mercury	0/ 7			0.10	0.0	O		0.20	0.00
Nickel	0/ 7			20.00	0.0	O		40.00	0.00
Potassium	7/ 7	519.00	3170.00	1670.00	797.7	N	4390.00	3170.00	3170.00
Selenium	0/ 7			2.50	0.0	O		5.00	0.00
Silver	0/ 7			5.00	0.0	O		10.00	0.00
Sodium	6/ 7	4770.00	21300.00	11500.00	8285.00	N	39600.00	21300.00	21300.00
Thallium	0/ 7			0.93	0.0	O		2.00	0.00
Vanadium	0/ 7			25.00	0.0	O		50.00	0.00
Zinc	4/ 7	14.60	42.00	17.40	11.73	X		42.00	42.00

^aResults less than the detection limit were set to one-half the reported detection limit.

^bDist. Codes: L = Distribution most similar to lognormal.
 N = Distribution most similar to normal.
 X = Distribution significantly different from normal and lognormal.
 D = Non-parametric distribution – frequency of detection <50%.
 0 = Zero detects – background criteria set to 0.00.

^cIf 95% UTL >max. detect then background criteria = max. detect.

If distribution determined not normal or lognormal or fewer than 3 results then background criteria = max. detect.
 Background criteria were set to zero if there were no detects.

Table 3-5. Summary Statistics for Facility-wide Bedrock Zone Unfiltered Groundwater in Background Wells

Analyte	Results > Detection Limit	Minimum Detect	Maximum Detect	Average Result ^a	Std. Dev. ^a	Dist. ^b	Parametric 95% UTL	Nonparametric 95% UTL	Background Criteria ^c
<i>Metals (µg/L)</i>									
Aluminum	7/ 7	1100.00	9410.00	3370.00	2824	L	28400.00	9410.00	9410.00
Antimony	0/ 7			2.50	0.0	O		5.00	0.00
Arsenic	1/ 7	19.10	19.10	4.81	6.31	D		19.10	19.10
Barium	5/ 7	35.10	241.00	98.00	94.5	L	2580.00	241.00	241.00
Beryllium	0/ 7			1.78	0.59	O		4.00	0.00
Cadmium	0/ 7			2.50	0.0	O		5.00	0.00
Calcium	7/ 7	12600.00	48200.00	31900.00	12887	N	75700.00	48200.00	48200.00
Chromium	2/ 7	7.90	19.50	7.49	5.41	D		19.50	19.50
Cobalt	0/ 7			25.00	0.0	O		50.00	0.00
Copper	4/ 7	7.50	17.00	8.75	5.62	L	40.30	17.00	17.00
Cyanide (mg/L)	0/ 7			0.01	0.0	O		0.01	0.00
Iron	7/ 7	2150.00	21500.00	6730.00	6697	L	65200.00	21500.00	21500.00
Lead	4/ 7	2.20	23.00	5.97	7.84	L	72.60	23.00	23.00
Magnesium	7/ 7	3930.00	13700.00	11000.00	3385	X		13700.00	13700.00
Manganese	7/ 7	51.00	1260.00	372.00	424	L	8850.00	1260.00	1260.00
Mercury	0/ 7			0.10	0.0	O		0.20	0.00
Nickel	3/ 7	22.40	85.30	30.20	24.35	D		85.30	85.30
Potassium	7/ 7	1230.00	6060.00	3070.00	1723	L	20200.00	6060.00	6060.00
Selenium	0/ 7			2.50	0.0	O		5.00	0.00
Silver	0/ 7			5.00	0.0	O		10.00	0.00
Sodium	6/ 7	4850.00	49700.00	15700.00	15940	L	232000.00	49700.00	49700.00
Thallium	0/ 7			0.89	0.20	O		2.00	0.00
Vanadium	2/ 7	7.70	15.50	21.20	6.92	D		50.00	15.50
Zinc	2/ 7	72.80	193.00	63.50	60.02	D		193.00	193.00

^aResults less than the detection limit were set to one-half the reported detection limit.

^bDist. Codes: L = Distribution most similar to lognormal.
N = Distribution most similar to normal.
X = Distribution significantly different from normal and lognormal.
D = Non-parametric distribution – frequency of detection <50%.
0 = Zero detects – background criteria set to 0.00.

^cIf the 95% UTL >max. detect then background criteria = max. detect.

If distribution determined not normal or lognormal or fewer than 3 results then background criteria = max. detect.

Background criteria was not set to zero if there were no detects.

Table 3-6. Summary Statistics for Facility-wide Bedrock Zone Filtered Groundwater in Background Wells

Analyte	Results > Detection Limit	Minimum Detect	Maximum Detect	Average Result ^a	Std. Dev. ^a	Distr. ^b	Parametric 95% UTL	Nonparametric 95% UTL	Background Criteria ^c
<i>Metals (µg/L)</i>									
Antimony	0/ 7			2.50	0.0	O		5.00	0.00
Arsenic	0/ 7			2.50	0.0	O		5.00	0.00
Barium	5/ 7	5.80	256.00	80.20	100	L	6560.00	256.00	256.00
Beryllium	0/ 7			2.00	0.0	O		4.00	0.00
Cadmium	0/ 7			2.50	0.0	O		5.00	0.00
Calcium	7/ 7	12700.00	53100.00	33500.00	14531	N	82900.00	53100.00	53100.00
Chromium	0/ 7			5.00	0.0	O		10.00	0.00
Cobalt	0/ 7			25.00	0.0	O		50.00	0.00
Copper	0/ 5			12.50	0.0	O		25.00	0.00
Cyanide (mg/L)	0/ 6			0.01	0.0	O		0.01	0.00
Iron	2/ 7	152.00	1430.00	261.00	517	D		1430.00	1430.00
Lead	0/ 7			1.50	0.0	O		3.00	0.00
Magnesium	7/ 7	3630.00	15000.00	11100.00	4303	N	25800.00	15000.00	15000.00
Manganese	6/ 7	21.20	1340.00	293.00	490	L	34100.00	1340.00	1340.00
Mercury	0/ 7			0.10	0.0	O		0.20	0.00
Nickel	1/ 7	83.40	83.40	29.10	24.0	D		83.40	83.40
Potassium	7/ 7	609.00	5770.00	2350.00	1932	L	32800.00	5770.00	5770.00
Selenium	0/ 7			2.50	0.0	O		5.00	0.00
Silver	0/ 7			5.00	0.0	O		10.00	0.00
Sodium	6/ 7	4480.00	51400.00	15500.00	16861	L	359000.00	51400.00	51400.00
Thallium	0/ 7			0.94	0.17	O		2.00	0.00
Vanadium	0/ 7			25.00	0.0	O		50.00	0.00
Zinc	2/ 7	46.80	52.30	31.20	15.22	D		74.70	52.30

^aResults less than the detection limit were set to one-half the reported detection limit.

^bDist. Codes: L = Distribution most similar to lognormal.
N = Distribution most similar to normal.
X = Distribution significantly different from normal and lognormal.
D = Non-parametric distribution – frequency of detection <50%.
0 = Zero detects – background criteria set to 0.00.

^cIf 95% UTL > max. detect then background criteria = max. detect.

If distribution determined not normal or lognormal or fewer than 3 results then background criteria = max. detect.

Background criteria was set to zero if there were no detects.

- Chemicals that are considered essential nutrients (calcium, chloride, iodine, iron, magnesium, potassium, phosphorus, and sodium) will not be evaluated as AOC-related unless grossly elevated relative to background. These chemicals are an integral part of the human food supply and are often added to foods as supplements; thus, these constituents are not generally addressed as contaminants (EPA 1989; EPA 1995). Data on essential elements, however, will be used to evaluate the subsurface geochemistry. Should risk assessment be required for essential nutrients, methods identified in *Risk Assessment Handbook, Vol. 1, Human Health Evaluation*, EM-200-1-4 (USACE 1999c) will be applied.

3.4 HUMAN HEALTH RISK ASSESSMENT

Using the results of the Phase II RI sampling at Load Line 1, a baseline human health risk assessment (HHRA) will be performed. The purpose of the risk assessment is to define the potential health risks associated with various current and future uses of the land at Load Line 1. The risk assessment will be performed in accordance with methods presented in the *Risk Assessment Guidance for Superfund*,

Volume I: Human Health Evaluation Manual, (Part A) (RAGS) (EPA 1989). Additional methodology will be taken from:

Dermal Exposure Assessment: Principles and Applications (EPA 1992);
Human Health Evaluation Manual, Supplemental Guidance “Standard Default Exposure Factors” (EPA 1991);
Exposure Factors Handbook (EPA 1989);
U.S. EPA Integrated Risk Information System (EPA 1997a); and
Health Effects Summary Tables (EPA 1997b).

The process used to accomplish the objectives of this risk assessment are:

- identify all COPCs at the site,
- conduct an exposure assessment for site-related COPCs,
- assess the toxicity of site-related COPCs,
- quantify risks to human health, and
- identify health-based remediation cleanup goals.

3.4.1 Selection of Chemicals of Potential Concern

The first step in the risk process involves identifying the COPCs. This step involves:

- screening data against available background data,
- screening data against risk-based screening levels, and
- evaluating remaining chemicals using various additional screens, as defined below.

Only validated data will be used for the assessment. Data flagged with an “R” qualifier during the analytical validation process will be evaluated for their usability. “Unusable” data will be excluded from the data set. The major data quality issue during Phase I RI stemmed from the need to dilute samples for explosives analysis because of the high concentrations of TNT in the samples. As the samples were diluted (generally 10 or 100 times) in order to be able to quantify results, the detection limit increased, generally on the same order as the dilution. The dilutions resulted in unacceptable detection limits for several analytes, primarily DNT. Several of the elevated detection limits exceed the risk-based screening criteria. In this situation, it is impossible to determine whether the analyte is present in the sample at levels above or below the risk-based screening values. Thus the results can not be used to determine if action is necessary to address that analyte, and the results will be excluded from risk estimates, and essential nutrient criteria.

The first step of the process is to screen results against frequency-of-detection criteria, naturally occurring, or “background” concentrations, and essential nutrient criteria. Chemicals detected at levels below background concentrations will not be considered COPCs. The data screening process is described in detail in Section 3.3.

The second step of the process is to screen data against the risk-based screening value. These values are very conservative [based on 10^{-7} risk levels and a hazard quotient (HQ) of 0.1]. Chemicals detected below these concentrations are screened from further consideration. The risk-based screening levels will be the most current residential PRGs published by EPA Region 9.

Once all screens have been performed, a list of COPCs will be developed for each data aggregate. The COPCs will be further evaluated in the remaining steps of the baseline risk assessment (BRA).

3.4.2 Exposure Assessment

This section describes the exposure setting, develops information on exposure pathways, estimates the contaminant concentrations at points of human exposure, and determines receptor intakes.

3.4.2.1 Site Setting

The RVAAP installation is located in two counties of northeastern Ohio, Portage County and Trumbull County, with a majority of the facility lying in Portage County. According to the 1990 Census, the total population of Portage and Trumbull counties was 142,585 and 227,813, respectively. The largest population centers in the area are the town of Ravenna (population 12,069), located approximately 2 miles to the west, and Newton Falls (population 4866), located approximately 1 mile to the southeast.

Land use within the facility is restricted access industrial. At the present time the RVAAP is an inactive facility maintained by a contracted caretaker, Tol-Test, Inc. Site workers infrequently visit the AOCs for maintenance purposes, e.g., mowing. The Ohio National Guard (ONG) also occupies parts of RVAAP and conducts training exercises. Personnel from the ONG may occasionally travel through AOCs at RVAAP but generally restrict training to areas outside of AOCs. No training exercises are known to be conducted within Load Line 1. The land use immediately surrounding the facility is primarily rural. Approximately 55 percent of Portage County is either woodland or farmland (Portage County Soil and Water Conservation District Resources Inventory 1985; Census Bureau 1992). To the south of the facility is the Michael J. Kirwan Reservoir, which serves as a potable water source and is used for recreational purposes. The Reservoir is south of the site, across State Route 5. The Reservoir is fed by the West Branch of the Mahoning River, which flows south along the western edge of the installation. Hinkley Creek flows south across the western portion of the facility and eventually flows into the West Branch of the Mahoning River. The major surface drainages at RVAAP, Sand Creek and the South Fork of Eagle Creek, exit the facility property and eventually flow east to the Mahoning River.

Residential groundwater use occurs outside of the facility, with most of the residential wells tapping into either the Sharon Conglomerate or the surficial unconsolidated aquifer. Groundwater from on-site production wells was used during operations at the facility (USACE 1996b); however, all but two production wells have been abandoned at the facility. These wells, located in the central portion of the facility, provide sanitary water to the facility. The Sharon Conglomerate is the major producing aquifer at the facility. The chemicals detected in the soil at Load Line 1 during Phase I are generally explosives and metals and, therefore, are relatively immobile in groundwater. In addition, groundwater sampling of selected residential wells adjacent to RVAAP conducted by the Ohio EPA during 1997 found no indications of explosives in groundwater at the locations sampled.

Currently surface water is primarily used by only wildlife. Based on conversations with site personnel, it is likely that some recreational trespasser use of surface water occurs on a limited basis in portions of RVAAP outside Load Line 1, primarily associated with fishing. It is unlikely that any fishing occurs near Load Line 1 since the drainages at the site are small and intermittent.

Future uses of the site are currently being determined; potential future uses include:

- continued storage of bulk explosives short term (<5 years);
- continued use of certain areas for training purposes by the ONG;

- expanded training and occupancy by the ONG to encompass the entire facility (long term) >5 years; and
- recreational use, e.g., hunting, fishing, hiking.

3.4.2.2 Selected Exposure Pathways

A complete exposure pathway consists of the following four elements: (1) a source and mechanism of contaminant release to the environment; (2) an environmental transport mechanism (fate and transport) for the released contaminants; (3) a point of human contact with the contaminated media (exposure point); and (4) a route of entry of the contaminant into the human receptor (exposure route) at the exposure point. An integration of sources and releases, fate and transport mechanisms, exposure points, and exposure routes is evaluated for complete exposure pathways.

Based on ongoing activities at RVAAP, current human receptors include:

- maintenance workers/Security Guard;
- military personnel, specifically ONG Training personnel; and
- recreational users (e.g., hunters, trespassers).

Future potential receptors include all of the above plus

- industrial workers and
- resident farmers.

Table 3-7 indicates potential pathways associated with each of the receptors. The National Guard receptor is assumed to conduct activities that result in contact with subsurface, as well as surface, soil. This receptor is also assumed to use groundwater as a potable water supply. Because incidental contact with groundwater while digging will result in much less exposure than potable use, only potable use is included in this scenario. A complete summary of exposure parameters and models proposed for use in the risk assessment are presented in Appendix C.

3.4.2.3 Exposure Point Concentration

The exposure point concentration is regarded as a reasonable maximum average concentration in an environmental medium that a receptor will encounter over the exposure period. The Load Line 1 risk assessment will evaluate the reasonable maximum exposure (RME). The RME is an estimate of the highest exposure reasonably expected to occur at a site. Because of the uncertainty associated with any estimate of exposure concentration, the UCL₉₅ for either a normal or lognormal distribution is the recommended statistic (EPA 1992b). A UCL₉₅ for surface soil and for the combined surface and subsurface soil data will be used to represent the exposure point concentrations for receptors at Load Line 1. In cases where the UCL₉₅ exceeds the maximum detected concentration, the maximum concentration will be used as an estimate of the RME. Table 3-1 summarizes the exposure point concentrations used to estimate exposure at the site.

3.4.2.4 Quantification of Exposure

For estimating exposures at Load Line 1, typical exposure models and parameter values from RAGS and from other regulatory guidance documents will be used. Parameter values include exposure frequencies,

Table 3-7. Conceptual Exposure Model for Load Line 1 at RVAAP

Pathway	Modified Caretaker – Managed Recreational			National Guard – Managed Recreational			Open Recreational	Open Industrial	Open Residential ^a	
	Security Guard (1)	Hunter/ Trapper (2)	Trespasser (3)	National Guard (4)	Hunter/ Trapper (2)	Trespasser (3)	Recreator (5)	Industrial Worker (6)	Resident Farmer – Adult (7)	Resident Farmer – Child (8)
<i>Surface Soil</i>										
Incidental soil Ingestion	●	●	●	●	●	●	●	●	●	●
Dermal contact with soil	●	●	●	●	●	●	●	●	●	
Inhalation of VOCs and dust	●	●	●	●	●	●	●	●	●	
<i>Subsurface Soil</i>										
Incidental sediment Ingestion				●				●	●	●
Dermal contact with sediment				●				●	●	
Inhalation of VOCs and dust				●				●	●	
<i>Sediment</i>										
Incidental soil Ingestion		●	●	●	●	●	●		●	●
Dermal contact with soil		●	●	●	●	●	●		●	
Inhalation of VOCs and dust		●	●	●	●	●	●		●	
<i>Surface Water</i>										
Incidental ingestion while swimming		●	●	●	●	●	●		●	
Dermal contact while swimming		●	●	●	●	●	●		●	
Inhalation of VOCs		●	●	●	●	●	●		●	
<i>Groundwater</i>										
Ingestion				●					●	
Dermal contact				●					●	
Inhalation of VOCs				●					●	
<i>Foodstuff</i>										
Ingestion of venison, game		●			●				●	
Ingestion of beef, pork									●	
Ingestion of milk products									●	●
Ingestion of vegetables									●	
Ingestion of fish		●			●				●	

^aA conservative approach is taken to evaluate the open residential land use. In most cases, since the adult farmer produces larger risks and hazards than the child farmer, the adult is predominantly evaluated. In scenarios where the child receptor results in greater exposures than the adult receptor, the child is also evaluated. Consequently, the noncarcinogenic effects for a child and adult are evaluated for soil/sediment ingestion, as well as for the ingestion of milk products (the child ingestion rates are higher than the adult ingestion rates for these exposures). The carcinogenic effects for these exposures are evaluated using a weighted average of the child and adult parameter values (which results in a larger exposure than evaluating only the adult).

exposure times, and exposure durations, as well as chemical-specific values to describe chemical partitioning and uptake. Some site-specific parameters will be used, primarily associated with ONG training personnel and for recreational users. Parameter values for use in the risk assessment are provided in Table C-1 in Appendix C.

The most likely pathways that will be quantified for exposures to contaminants at Load Line 1 are soil ingestion, dermal contact with soil, and inhalation of soil particles. For the future resident farmer, ingestion of foodstuff will also be addressed. For the industrial worker, only partial ingestion exposure to groundwater will be included. Additional pathways may be quantified as needed (e.g., inhalation of volatiles) but are not discussed below. The methodology used to estimate intakes is provided in Appendix C. Summaries of these equations are provided below. Intakes from ingestion are:

$$\text{Chemical Intake (mg/kg - d)} = \frac{C \times IR \times CF \times EF \times ED}{BW \times AT},$$

where:

- C = chemical concentration in environmental media (mg/kg; mg/L),
- IR = ingestion rate (mg/d; L/d),
- CF = conversion factor (10^{-6} kg/mg - soils only),
- EF = exposure frequency (days/year),
- ED = exposure duration (years),
- BW = body weight (kg),
- AT = averaging time (carcinogens: 25,550 days; noncarcinogens: ED × 365 days).

The absorbed dose from dermal contact with soil is calculated using the method presented in the EPA Dermal guidance (1992) as follows:

$$\text{Chemical DAD (mg/kg - d)} = \frac{C_s \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT},$$

where:

- DAD = dermally absorbed dose,
- C_s = chemical concentration in soil (mg/kg),
- CF = conversion factor (10^{-6} kg/mg),
- SA = skin surface area exposed to soil (cm^2/day),
- AF = soil to skin adherence factor (mg/cm^2),
- ABS = absorption factor (chemical-specific),
- EF = exposure frequency (days/year),
- ED = exposure duration (years),
- BW = body weight (kg),
- AT = averaging time (carcinogens: 25,550 days; noncarcinogens: ED × 365 days).

The **contaminant concentration as particulated dust** is calculated using a dust loading factor based on typical site activity by the following equation (DOE 1989):

$$C_d = C_s \times K,$$

where:

- C_d = concentration in dust (mg/m^3),
 C_s = concentration in soil (mg/kg),
 K = dust loading factor (kg of soil/ m^3 of air).

The **intake for inhalation of soil particulates** was calculated as follows:

$$\text{Chemical Intake (mg/kg-d)} = \frac{C_d - IR - ET - EF - ED}{BW - AT},$$

where:

- C_d = contaminant concentration in air (mg/m^3),
 IR = inhalation rate (m^3/hr),
 ET = exposure time (hr/day),
 EF = exposure frequency (days/year),
 ED = exposure duration (years),
 BW = body weight (kg),
 AT = averaging time (25,550 days for carcinogens, $ED \times 365$ days for noncarcinogens).

Evaluation of ingestion of foodstuff will be based on modified equations presented in Baes et al. (1984).

3.4.3 Toxicity Assessment

The toxicity assessment will be performed using standard EPA-derived toxicity factors. Toxicity factors have not been developed for several explosives derivatives. In these cases, EPA, and U.S. Army toxicologists will be consulted. The two primary toxicity factors used in the risk assessment include the cancer slope factor (CSF) and the reference dose (RfD). The CSF is defined as a plausible upper-bound estimate of the probability of a response (e.g., cancer) per unit intake of a chemical over a lifetime (EPA 1989). Slope factors are specific for each contaminant and route of exposure. The potential for noncarcinogenic health effects resulting from exposure to chemicals is assessed by comparing an intake or dose to a RfD. The chronic RfD is defined as an estimate of daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime (EPA 1989). An RfD is also specific to a chemical and route of exposure.

Oral and inhalation CSF and RfDs are currently available. The inhalation values take into consideration a fractional amount of chemical absorbed by the mucus membranes into the blood. The oral values take into consideration a fractional amount of contaminant absorbed across the gastrointestinal (gi) tract into the bloodstream when estimating toxic doses. Dermal CSFs and RfDs will be estimated from the oral toxicity values using chemical-specific gut absorption factors to calculate the total absorbed dose by the following equations (EPA 1992b):

$$\begin{aligned}
 RfD_{\text{dermal}} &= RfD_{\text{oral}} - ABS_{\text{gi}}, \\
 CSF_{\text{dermal}} &= CSF_{\text{oral}} / ABS_{\text{gi}},
 \end{aligned}$$

where:

- CSF = chemical-specific cancer slope factors (mg/kg-day)⁻¹,
- RfD = chemical-specific reference doses (mg/kg-day),
- ABS_{gi} = chemical-specific gut absorption factor (unitless).

Gut absorption factors provided by USACE (2000b) will be used to estimate dermal toxicity values.

3.4.4 Risk Characterization

Risk characterization integrates the findings of the exposure assessment to estimate the likelihood that receptors experience adverse effects as a result of exposure to COPCs (EPA 1991). Risks will be calculated from toxicity information and the results of the exposure assessment. For carcinogens, incremental lifetime cancer risks (ILCRs), or the increased lifetime probability of cancer, will be calculated. These ILCRs represent the increase chance above the background of contracting cancer. In the United States, the background chance is approximately 3 chances in 10, or 3×10^{-1} (American Cancer Society 1990). The resulting ILCRs are compared to the range specified in the National Contingency Plan (NCP) (EPA 1990) of 10^{-6} to 10^{-4} , or 1 in 1 million to 1 in 10,000 persons developing cancer. ILCRs below 10^{-6} are considered negligible. ILCRs above 10^{-4} , are considered unacceptable risks. For risks between 10^{-6} and 10^{-4} any decisions to address the risk further either through further study or engineered control measures should carefully weight the risk benefit and cost impact of the action. Risk results will be presented for the total concentration of inorganic COPCs detected at the site and background concentrations of inorganic COPCs.

The risk of developing cancer will be estimated as follows (EPA 1989):

$$ILCR = I \times CSF$$

where:

- ILCR = Incremental Lifetime Cancer Risk (unitless probability),
- I = chronic daily intake or dermally absorbed dose from exposure assessment (mg/kg-day or pCi),
- CSF = Cancer Slope Factor (mg/kg-day)⁻¹.

For a given pathway, with simultaneous exposure of a receptor to several carcinogens, the total risk to a receptor is estimated as the sum of the ILCRs for each carcinogen encountered in all sources and each pathway. The equation that will be used to calculate the total ILCR is :

$$ILCR_{total} = \sum ILCR_i$$

where:

- ILCR_{total} = total chance of cancer incidence,
- ILCR_i = ILCR for the ith contaminant.

In addition to developing cancer from exposure to contaminants, an individual may experience toxic effects from exposures to hazardous substances. The term “toxic effects” describes a wide variety of systemic effects, ranging from minor irritations such as eye irritation and headaches to more substantial

effects such as kidney or liver disease and neurological damage. The risks associated with toxic chemicals are evaluated by comparing an exposure level or intake to a reference dose. The reference dose is the threshold level below which no toxic effects are expected to occur in a normal population, including sensitive subpopulations. The ratio of intake over the reference dose is termed the HQ (EPA 1989) and is defined as:

$$HQ = \frac{I}{RfD}$$

where:

HQ = Hazard Quotient (unitless ratio),
 I = daily intake of a contaminant (mg/kg-day),
 RfD = Reference Dose (mg/kg-day).

The HQs for each contaminant are summed to obtain a hazard index (HI). An HI >1 has been defined as the level of concern for potential adverse noncarcinogenic health effects (EPA 1989). This approach is different from the probabilistic approach used to evaluate carcinogens. An HQ of 0.01 does not imply a 1 in 100 chance of an adverse effect, but indicates only that the estimated intake is 100 times less than the threshold level at which adverse health effects may occur. In the case where simultaneous exposure of a receptor to several chemicals occurs, a total HI is calculated as the sum of the individual HQs for all noncarcinogens encountered in all sources for each pathway as follows:

$$HI = \sum HQ_i$$

where:

HI = Total Hazard Index for toxic effects,
 HQ = Hazard Quotient for the ith contaminant.

A total ILCR and a total HQ associated with each media for each receptor will be estimated by summing the pathway-specific values. HQs will be summed where multiple chemicals affect the same organ or affect similar processes, or have similar methods of toxicity.

COCs will be identified as those COPCs that exceed acceptable risk criteria for each receptor and pathway. The COCs will be specific to media and receptor. These chemicals represent the main contributors to human health risks at the site that will need to be addressed during remedial action.

3.4.5 Uncertainty Analysis

There is uncertainty associated with every risk assessment. As part of the risk evaluation for Load Line 1, uncertainties will be identified and addressed wherever possible in order to better understand the risk results. Assumptions built into the risk assessment tend in general to overestimate rather than underestimate potential risks, but occasionally can result in underestimating risk. For example, it is assumed that the toxic and carcinogenic effects of the COCs are additive with respect to pathway and media. This assumption can result in an underestimation of risks due to synergistic toxic effects, or an overestimation of risks due to antagonistic toxic effects. In addition, the typical risk parameters used in the assessment reflect an upper bound for a given population. These conservative assumptions compounded for each parameter, may result in an overestimation of risks to the typical population.

3.4.6 Remedial Goal Options

The Baseline HHRA will develop remedial goal options (RGOs) for COCs that may potentially require remediation. RGOs will only be used if a remedial action is warranted. If necessary, RGOs will be developed using RAGS Part B equations and parameters developed in conjunction with the risk manager during preparation of the Draft Final revision of Phase II RI Report. These values are risk-based criteria that are used in the Feasibility Study to define the extent of contamination in an area that must be remediated to help cost various alternatives. The results of the ecological risk assessment (ERA) as well as land use decisions are also a factor in evaluating remedial alternatives. Stakeholders will work together to determine the best land use/pathway combinations from the risk assessment for developing the RGOs should they be necessary.

3.5 SCREENING ECOLOGICAL RISK ASSESSMENT

The planned ERA at RVAAP will follow the general framework recommended by EPA (1992a, 1997c) and by the U.S. Army (Wentzel et al. 1996). Briefly, this framework consists of four interrelated activities: problem formulation, exposure assessment, effects assessment, and risk characterization. Additional guidance, as provided in the Scope of Work and by the Ohio EPA during finalization of this Work Plan Addendum, will be followed as well.

There are a number of site- or RVAAP-specific matters whose resolution is part of the problem formulation activity. This plan presents how these site-specific matters will be addressed. Current consensus is based on meetings in December 1997, January 1998, and several in 1999 at RVAAP with ecologists and risk assessors from Ohio EPA, USACE, RVAAP, and SAIC. The following subsections describe the process to be employed for the Load Line 1 ERA.

3.5.1 Conceptual Site Model Diagram

The conceptual site model for Load Line 1 describes how receptors present or likely to be present at the site are potentially exposed to contaminants present in one or more source media. The transport and exposure pathways linking contaminated source media and potential ecological receptors are diagrammed in [Figure 3-1](#). Potential routes of exposure to contaminants in potential exposure media (e.g., air, soil, surface water/sediment, and food) are indicated and evaluated for terrestrial and aquatic receptor classes. For example, there are year-round streams inside the boundary of Load Line 1 and sediments are also present as well in dry material in shallow water conveyances. Therefore, exposure is possible to fish and sediment-dwelling organisms inside Load Line 1. Surface water is able to leave Load Line 1 and carry contaminated soil particles to a stream outside Load Line 1. Many terrestrial plants and animals will be exposed to soil as well as food. For example, mammals and birds directly ingest soil, and the soil fraction of diet will be used in the exposure equations. Such fractions as 5 and 10% are typical. The principal source of these data will be the Wildlife Exposures Handbook (EPA 1993). However, this source as well as knowledge of terrestrial top predators' (hawk and fox) diet shows a soil fraction of diet at 0%. Top predators are exposed indirectly from soil via their prey organisms. For each type of receptor, potential exposure routes or pathways are classified as complete or incomplete depending on how likely is exposure by that route. Complete pathways are further classified as being evaluated quantitatively or qualitatively. Quantitatively means the use of numbers for exposure and effects. Qualitatively means the use of words, logic, and technical common sense.

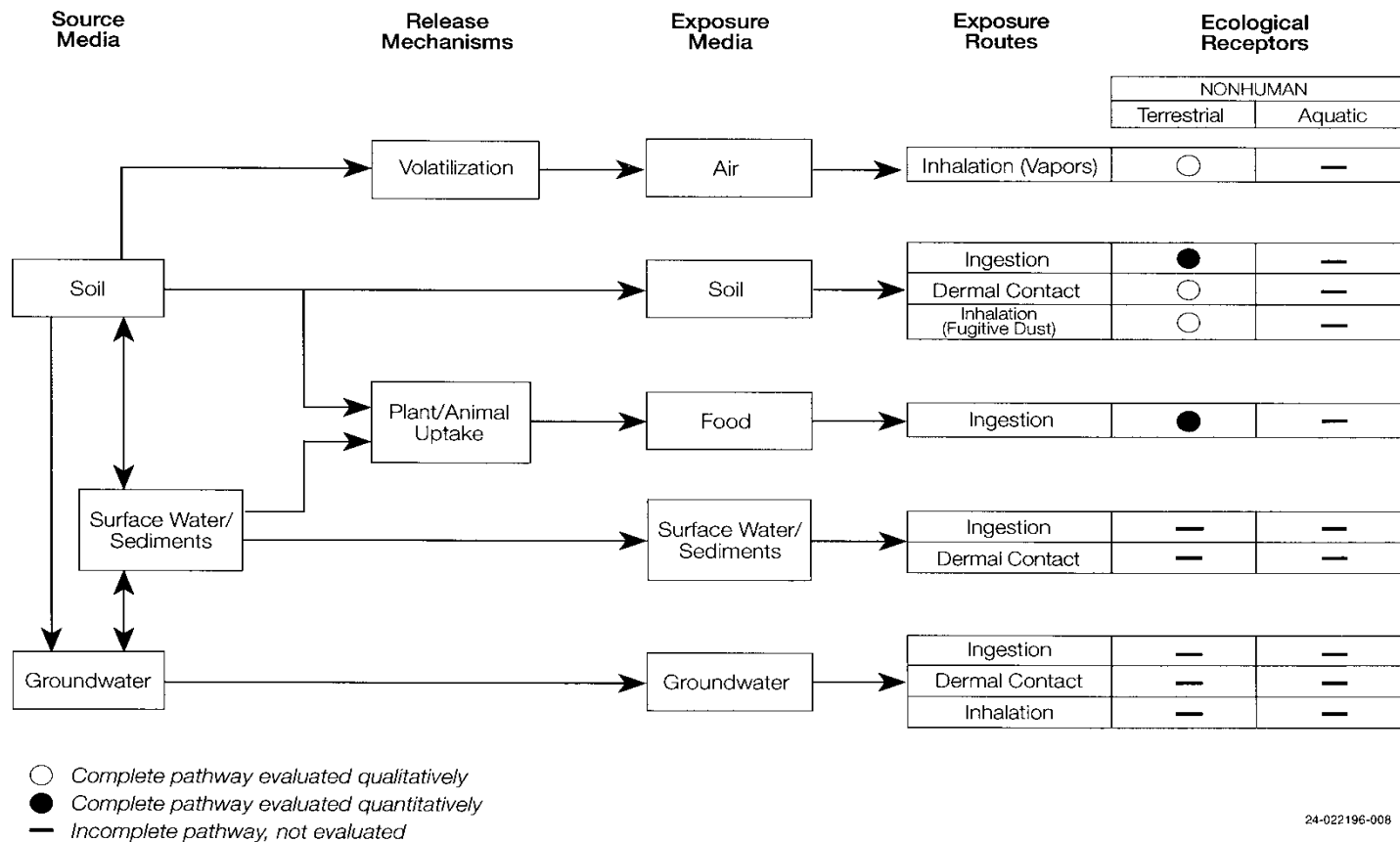


Figure 3-1. Exposure Pathways for Terrestrial and Aquatic Receptors

3.5.2 Selection Criteria for Ecological Receptors

Receptors for the ERA for Load Line 1 were selected based on three criteria specified in *Proposed Guidelines for Ecological Risk Assessment* (EPA 1997c) and previous documents. Receptors were selected according to their ecological relevance, susceptibility to known or potential stressors, and representativeness of management goals (see Table 3-8). Ecological relevance means that the receptor has or represents a role in energy flow (e.g., plants); nutrient cycling (e.g., earthworms); or population regulation (e.g., hawk, owl, and fox). Susceptibility means that the receptor is known to be sensitive to chemicals (e.g., rabbits) and/or exposure because food preference is high (e.g., shrews). Management goals mean the sustaining of ecosystems and ecological processes while maintaining the central mission of RVAAP, which is to store bulk explosives and inert materials. The large tracts of natural land, needed as safety buffers, provide the natural resource base to be managed. Such management goals as the following support the mission and natural resource management plan: erosion control through vegetation, population management through hunting of such animals as deer, and protection of rare, threatened and endangered species such as the barn owl.

Table 3-8. Reasons for Selecting Receptors for Ecological Risk Assessment at LL1

Receptor	Selection Criteria (USEPA 1996)		
	Criterion 1 Ecological Relevance	Criterion 2 Susceptibility	Criterion 3 Represents Management Goals ^a
Plants (<i>various species</i>)	+++	+	+++
Earthworms (<i>various species</i>)	++	+	+
Short-tailed shrew (<i>Blarina brevicauda</i>)	+	++	+
American robin (<i>Turdus migratorius</i>)	+	++	+
Meadow vole (<i>Micotus pennsylvanicus</i>)	++	++	++
White-tailed deer (<i>Odocoileus virginianus</i>)	+	+	+++
Eastern cottontail (<i>Sylvilagus floridanus</i>)	+	++	+
Red-tailed hawk (<i>Buteo jamaicensis</i>)	++	+	++
Barn owl (<i>Tyto alba</i>) endangered species	+	+	+++
Red fox (<i>Vulpes vulpes</i>)	++	+	+

^a Includes protection of T&E or other special status species.

+++ = receptor very strongly meets criterion; ++ = receptor strongly meets criterion; and + = receptor meets criterion.

The selected receptors are ecologically relevant because they represent important elements of the ecosystems at RVAAP, contributing to the structure, function, and biodiversity. These receptors interact as resources and consumers, forming a food web through which both nutrients and contaminants move through the ecosystem. Due to their range of habitats, body sizes, diets, life spans, reproductive rates, home ranges and taxonomic relationships, these receptors represent a range of potential susceptibilities to contaminants at Load Line 1. All of these receptors are potentially exposed to contaminants at Load Line 1 because they are present or likely occur there, and they ingest or live in direct contact with contaminated media. The selected receptors are judged to be consistent with general management goals of protecting the environment, including threatened and endangered (T&E) or other species with special status. Regarding T&E species, other species of federal and state interest have been identified (ODNR 1993). For example, the Indiana bat (*Myotis sodalis*) was captured on the RVAAP installation. These T&E species will be handled qualitatively, and the barn owl will be handled quantitatively in the ERA.

3.5.3 Terrestrial Food Web for Ecological Receptors

Figure 3-2 provides ingestion pathways for a variety of receptors in the terrestrial food web. Note that there are fewer receptors than really exist at RVAAP. The planned ERA is a screening level evaluation. As such, it is satisfactory to deal with representatives of groups of organisms (e.g., shrew and robin for all insectivorous and worm-eating organisms). Assessment and measurement endpoints to this point in the planning or problem formulation activity were developed cooperatively with Ohio EPA and the U.S. Army in December 1997 and January 1998.

3.5.4 Assessment Endpoints, Measurements, and Decision Rules

Table 3-9 emphasizes the relationships among policy goals, assessment endpoints, measurement endpoints, and the decisions relative to HQs. Each type of receptor has separate assessment endpoints, measurement endpoints, and decision criteria. An assessment endpoint is defined by EPA (EPA 1992b) as “an explicit expression of the environmental value that is to be protected.” A measurement endpoint is defined by EPA (EPA 1992b) as “a measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint.” Further explanations about these terms are found in Wentsel (1996) and EPA (1997c).

For each endpoint species or receptor in the food web and Table 3-9, the ERA will provide information on home range, feeding habits, and other characteristics. Table 3-10 shows an example of such information in tabular format for the shrew.

3.5.5 Procedural Assumptions for Exposure, Effects, and Risk Characterization

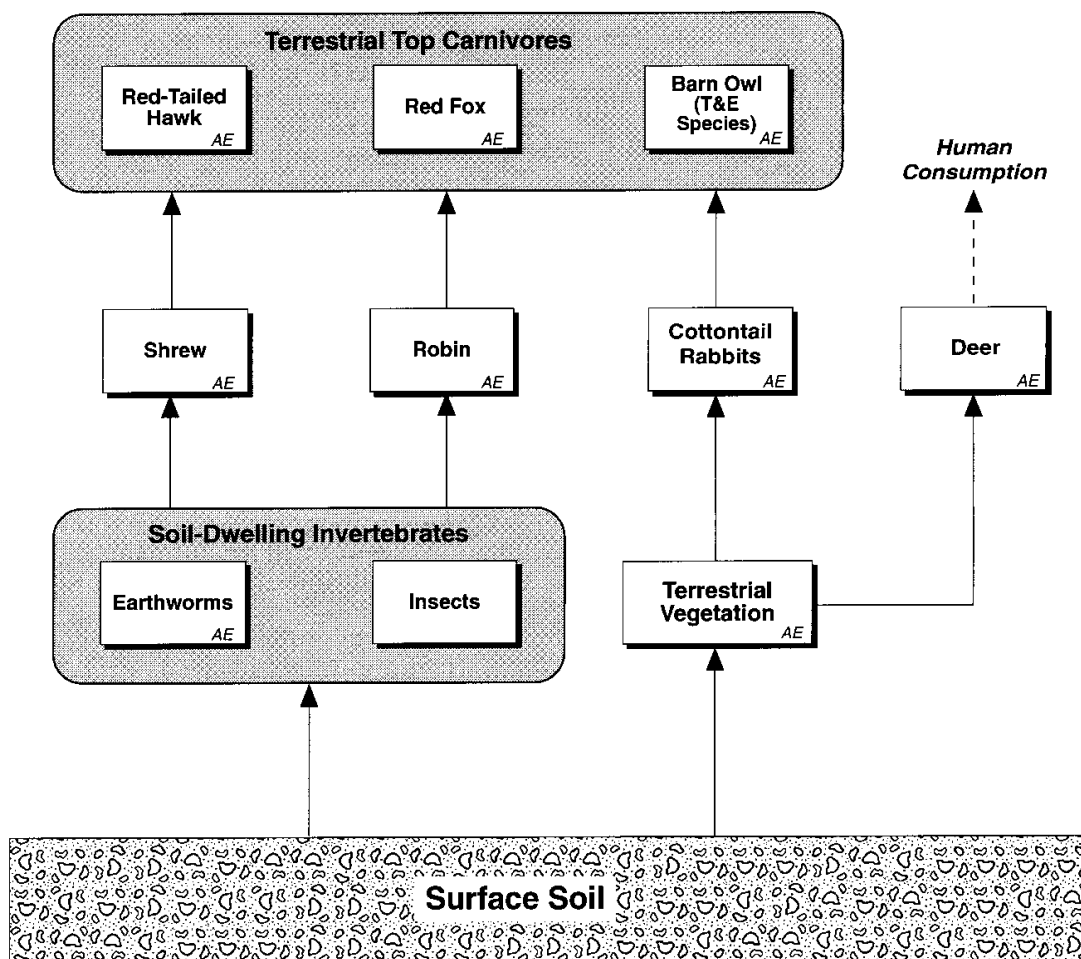
This section provides the important technical assumptions and reference material to be used in the screening ecological risk assessment.

General:

- RME concentrations will be used during the screening risk assessment. The RME is the smaller of the maximum detected concentration and the 95th upper confidence limit on the mean (UCL₉₅). RMEs will be used for soil, sediment, and surface water. When the UCL₉₅ cannot be calculated, the measured maximum concentration will be used. Modeled tissue concentrations based on the RMEs based on measured abiotic media concentrations will be used in food chains.
- The screening of site-wide concentrations was done for soil, sediment, and surface water. The Ohio EPA recommended the following hierarchy to be used for toxicity screening values for the Load Line 1 ERA.

For Soil:

- Efroymson et al. (1997a). *Preliminary Remediation Goals for Ecological Endpoints*. ES/ER/TM-162/R2.
- Efroymson et al. (1997b). *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Processes: 1997 Revision*. ES/ER/TM-126/R2.



AE = assessment endpoint; organisms with no AE in box means they are intermediate in terms of transfers.

Figure 3-2. Food Web at RVAAP for Ecological Risk Assessment

Table 3-9. Policy Goals, Ecological Assessment Endpoints, Measurement Endpoints, and Decision Rules for WBG

Policy Goals	Assessment Endpoint	Measurement Endpoint	Decision Rule
Policy Goal 1: The preservation and conservation of T&E species and their critical habitats.	Assessment Endpoint 1: Preservation of any state- or federally designated, threatened, or endangered species. Endpoint Species: Barn owl	Measurement Endpoint 1: Modeled contaminant concentrations in prey (shrews, robins, and rabbits) based on measured soil concentrations.	Decision Rule for Assessment Endpoint 1: If T&E species are not present, or RME concentrations in the media do not contribute to chronic NOAEL exceedance (i.e., HQs <1), then it is indicated that the contaminant alone is unlikely to cause adverse ecological effects and, therefore, the T&E species should be preserved. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.
Policy Goal 2: The maintenance and protection of terrestrial populations and ecosystems.	Assessment Endpoint 2: Maintenance of plant community for erosion control and energy production. Endpoint Species: plants of various species	Measurement Endpoint 2: Measured soil contaminant concentrations.	Decision Rule for Assessment Endpoint 2: If the HQ is <1, then it is indicated that the contaminant alone is unlikely to cause adverse ecological effects and, therefore, maintain the plant populations and communities. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.
	Assessment Endpoint 3: Maintenance of soil-dwelling invertebrate community for nutrient and energy processing. Endpoint Species: earthworms	Measurement Endpoint 3: Measured soil contaminant concentrations	Decision Rule for Assessment Endpoint 3: If the HQ is <1, then it is indicated that the contaminant alone is unlikely to cause adverse ecological effects and, therefore, maintain the soil invertebrate community. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.

Table 3-9. Policy Goals, Ecological Assessment Endpoints, Measurement Endpoints, and Decision Rules for WBG (continued)

Policy Goals	Assessment Endpoint	Measurement Endpoint	Decision Rule
	<p>Assessment Endpoint 4: Maintenance of populations of herbivorous animals.</p> <p>Endpoint Species: meadow voles, cottontail rabbits and deer</p>	<p>Measurement Endpoint 4: Modeled contaminant concentrations in food chain based on measured soil contaminant concentrations.</p>	<p>Decision Rule for Assessment Endpoint 4: If the HQ is <1, then it is indicated that the contaminant alone is unlikely to cause adverse ecological effects and, therefore, populations of the herbivores, e.g., voles, cottontail rabbits, and deer, are maintained. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.</p>
	<p>Assessment Endpoint 5: Maintenance of worm-eating and/or insectivorous animals.</p> <p>Endpoint Species: mammal - shrew; bird – robin</p>	<p>Measurement Endpoint 5: Modeled contaminant concentrations in earthworms and other prey based on measured soil contaminant concentrations.</p>	<p>Decision Rule for Assessment Endpoint 5: If the HQ is <1, then it is indicated that the contaminant alone is unlikely to cause adverse ecological effects and, therefore, populations of worm-eating and/or insectivorous animals are maintained. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.</p>
	<p>Assessment Endpoint 6: Maintenance of terrestrial predators.</p> <p>Endpoint Species: mammal - red fox; bird - red-tailed hawk</p>	<p>Measurement Endpoint 6: Modeled contaminant concentrations in prey (shrews, robins, and rabbits) based on measured soil contaminant concentrations.</p>	<p>Decision Rule for Assessment Endpoint 6: If the HQ is <1, then it is indicated that the contaminant alone is unlikely to cause adverse ecological effects, and, therefore, populations of terrestrial predators are maintained. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.</p>

Table 3-9. Policy Goals, Ecological Assessment Endpoints, Measurement Endpoints, and Decision Rules for WBG (continued)

Policy Goals	Assessment Endpoint	Measurement Endpoint	Decision Rule
Policy Goal 3: The maintenance and protection of aquatic populations and ecosystems.	Assessment Endpoint 5: Maintenance of sediment-dwelling organisms. Endpoint Species: sediment-dwelling organisms	Measurement Endpoint 5: Measured sediment contaminant concentrations.	Decision Rule for Assessment Endpoint 5: If the HQ is <1, then it is indicated that the contaminant alone is unlikely to cause adverse ecological effects and, therefore, populations of sediment-dwelling organisms are maintained. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.
	Assessment Endpoint 6: Maintenance of aquatic organisms. Endpoint Species: aquatic organisms	Measurement Endpoint 6: Measured surface water contaminant concentrations.	Decision Rule for Assessment Endpoint 6: If the HQ is <1, then it is indicated that the contaminant alone is unlikely to cause adverse ecological effects, and, therefore, populations of aquatic organisms are maintained. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.
	Assessment Endpoint 7: Maintenance of aquatic organism and fish-eating predator population for population regulation. Endpoint Species: raccoon and great blue heron	Measurement Endpoint 7: Measured contaminant concentrations in surface water for raccoon and modeled contaminant concentrations in prey fish based on measured surface water concentrations for the great blue heron..	Decision Rule for Assessment Endpoint 7: If the HQ is <1, then it is indicated that the contaminant alone is unlikely to cause adverse ecological effects, and, therefore, populations of terrestrial predators are maintained. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.

RME = Reasonable maximum exposure.
 T&E = Threatened and endangered.
 NOAEL = No observed adverse effects level.
 HQ = Hazard (risk) quotient.

Table 3-10. Receptor Parameters for Short-tailed Shrew

Parameter	Definition	Receptor: Short-tailed shrew (<i>Blarina brevicauda</i>)	
		Value	Reference / Notes
BW	Body weight (kg)	0.017	Arithmetic mean of means, both sexes, fall and summer, western Pennsylvania (EPA 1993)
HR	Home range (ha)	0.36	Maximum, adult female, summer, Michigan (EPA 1993)
TUF	Temporal use factor	1	Will be 1 unless a specific value exists for a receptor
AUF	Area use factor	1	Will be 1 to maximize exposure
IR _F	Food ingestion rate (g/g-d = kg/kgBW/d) ^a	0.56	Arithmetic mean of adults, both sexes, 25°C, Wisconsin (EPA 1993)
PF	Plant fraction of diet	0.13	June through October, New York (EPA 1993); assuming vegetative parts and fungi
AF	Animal fraction of diet	0.87	June through October, New York (EPA 1993); assuming 100% earthworms
SF	Soil fraction of diet	0.13	Talmage and Walton (1993)
IR _w	Water ingestion rate (g/g-d = L/kgBW/d)	0.223	Adult, both sexes, Illinois, lab (EPA 1993)

^a Food ingestion rate (g/g-d) re-expressed as kg/kgBW/d is assumed not to include ingested soil; therefore, PF+AF = 1.0.

- Efroymsen et al. (1997c). *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision*. ES/ER/TM-85/R3.
- Ecological Data Quality Levels (EDQL), U.S. EPA, Region 5, Final Technical Approach for Developing EDQLs for RCRA Appendix IX Constituents and Other Significant Contaminants of Ecological Concern, April 1998.

For Sediment:

- EPA January 1996. *Ecotox Thresholds. ECO Update*. EPA 40/F-95/038. Refer to Region 5 Guidance on the use of Ecotox Thresholds.
- Persaud et al. 1994. *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario*. Ontario Ministry of the Environment and Energy.
- Ingersoll, C. G., Haverland, P. S., Brunson, E. L., Canfield, T. J., Dwyer, F. J., Henke, C. E., Kemble, N. E., Mount, D. R., Fox, R. G. 1996. Calculation and Evaluation of Sediment Effect Concentrations for the Amphipod *Hyaella azteca* and the Midge *Chironomus riparus*. J. Great Lakes Res 22:602-623.

For Surface Water:

- Ohio Chronic Water Quality Criteria (Ohio Administrative Code Chapter 3745-1 as amended on October 31, 1997).

- National Ambient Water Quality Criteria (40 CFR Part 131, 1992).
- Tier II Chronic Screening Values (Suter and Tsao 1996).
- When the first value is available, it is used, regardless if a lower number exists from another source. When the first listed source has no number, reliance is given the second source and so forth.
- The area use factor will be 1.0 regardless of the size of home range area relative to exposure unit area.
- Exposure or transfer factors will be used extensively. For example, soil to plant uptake factors as well as plant to animal bioaccumulation factors will be used as published in the technical literature. This will provide estimated contaminant concentrations in prey based on measured soil, sediment, and water concentrations at Load Line 1. The primary sources are Baes et al. (1984), Travis and Arms (1988), and ATSDR (various years). A good secondary source is HAZWRAP (1994). When there is no value, the default value will be 1.0 for inorganic chemicals and 1.0 for organic chemicals.
- Bioavailability is assumed to be the same as that in the controlled laboratory/field exposure studies. There will be no adjustments.
- No Observed Adverse Effect Level (NOAEL), especially chronic NOAELs, from controlled laboratory/field exposure studies will be the appropriate toxicological data for toxicity thresholds in the food web modeling of the screening ecological risk assessment. When chronic NOAELs are not available and subchronic NOAELs are available, a conversion factor of 10 will be used to convert sub-chronic to chronic NOAEL. When no NOAEL is available and a Lowest Observed Adverse Effect Level (LOAEL) is available, a conversion factor of 10 will be used to convert a LOAEL to a NOAEL.
- Body weight conversions from the test organism (usually a laboratory organism) to the receptors at RVAAP (usually wildlife) have a technical basis (metabolic) and will be used to adjust toxicity thresholds. Allometric or body-scaling will be done only after all conversions of toxicity values, e.g., LOAEL to NOAELs.
- An HQ >1.0 suggests unacceptable risk or the need for further work.

3.5.6 Next Step

Dialogue among USACE, Army, Ohio EPA, the public, risk assessors, and risk managers will determine what the findings of the screening ecological risk assessment mean. Such professional judgments and discussions need to clarify what to protect and what additional, if any, definitive ecological risk characterization is warranted.

The development of professional judgment criteria can take different approaches. The most likely approach is a weight-of-evidence approach that consists of such principles as:

- temporal association,
- spatial association,
- strength of dose response association, or
- biological plausibility.

These are based on three types of evidence:

- biological and habitat surveys at Ravenna,
- contaminant body burden measurements (if available) at Ravenna, and
- chemical specific toxicity information from the literature.

Note that many of these considerations may be part of a future installation-wide risk assessment protocol and implementation.

4.0 FIELD ACTIVITIES

4.1 GROUNDWATER

4.1.1 Rationale

The Phase II groundwater monitoring wells at Load Line 1 were completed in September 1999. The rationale for the placement of wells for the Phase II RI is explained in Section 4.1.1.1 of the SAP Addendum No. 1 (USACE 1999b). Well placement was designed to maximize the potential to assess shallow groundwater contaminated by leaching and infiltration from the most contaminated soils identified in Phase I. Groundwater samples were collected from the eight newly installed wells and the six Phase I wells (two of which are located downgradient of Load Line 2) in September 1999 as described in the SAP Addendum No. 1.

4.1.1.1 Groundwater sample collection for field and laboratory analysis

Both the eight new wells installed for the Phase II RI and the six existing Phase I RI wells (LL1mw-059, -060, -063, -064, -065, and -067) will be sampled for an additional round of chemical analyses to further characterize contaminant nature and extent (see [Figure 1-3](#)). All monitoring wells will be field screened for VOCs prior to sample collection using a hand-held photoionization detector (PID) organic vapor analyzer (OVA) at the top of the riser pipe. No samples will be collected for additional headspace analysis. Field measurements of pH, conductivity, temperature, and dissolved oxygen concentration will be recorded for each groundwater sample. Water level measurements will be collected immediately prior to groundwater sampling.

Filtered groundwater samples will be collected from each monitoring well and submitted for laboratory analysis of explosives, propellants, TAL metals, and cyanide. Filtering will be performed in the field according to Section 4.3.5 of the Facility-wide SAP. Additional samples will be collected from all wells and analyzed for VOCs, SVOCs, and pesticides/PCBs. [Table 4-1](#) summarizes the number of samples and the types of groundwater analyses to be performed during the Phase II RI. [Table 4-2](#) presents the rationale for sampling at each location. [Tables 5-1](#) through [5-3](#) present specific sample locations (see Chapter 5.0), including Phase I RI locations to be resampled in Phase II.

4.1.1.2 Quality Assurance/Quality Control and blank samples and frequency

Field duplicate QC samples, equipment rinsate blanks, source blanks, and trip blanks will be collected during the Phase II RI as described in the SAP Addendum No. 1 (USACE 1999b). Split samples [quality assurance (QA) samples] will be submitted to USACE's subcontract laboratory (GP Environmental, 202 Perry Parkway, Gaithersburg, MD 20877) for independent analysis.

4.1.2 Documentation

4.1.2.1 Photographs

All photographic documentation will be conducted according to the procedures presented in Section 4.3.2.4.3 of the Facility-Wide SAP.

RVAAAP Load Line 1 Phase II RI – Sampling and Analysis Plan Addendum No. 2

^aThe number of sample stations has been estimated for this SAP Addendum. The actual number of sample locations will be determined in the field, depending on accessibility to all requisite depth intervals, and results of colorimetric analysis of explosives.

Table 4-2. Rationale for sampling at each location

Site Location	No. of Sample Stations	Rationale
<i>Soil Samples (see Figure 4-1)</i>		
Bldg. CB-17	10	Fully characterize nature and extent around building perimeter, dripline, floor drains.
Bldg. CB-14	10	Fully characterize nature and extent around building perimeter, dripline, floor drains
Bldgs. CB-13, -13B	16	Fully characterize nature and extent around building perimeter, dripline, floor drains
Bldg. CB-10 Central LL1; drill and booster	18	Fully characterize nature and extent around building perimeter, dripline, floor drains
Bldg. CA-6	10	Fully characterize nature and extent
Bldg. CB-4 Melt-pour building	18	Fully characterize nature and extent around building perimeter, dripline, floor drains
Bldg. CB-4A Melt-pour building	18	Fully characterize nature and extent around building perimeter, dripline, floor drains
Hill south of Bldg. CB-4A Adjacent to melt-pour building	4	Fully characterize nature and extent near building, dripline, floor drains
Bldg. CB-3A Downgradient of former settling tank	12	Fully characterize nature and extent beneath and around former tank
Bldg. CB-2 Between CB-3 and CB-801; truck maintenance	10	Fully characterize nature and extent around building perimeter, dripline, floor drains
Settling Basin North of Melt-Pour Bldgs.	21	Resample Phase I locations and characterize underlying soils (tank removed)
Bldg. CA-6A	12	Characterize south end of load line
Bldg. CA-6A Ditch	12	Possible accumulation point for explosives
Random grid samples	30	Characterize soil in between areas of known contamination
Water Tower	3	Characterize metals and PCBs from paint stripping at dripline
Floor slab - CB-13	3	Characterize underlying soils where cracks or holes are evident in the floor slabs
Floor slab - CB-10	3	Characterize underlying soils
Floor slab - CB-4	3	
Floor slab - CB-4A	3	Characterize underlying soils
Floor slab - CA-6	2	Characterize underlying soils
Floor slab - CA-6A	2	Characterize underlying soils
Track CB soils	10	Characterize soils for suitability for placement of clean hardfill from demolitions
Scraped soil piles from Change House demo	3	Characterize the soils for disposal
Sites East of CA-6	3	Resample Phase I surface soil location
TOTAL SOIL LOCATIONS	236	
<i>Sediment Samples (see Figures 4-2, 4-3, and 4-4)</i>		
Ditch	1	Possible accumulation point for explosives
Ditch at Inlet A14	1	Possible accumulation point for storm sewer discharge

Table 4-2. Rationale for sampling at each location (continued)

Site Location	No. of Sample Stations	Rationale
Ditch to Charlie's Pond	6	Resample elevated chromium sites from Phase I; possible accumulation point
Sanitary Sewer Lines	12	Possible accumulation point for explosives
Storm Sewer Lines	23	Characterize surface water
Ditches From Charlie's Pond	2	Resample Phase I sediment sampling location
Off-AOC Stream Sediment	6 (Twice)	Confirm presence of contaminants in PF-534 and other locations; to be completed in two rounds
TOTAL Sediment Stations	52 (58)	
<i>Surface Water (see Figures 4-2, 4-3, and 4-4 and Table 4-3)</i>		
Storm Sewers	4	Possible accumulation points for explosives
Sanitary Sewers	3	
Off-AOC Surface Water	6	Confirm presence of contaminants in PF-534 and other locations; to be completed in two rounds
Charlie's Pond	1	Accumulation point for contaminated sediment/surface water
Griggy's Pond	1	
Total Surface Water Stations	15	
<i>Groundwater (see Figure 1-3)</i>		
Phase I and II wells	14	Monitor downgradient water quality
Total Groundwater Stations	14	
Contingency Soils	52	Fully characterize nature and extent of contamination (21 subsurface)

4.1.2.2 Water Level Measurement

Water level measurements will follow the procedure presented in Section 4.3.2.6 of the Facility-Wide SAP. Water level measurements will be collected in a single day from all 14 specified monitoring wells.

4.1.3 Field Measurement Procedures and Criteria

All field measurement procedures and criteria will follow Section 4.3.3 of the Facility-Wide SAP. All monitoring wells will be field screened for VOCs using a PID OVA during groundwater sample collection. Screening will be accomplished by monitoring the headspace vapors at the top of the riser pipe.

4.1.4 Sampling Methods for Groundwater

Groundwater sampling from monitoring wells will follow the procedures presented in Section 4.3.4 of the Facility-wide SAP and the Phase II RI SAP Addendum No. 1. The integrity of the wells will be checked by inspection of the surface casing and riser pipe and by performing an alignment test in accordance with Section 4.3.2.3.13 of the Facility-Wide SAP. If the integrity of an existing well is questionable, the well will not be sampled and the USACE technical representative will be notified.

Provisions for groundwater sample collection, well purging, collection of filtered and unfiltered samples, sample containers and preservation, field QC, and equipment decontamination shall follow the Facility-Wide SAP and SAP Addendum No. 1 for this Phase II RI. Monitoring well purging and sampling will be accomplished using a micro-purging system, as described in the Addendum No. 1.

4.2 SUBSURFACE SOILS

4.2.1 Rationale

Subsurface soils will be collected during the Phase II RI at Load Line 1 to investigate potential subsurface contamination occurring as a result of the dispersal of explosives and other contaminants, and to identify transport pathways to the deeper subsurface for these contaminants. [Table 4-1](#) summarizes the planned subsurface soil sampling activities for this Phase II RI.

Because the majority of former buildings considered to be sources of contamination at Load Line 1 are underlain by bedrock, opportunities for the collection of subsurface soil data are expected to be minimal. Subsurface soil sampling will be biased to areas where > 0.3 m (1 foot) of soil is present, and where surface soil samples from either Phase I or Phase II exhibit explosives contamination (see Section 4.3). Maximum depth for surface sampling shall be (5 feet).

4.2.1.1 Soil boring locations

As shown in [Table 4-1](#), subsurface soil sampling is planned at 58 locations in the load line where soil cover is known or expected to be greater than 1 foot deep. The proposed locations will be selected on the basis of the DQOs, the conceptual site model, and the Phase I and II RI data (see Sections 1 and 3.2). The planned soil boring locations are shown in [Figure 4-1](#). Actual locations will be marked in the field.

Soil borings are planned at several former building locations and drainage features identified in Phase 1 RI as having either explosives in excess of 1 ppm or lead in excess of 100 ppm in the surface soils. Subsurface soil samples are planned at each of the areas where surface soil samples collected during Phases I and II of the RI exhibit the highest levels of explosives contamination. The main features of interest include buildings CB-4 and -4A, CB-13 and -13B, CB-10, CB-3A, CA-6 and CA-6A, and the former water tower.

Samples will be collected initially at (1 to 3 feet) to evaluate the vertical extent of contamination. A maximum of 58 samples will be collected in the (1 to 3 feet) interval and submitted for laboratory analysis of explosives and metals. These samples will be additionally analyzed in the field via colorimetry for TNT and RDX, and via X-ray fluorescence (XRF) for metals. If field analyses show the 1 to 3 foot interval to be contaminated with explosives or metals, the (3 to 5 foot) interval will be sampled and submitted for laboratory analysis of explosives and metals, as well as field measurement of metals (if sufficient soil is present). It is anticipated that no more than eight samples will be collected in the (3 to 5 foot) interval from various former Load Line 1 features. Lithologic information will also be acquired from the subsurface intervals.

Approximately twenty-one additional subsurface samples are planned as contingency samples to be collected from areas adjacent to the former buildings and drainage features that exhibit evidence of surface soil contamination based on field colorimetric analysis. Subsurface soil samples collected from these areas will be similarly submitted for field explosives and metals analyses as well as laboratory

Figure 4-1. Planned Phase II RI soil sample locations (see Plate 1 at end of chapter)

explosives and metals analyses according to [Table 4-1](#). The final number of contingency samples used depends upon field accessibility to the required depth intervals, and on the results of colorimetric analyses of soils for explosives.

4.2.1.2 Discrete/composite soil sampling requirements

All subsurface soil samples collected in this Phase II RI will be derived from the 0.3- to 0.9-m (1 to 3 foot) and (3 to 5 foot) depth intervals only. The subsurface sample will be a vertical composite, homogenized over the interval, and may either be located separately from surface samples or co-located with surface samples. If the subsurface sample is co-located with a surface sample, the subsurface sample will be collected from the approximate center of the three surface soil composite samples, which are to be collected for explosives and propellants only (see Section 4.3). All VOC samples will be collected as discrete aliquots from the middle of the interval without homogenization. All remaining samples will be derived from homogenized soil collected in a bucket hand auger over the depth interval. Soil will be collected in the auger, placed into a stainless steel bowl, and homogenized. Representative aliquots will be placed into sample containers in accordance with Section 4.4.2.5.2 of the Facility-Wide SAP.

4.2.1.3 Sample collection for laboratory analysis

All subsurface samples will be submitted for off-site laboratory analysis of TAL metals. Half of the samples will be analyzed for cyanide. Twenty-five samples will be selected for explosives and propellants analyses, based on field colorimetry results. VOCs, SVOCs, and PCB analyses will be performed on three of the subsurface samples.

If possible, two disturbed geotechnical samples will be collected at representative locations beneath the melt-pour buildings, and will be analyzed for grain size, Atterberg limits and Unified Soil Classification System (USCS) characterization. All subsurface soils will be analyzed for moisture content.

4.2.1.4 Organic vapor screening

All soil borings will be field screened for VOCs using a hand-held PID OVA during sample collection. All OVA readings will be recorded in field logbooks. No samples will be collected for headspace analysis of VOCs.

4.2.1.5 Field quality control sampling procedures

Subsurface QA/QC samples will be collected during the Phase II RI ([Table 4-1](#)). Duplicate and split samples will be selected on a random statistical basis and submitted for the same analyses as the environmental samples. Section 8.0 of the Load Line 1 Phase II RI Quality Assurance Project Plan (QAPP) Addendum summarizes QA/QC sampling.

Duplicate soils will be collected at a frequency of 10 percent (1 per 10 environmental samples). Split samples will be collected at the same frequency. No field or rinsate blanks will be collected for subsurface soils. Split samples will be submitted to USACE's contract laboratory (GP Environmental, Inc., Gaithersburg, MD) for independent analysis.

4.2.2 Procedures

4.2.2.1 Drilling methods

A hand-operated power auger will be used in conjunction with bucket hand augers to create the subsurface borings. The power auger will be used to advance the soil boring to the target depth interval, if necessary, as described in Sections 4.4.2.4.2 and 4.4.2.5.2 of the Facility-Wide SAP. Once the boring has been advanced to the top of the 0.3- to 0.9-m (1- to 3-foot) interval with the power auger, a bucket hand auger will be used for the collection of the soil sample. After the sample is collected, the power auger will be used to advance the boring to the top of the (3- to 5-foot) interval, if possible. A hand auger will then be used to collect the soil sample.

Samples will be collected as described in Sections 4.2.2.3 and 4.2.2.4 below.

4.2.2.1.1 Equipment condition and cleaning

Requirements for the condition and cleaning of equipment used for subsurface soil borings are described in Section 4.3.2.1.1 of the Facility-Wide SAP. These requirements will be applied as necessary to the soil boring equipment.

4.2.2.2 Field measurement procedures and criteria

All field measurement procedures and criteria will be in accordance with Section 4.4.2.3 of the Facility-Wide SAP, except that headspace gases will not be screened for organic vapors. In addition, field screening methods will be used to make preliminary determinations of the concentrations of explosives (TNT and RDX) and metals in subsurface soils.

Colorimetric analysis of all subsurface soils for TNT and RDX will be performed following the field method presented in Appendix A of this Phase II SAP Addendum. The purpose of this analysis is to define the extent of contamination. One discrete soil sample will be collected from each of two depth intervals (1 to 3 and 3 to 5 feet) at each soil boring location (where soil thickness is sufficient) and submitted for field colorimetric analysis of explosives. Off-site laboratory analysis for explosive compounds will also be performed. The following strategy will be used.

- If the concentration of TNT is ≥ 1 ppm, based on field colorimetric analysis, the sample will be sent to the off-site laboratory for analysis of explosives and propellants.
- If the concentration of TNT is < 1 ppm, the field colorimetric analysis for RDX will be performed.
- If the concentration of RDX is ≥ 1 ppm with the field colorimetric method, the sample will be sent to the off-site laboratory for analysis of explosives and propellants.
- 15 percent of all subsurface samples that show non-detects for explosives with the field method will also be sent to the off-site laboratory for confirmatory analysis.

XRF analysis of soils for metals will be performed by an approved subcontractor using procedures described in their QAPP. The purpose of the metals screening is to demonstrate the suitability of field-portable XRF spectrometry for performing real-time analysis of metals of comparable quality to laboratory analytical data. Therefore, each discrete soil sample collected from a subsurface depth interval

will be submitted for field XRF determinations of metals, and will be sent to the off-site laboratory for TAL metals analysis regardless of the field XRF result.

Off-site laboratory analysis for cyanide, pesticides/PCBs, VOCs, and SVOCs will be performed according to [Table 4-1](#), which summarizes the analytical parameters and methods that will be used during the Phase II RI. Analytical laboratory methods, analytes, and procedures are further discussed in the Phase II RI QAPP Addendum.

4.2.2.3 Sampling for geotechnical analyses

Subsurface soil samples collected using the bucket hand auger method are classified as disturbed samples. Therefore, geotechnical analysis of soils collected in this fashion will be limited to moisture content, grain size, Atterberg limits, and USCS. Each soil sample collected will be visually classified in the field according to the USCS. Procedures for sampling for geotechnical analysis are presented in Section 4.4.2.4.2 of the Facility-wide SAP.

4.2.2.4 Sampling for chemical analyses

Procedures for sampling of subsurface soils for chemical analysis using the bucket hand auger method are presented in Section 4.4.2.5.2 of the Facility-Wide SAP.

All subsurface soil samples will be analyzed for TAL metals. A maximum of 29 subsurface samples will receive analyses for explosives and propellants. Some contingency capacity is reserved for additional analyses for these constituents. In addition, 10 percent of all subsurface samples will receive analyses for SVOCs, VOCs, and PCBs. These analyses may be reserved or biased to areas of the load line where known or suspected contamination with these compounds occurred.

4.2.2.5 Sample containers and preservation

Requirements for sample containers and preservation techniques for subsurface soil samples are presented in Section 4.4.2.6 of the Facility-Wide SAP and in Section 4.0 of the Load Line 1 Phase II RI QAPP Addendum.

Efforts will be made to ensure proper refrigeration of soil samples en route to the off-site laboratory via courier. Because of the short transit time between the field and the analytical laboratory for some samples, it is not always possible for the containerized soils to reach 4°C before they are delivered to the laboratory. In the unlikely event of this occurrence, the sample manager will make a notation on the Chain-of Custody form to document that the samples have been on ice less than the time it takes for them to reach preservation temperature.

4.2.2.6 Decontamination procedures

The decontamination procedure for subsurface soil sampling activities presented in Section 4.4.2.8 of the Facility-Wide SAP will be followed.

4.2.2.7 OE Screening

OE support staff performed surface clearance of Load Line 1 during the installation of the Phase II RI monitoring wells in September 1999 and during the demolition operations that took place from March to June 2000. Based on the results of these surveys, there is no reason to expect that OE or UXO will be encountered during the remaining Phase II RI soil sampling activities at Load Line 1. OE surveys will be

conducted during subsurface soil sampling by a UXO specialist. However, the UXO specialist will be on site during the collection of all samples and will be responsible for the performing visual and magnetometer surveys of all work areas and, if necessary, individual sample locations.

4.3 SURFACE SOIL AND SEDIMENT

4.3.1 Rationales

Surface soil samples will be collected during the Phase II RI at Load Line 1 to (1) reinvestigate Phase I soil sampling locations that may have been affected by dispersal of contaminants during the subsequent demolition of buildings; (2) define extent of surface soil contamination; and (3) investigate potential source areas not sampled in Phase I. The soil sampling program will employ both biased (targeted to known hot spots) and statistical (random-grid) sampling to characterize not only the known problem areas but the spaces in between them.

The sampling program also incorporates collection of sediments from drainage ditches and catch basins, in order to assess the potential for contaminant migration via leaching or erosion from surface soils to surface water and sediment. In addition, samples will be collected from locations along the main storm water and sanitary sewer lines in order to determine whether they are sources of contaminant dispersal to surface water and groundwater. [Table 4-1](#) summarizes the planned Load Line 1 Phase II RI surface soil and sediment sampling activities. [Table 4-2](#) provides the specific rationales for placement of samples.

4.3.1.1 Surface soil sampling locations

The rationale for biased surface soil sampling locations at Load Line 1 is based on findings from the Phase I RI. Phase II RI surface soil sampling is planned at locations identified in the Phase I RI as having either explosives in excess of 1 ppm or lead in excess of 100 ppm in the surface soils. A total of 279 samples will be collected from the 0- to 0.3-m (0- to 1-foot) interval in clusters surrounding former buildings or structures that exhibited elevated contaminant concentrations in Phase I. The primary features of interest are the following:

- CA-17
- CB-13 and CB-13B
- CB-14 south end
- CB-10 and vacuum pump houses
- CB-4 and CB-4A
- CA-6 and CA-6A
- Concrete settling tank east of CB-4
- Concrete settling tank south of CB-4A
- CB-2
- Water tower.

The Phase II sampling will also investigate the potential for contamination in soils beneath the concrete floor slabs at several buildings. Samples will be collected from soils underlying obvious cracks, holes, or drains at former buildings CB-13, CB-10, CB-4, CB-4A, CB-6, and CB-6A.

The former railroad track CB, central to Load Line 1, will also be characterized with surface soil sampling beneath the ballast. The purpose of collecting the ten samples along the track is to determine the suitability of the track area for accepting clean hardfill from building demolition.

As shown in [Table 4-2](#), surface soil samples are planned at several locations associated with these former buildings and structures. The proposed locations were selected on the basis of DQOs, the Phase I RI results, and the conceptual site model developed for Load Line 1. The planned sampling locations are shown in [Figure 4-1](#). The final sample locations will be marked in the field based on soil conditions and site access.

In addition to the biased surface soil sampling described above, 30 random-grid samples will be collected at Load Line 1. As explained in Section 3.9 of this SAP Addendum No. 2, the objective of random-grid sampling is to characterize areas between the features that were identified as contaminated in the Phase I RI, as well as areas outside the functional area of the load line. Grid samples will be analyzed for field explosives and metals, and will receive laboratory analyses for explosives, metals, and cyanide. Ten percent of these samples will receive the full suite of analyses. This sampling approach will be used to confirm that no contamination in soils associated with Load Line 1 has been overlooked in the RI.

Approximately 48 contingency surface soil samples will be used to characterize any additional identified areas exhibiting obvious visual evidence of contamination. The rationale for locating contingency surface soil samples is to target areas of obvious staining or discoloration, evidence of OE, or areas in which additional sampling is deemed necessary based on field observations. If field testing indicates no explosives are present, no further sampling will be performed in that area. However, if colorimetry shows explosives > 1 ppm (TNT or RDX), then additional subsurface soil sampling (Section 4.2.1.1) will be performed using contingency samples to determine both horizontal and vertical extent at one location. Additional surface soil contingency samples will be located ~ (15 feet) outward from the identified contamination. The intent is to use contingency soil samples to bound the extent (vertical and horizontal) of contamination identified at each area investigated. Contingency sampling will be utilized based on field colorimetry and XRF results to define extent in each area; however, the contract capacity for sampling cannot be exceeded. In the event that an area (s) cannot be fully delineated using contingency sampling, a supplemental investigation will be necessary.

4.3.1.2 Sediment sampling locations from drainage channels, sewer lines, and basins

Eight surface water drainage features within Load Line 1 have been identified as requiring additional sampling in order to fully characterize nature and extent of contamination. These features include unlined drainage ditches, storm and sanitary drain outlets, and catch basins. Surface water samples were not collected from Griggy's and Charlie's Ponds in Phase I, and will be included in Phase II. The locations within Load Line 1 will be used to evaluate contaminants from source areas and assess whether they are migrating via surface water dissolution and soil erosion to accumulate in sediments. These locations are shown in [Figures 4-2](#), [4-3](#), and [4-4](#). Large-scale versions of these maps will be used to locate sampling points in the field.

In addition, six stream sampling locations outside and downstream of Load Line 1 will be sampled in order to characterize the primary surface water exit pathway off the AOC. These samples will provide data on potential contaminants exiting the site and accumulating in the surface water system's sediments. Samples will be collected from these locations in two rounds, separated by a period of two to three months.

Sediment sampling locations within Load Line 1 include

- Storm sewer outlets A, B, C, D, and E
- Sanitary sewer manholes 203-208, 210, 218, and 221
- Sanitary ejector station 1

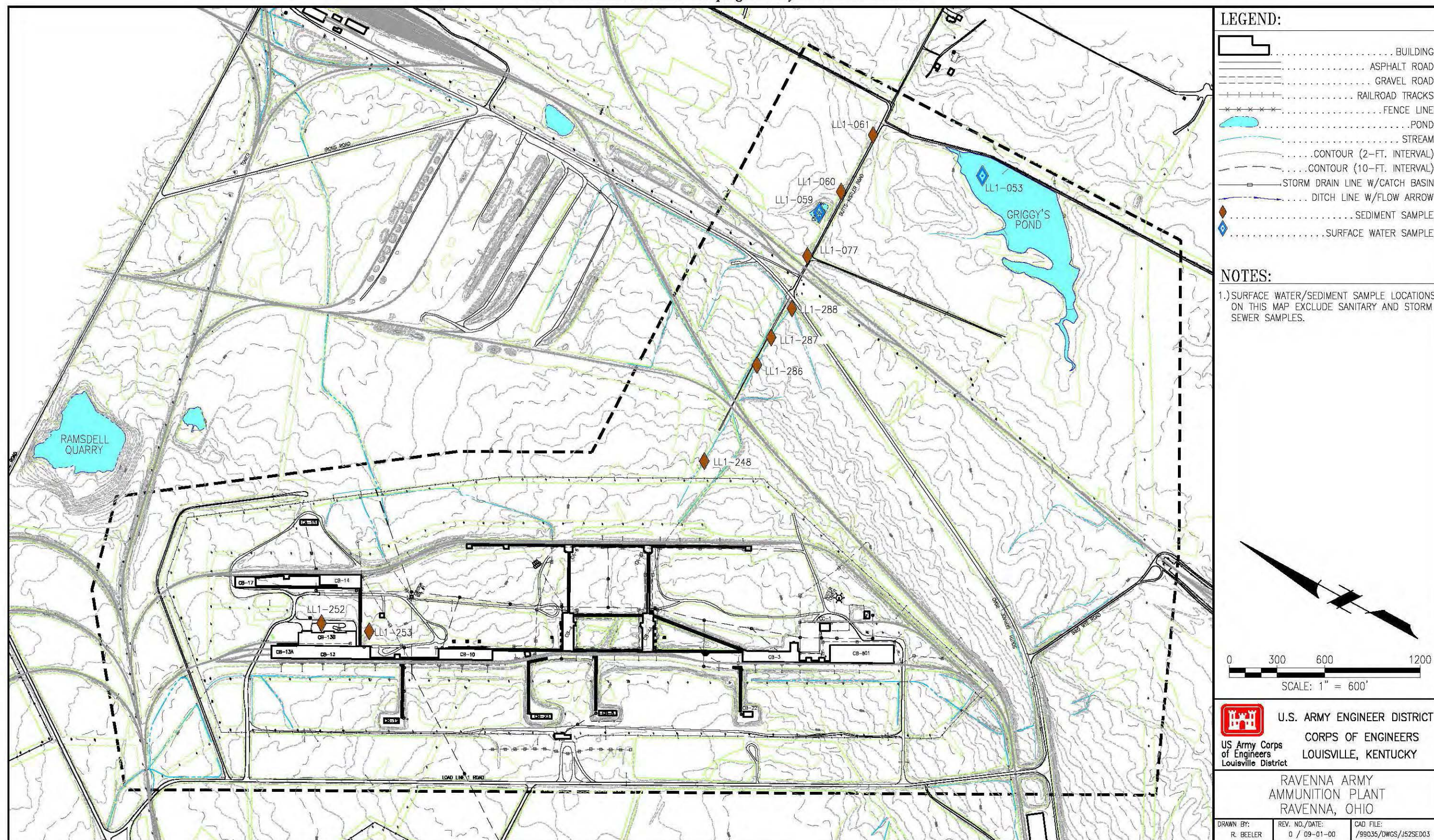


Figure 4-2. Planned Phase II RI Surface Water and Sediment Sample locations in Load Line 1

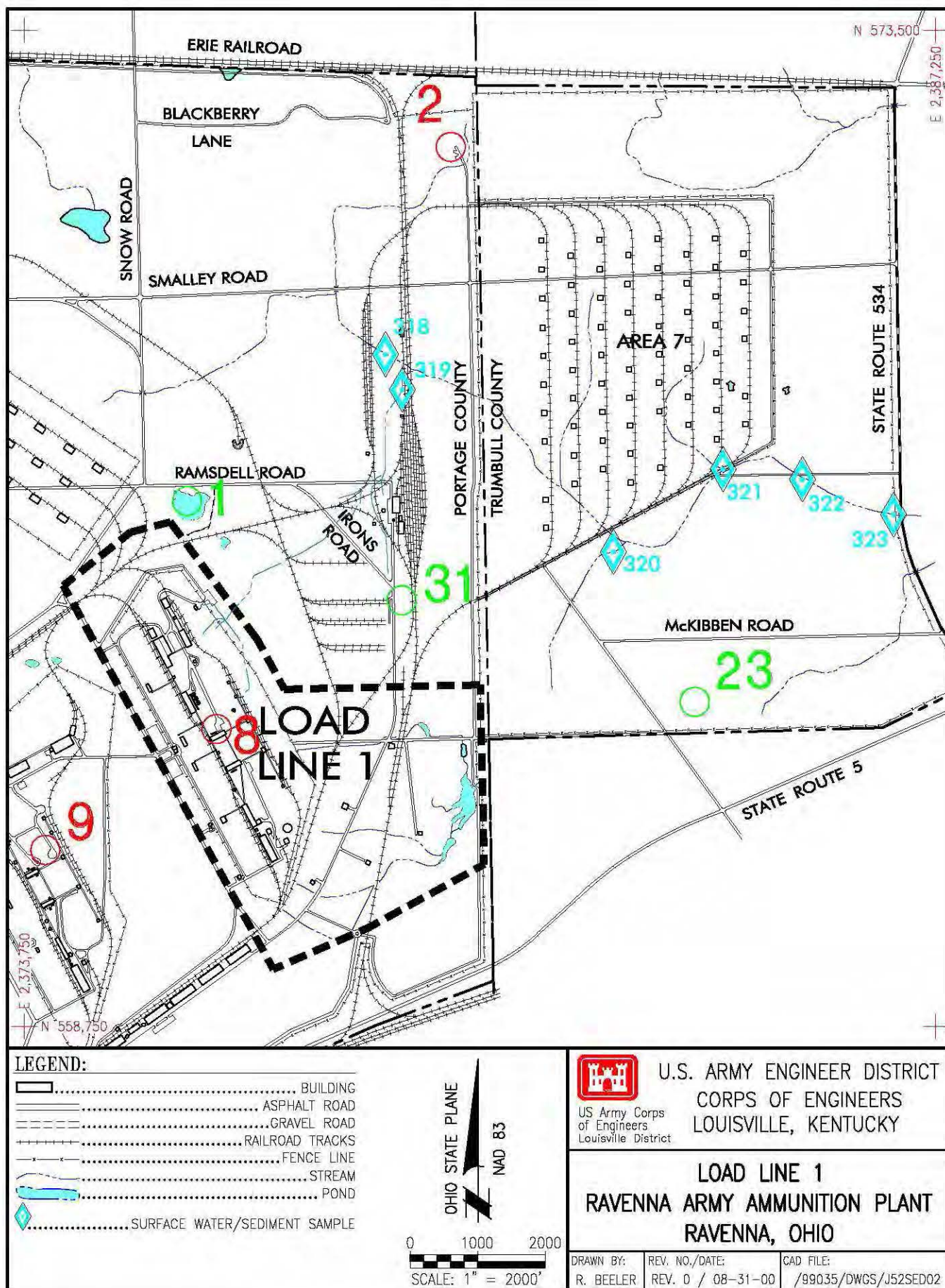


Figure 4-3. Planned Phase II RI Surface Water & Sediment Sample Locations Outside Load Line 1

[illegible]

Figure 4-4. Planned Phase II RI Sanitary and Storm Sewer Line Survey and Sample Locations

- Ejector station 1 headwall
- Sanitary sewer cleanout at manhole 1
- Drainage ditch at CA-6A
- Drainage ditch to Charlie's Pond
- Drainage ditch north of CB-13

Sediment sampling locations beyond the AOC boundary include the following:

- Parshal flume at Route 534
- Bailey bridge at Ramsdell Road
- Upstream of confluence of second-order tributary south of Area 7
- South fork of Sand Creek upstream of confluence with north fork
- North fork of Sand Creek between railroad tracks
- Upstream of confluence of second-order tributary north of rail siding

4.3.1.3 Discrete/Composite Soil and Sediment Sampling Requirements

All surface soil 0 to 0.3 m (0 to 1 ft) and dry ditch sediment samples (0 to 0.15 m (0 to 0.5 ft) to be analyzed for explosives and propellants will be composited from three subsamples collected about 0.9 m (3 ft) from one another in a roughly equilateral triangle pattern. Each subsample will be augered to a depth of 30.48 cm (1.0 ft). The remaining content of each subsample will be added to a stainless-steel bowl and thoroughly homogenized. This will be accomplished using a stainless steel spoon or scoop. Aliquots for explosives and propellants analyses will be extracted from the homogenized mixture. Once the subsamples are composited, a portion will be analyzed with the colorimetry method described in Appendix A, and another portion will be sent for laboratory analysis as described in Section 4.3.1.4.

A point located at the approximate center of the triangle will be selected for the collection of the remaining samples. Aliquots for VOC analyses will be collected at the center of the interval [15.24 cm (0.5 ft)] immediately upon extraction from the boring. No VOC sample will be collected from homogenized or composited soil sample volumes. Surface soils to be analyzed for metals, cyanide, SVOCs, and PCBs will then be collected, placed in a stainless steel bowl, and homogenized. Sample volumes will be taken from the approximate center of the (0 to 1-ft) interval unless a zone of obvious contamination is observed.

Because of the potential difficulty in gathering soils and sediment for samples from streams, beneath floor slabs and from the storm and sanitary sewer lines, composite sampling is not required for these sampling locations.

4.3.1.4 Sample Collection for Field and Laboratory Analysis

All surface soil and sediment samples will be field screened for VOCs using a hand-held PID OVA during collection. No samples will be collected for headspace analysis of VOCs.

All surface soil and sediment samples will be subject to field colorimetric analysis for TNT and RDX. The purpose of this analysis is to define the extent of contamination. Therefore, the following strategy will be used.

- If the field method indicates TNT is present at ≥ 1 ppm, the composite sample will be sent to the off-site lab for analysis of explosives and propellants.

- If the concentration of TNT is <1ppm, the analysis for RDX will be performed.
- If RDX is present at concentrations ≥ 1 ppm, the sample will be sent to the off-site laboratory for analysis of explosives and propellants.
- In addition, 15 percent of the samples showing non-detects of TNT or RDX will be sent to the off-site laboratory for analysis of explosives and propellants.

All samples collected will be screened in the field for metals using XRF, and will be submitted for TAL metals and cyanide analysis at the off-site laboratory regardless of the field result. However, the contract capacity for analyses as defined in [Table 4-1](#) will not be exceeded.

All surface soil samples will be analyzed by a geotechnical laboratory for moisture content. All sediment samples will be analyzed for Total Organic Carbon (TOC) and grain size distribution. Five soil samples will receive additional analyses for Atterberg limits, grain size distribution, and USCS. Visual classification of soil types according to the USCS shall be noted in the field. Moisture content will also be estimated and noted on field logs.

4.3.1.5 Field quality control sampling procedures

Surface soil and sediment QA/QC samples will be collected during the Phase II RI (See [Table 4-1](#)). Duplicate and split samples will be selected on a random statistical basis and submitted for the same analyses as the environmental samples. Section 8.0 of the Phase II Load Line 1 QAPP Addendum summarizes QA/QC sampling.

Duplicate (QC) surface soil and sediment samples will be collected at a frequency of 10 per cent (1 per 10 environmental samples). Split samples will also be collected at a frequency of 10 per cent. No field or rinsate blanks will be collected for surface soil or sediment. Split (QA) samples will be submitted to USACE's contract laboratory (GP Environmental, Inc., Gaithersburg, MD) for independent analysis.

4.3.2 Procedures

4.3.2.1 Sampling methods for soil/dry sediments

4.3.2.1.1 Bucket hand auger method

Surface soil and dry sediment samples will be collected with a bucket hand auger in accordance with Section 4.5.2.5 of the Facility-Wide SAP. In this investigation, auger buckets 15.24 cm (6.0 in.) in length and 7.62 cm (3.0 in.) in diameter will be used. At each location, an auger will be advanced in 15.24-cm (6-in.) increments.

For surface soils, as noted in Section 4.3.1.3, composite soil samples for explosives and propellant analyses will be created from three subsamples. The remaining analyte fractions will be collected from a point in the middle of the triangle formed by the three subsamples, with the volatile fraction collected first from unhomogenized material.

For sampling of soils that underlie building floor slabs (e.g., at buildings CB-4 and -4A), concrete coring or drilling will be performed at the locations of cracks, holes, or other breaches in the concrete where building washdown water may have leaked to underlying soils. Concrete cutting will be conducted such that a minimum quantity of potable water is used and captured. The diameter of the hole in the floor slab will be sufficient to allow the power auger flights to be inserted. When the concrete floor slab has been

fully penetrated, a hand auger will be used to acquire samples and, if necessary, a power auger will be used to advance the soil boring to the target depth interval. The soil samples thus collected will be homogenized from a single boring; no composite sample is required. Samples to be collected include cores of the concrete itself, the gravel fill layer directly beneath it, and the soil.

4.3.2.1.2 Trowel/scoop method

A stainless steel trowel or scoop may be used to collect surface soil samples in soft, loose soil, if feasible. The protocol for compositing, homogenization, and discrete VOC sample collection will follow that described in Section 4.3.2.1.1 above for bucket hand augers.

4.3.2.2 Sampling methods for subaqueous sediments from streams and surface water basins

4.3.2.2.1 Trowel/scoop method

Sediment samples in locations where water depth does not exceed 15.24 cm (0.5 foot) will be collected with a stainless steel trowel or scoop. The trowel will be used to manually obtain sediment to a depth of 15.24 cm (0.5 feet) below the sediment surface. Sediment will be placed into a stainless steel bowl as it is collected. At sample locations where VOC fractions are to be collected, the VOC containers will be filled immediately with the first sediment obtained. Sample containers for the remaining analyte fractions will be filled as described in Section 4.5.2.5 of the Facility-Wide SAP.

4.3.2.2.2 Hand core sampler method

A sludge sampler will be used to collect sediment at locations where (1) the depth of surface water exceeds 15.24 cm (0.5 foot) or (2) the depth to sediment in a confined space (e.g., a sanitary sewer ejector station) is too great to be accessed directly with trowels and scoops.

All samples collected with the sludge sampler will be obtained following the guidelines presented in Section 4.5.2.5 of the Facility-Wide SAP. The sludge sampler consists of a stainless steel, 8.26-cm (3.25-in.) outside diameter, 30.48-cm (12-in.) long capped tube that can be fitted with either an auger- or core-type sampler end. Each sampler is equipped with a butterfly valve to prevent loss of sample upon retrieval. In this investigation, the core-type sampler end will be used. The auger-type sampler end will be used only in the event that sediment is too gravelly or consolidated for efficient use of the core-type sampler end. The sludge sampler will be extended to the sampling depth by connecting stainless steel extension rods of various lengths to the sampler. The extension rods will be attached to a handle, and will be pushed or augered by hand.

Sediment will be placed into a stainless steel bowl as it is collected. At sample locations where VOC fractions are to be collected, the VOC containers will be filled immediately with the first sediment obtained. Sample containers for the remaining analyte fractions will be filled as described in Section 4.5.2.5 of the Facility-Wide SAP.

4.3.2.3 Field measurement procedures and criteria

4.3.2.3.1 Field determinations of explosive and metals

Colorimetric analysis of surface soils and sediment for TNT and RDX will be performed following the field method presented in Appendix A of this SAP Addendum. One composite soil sample will be collected from each of the surface soil/sediment boring locations and submitted for field colorimetric analysis of explosives.

XRF analysis of surface soils and sediment for metals will be performed according to the field procedures established by the subcontracted field laboratory. One discrete soil sample will be collected from each of the sampling locations and submitted for XRF analysis of metals.

Table 4-1 summarizes the analytical parameters and methods that will be used during the Phase II RI. Analytical laboratory methods, analytes, and procedures are further discussed in the Phase II RI QAPP Addendum.

4.3.2.3.2 Organic Vapor Screening

All field measurement procedures and criteria will follow Section 4.4.2.3 of the Facility-Wide SAP, with the following exception. Headspace gases will not be screened in the field for organic vapors. Because there were no notable detections of VOCs during Phase I RI soil sampling, organic vapor monitoring of headspace gases is not necessary in Phase II.

4.3.2.4 Sampling for Geotechnical Analysis

Surface soil and sediment samples collected using the hand auger method are classified as disturbed samples. Therefore, geotechnical analysis of samples collected using these methods will be limited to grain size, Atterberg limits, moisture content, and USCS characterization. Procedures for sampling for geotechnical analysis using the bucket hand auger method are presented in Section 4.4.2.4.2 of the Facility-Wide SAP. A maximum of five representative surface soil/sediment samples shall be submitted for geotechnical analysis.

4.3.2.5 Sampling for Chemical Analysis

Procedures for sampling of surface soils and sediment for chemical analysis using the Bucket Hand Auger Method are presented in Section 4.4.2.5.2 of the Facility-Wide SAP. Sediments collected from drainage ditches, storm water outfalls, and catch basins will be analyzed for TAL metals, explosives, and propellants, as shown in Table 4-1. All surface soil samples will be analyzed for TAL metals; approximately one third of these will also be analyzed for explosives and propellants, based upon field colorimetric results. Ten percent of the surface soil samples collected will be analyzed for VOCs, SVOCs, and PCBs. These analyses will be assigned based on areas where such contamination is expected (e.g., the former truck maintenance shop at CB-2), and to a portion of the random-grid samples.

4.3.2.6 Sample Containers and Preservation

Requirements for sample containers and preservation techniques for surface soil and sediment samples are presented in Section 4.4.2.6 of the Facility-Wide SAP.

4.3.2.7 Field Quality Control Sampling Procedures

Surface soil and sediment QA/QC samples will be collected during the Phase II RI. Duplicate soil samples will be collected at a frequency of 10 percent (1 per 10 environmental samples). Split samples will be submitted to the USACE subcontracted laboratory for independent analysis. Split samples will be collected at a frequency of 5 percent (1 per 20 environmental samples). Duplicate and split samples will be selected based on a random statistical basis and submitted for the same analyses as the environmental samples. No field or rinsate blanks will be collected for surface soils. Table 1-1 of the Phase II RI QAPP Addendum summarizes QA/QC sampling.

4.3.2.8 Decontamination Procedures

The decontamination procedure for surface soil and sediment sampling activities is presented in Section 4.4.2.8 of the Facility-Wide SAP.

4.3.2.9 OE Screening

As explained in Section 4.2.2.7 above, OE support for surface soil and sediment sampling teams is not expected to be routinely required for the Phase II RI at Load Line 1. However, a UXO specialist will conduct a reconnaissance survey of all sampling areas. The UXO specialist will be on site during collection of all samples, and will be responsible for performing visual and magnetometer surveys of all work areas and, if necessary, individual sample locations. Sediment samples extracted from storm or sanitary sewers may potentially contain high concentrations of bulk explosives. Therefore, sampling in such areas will be conducted under the oversight of a certified UXO technician.

4.4 SURFACE WATER

4.4.1 Rationales

Thirteen surface water samples will be co-located with sediment samples. Evaluation of surface water is a critical element of the Phase II RI because surface water may represent a contaminant transport pathway off the AOC (either as dissolved constituents or as constituents sorbed to sediment particles). The primary focal points of surface water sampling are Charlie's and Griggy's Ponds (surface water was not sampled in the Phase I RI) and any drainage ditches that contain flowing water at the time of the field sampling effort. The main sewer line collection points at buildings CB-4 and CB-4A are also of primary interest. Surface water samples are planned for an ejector station and manholes in the sanitary and storm sewer systems. It is recognized that any contaminants identified in surface water during this phase of the investigation may result from the reworking and mobilization of contaminated soils during the recent demolition of the buildings, rather than migration over time of contaminants left in situ.

Sampling of surface water is planned at locations outside the AOC in order to more fully characterize Load Line 1's contribution to surface water quality as it exits the installation to the east, through Sand Creek. Six sample locations have also been selected to characterize ambient water quality. Samples of surface water at these locations will be collected in two rounds, separated by a period of two to three months.

4.4.1.1 Locations

Surface water sampling locations are shown on [Figures 4-2 through 4-4](#). Fifteen locations are planned; six are located off the AOC and are distributed as follows:

- Parshal flume at Route 534,
- Bailey bridge at Ramsdell Road,
- Upstream of confluence of second-order tributary south of Area 7,
- South fork of Sand Creek upstream of confluence with north fork,
- North fork of Sand Creek between railroad tracks, and
- Upstream of confluence of second-order tributary north of rail siding.

The remaining locations are planned within Load Line 1, as follows:

- Griggy’s Pond (no sediment sample),
- Charlie’s Pond (no sediment sample),
- Manhole A1,
- Manhole B1,
- Manhole C1,
- Manhole D2,
- Manhole 208,
- Ejector Station 1, and
- Manhole 1 Cleanout.

4.4.2 Procedures

All surface water sampling will be conducted as described in Section 4.6.2.1.1 of the Facility-Wide SAP. The hand-held bottle method will be used to sample water in ditches where water is flowing, and in the ponds. The sample container will be submerged, with the cap in place, into the surface water flow. The container will then be slowly and continuously filled, using the cap to regulate the rate of sample flow into the container. The sample container will be removed from the flow with minimal disturbance to the sample. Immediately after collection of the sample and proper labeling, the container will be placed into an ice-filled cooler to ensure preservation.

Where possible, the surface water sample will be collected from areas of active flow, rather than from pools. All surface water sample collection will begin at the sampling point furthest downstream in the channel and proceed upstream to minimize the effects of sediment turbidity on surface water quality. Surface water samples will be collected before the commencement of sediment sampling at co-located sampling points.

Surface water samples will not be filtered prior to analysis.

4.4.2.1 Field measurement procedures and criteria

Surface water quality measurements to be performed in the field will include pH, conductivity, dissolved oxygen content, and temperature. These measurements will be made in the same manner as described in Section 4.3.3 of the Facility-Wide SAP. All field measurements will be recorded in the field logbooks.

4.4.2.2 Sampling for chemical analysis

All unfiltered surface water samples will be submitted to the analytical laboratory for analysis of explosives, propellants, TAL metals, and cyanide. VOCs, SVOCs, and pesticides/PCBs will be analyzed in 9 samples, as shown in [Table 4-1](#). Provisions for sample containers, preservation, and field quality control sampling are discussed in the Phase II RI QAPP Addendum. Decontamination of sampling equipment is not anticipated; however, should non-dedicated sampling equipment be required, it will be decontaminated before each use according to Section 4.3.8 of the Facility-Wide SAP. Field measurement instruments will also be decontaminated between sampling locations. Only those portions of each instrument that come in contact with potentially contaminated surface water will be decontaminated. This will be accomplished with a deionized-water rinse of the measurement probe and collection cup.

4.5 SITE SURVEY

The horizontal coordinates of all Phase II soil, sediment, and surface water sampling stations will be determined to the closest 3 to 4 feet using a Global Positioning System unit. For surface water locations and sediment sampling stations that are not underwater, the survey point will be at the water's edge. For surface water locations within ponds and for sediment sampling stations underwater, the elevation of the water surface, depth to bottom, and elevation of the bottom will be determined.

Survey data will be conveyed to USACE in Ohio State Plane Coordinates (NAD 83). The vertical datum for all elevations will be the 1929 National Geodetic Vertical Datum. All coordinates and elevations will be recorded on copies of the boring logs upon receipt of quality-assured survey results. In addition, electronic results will be provided to USACE and RVAAP in ASCII format.

4.6 SEWER LINE VIDEO SURVEY

4.6.1 Rationale

Migration of contaminants to surface water (by flushing during storm events) or groundwater (through leaking or breached sewer pipe) from the storm water and sanitary sewer systems at Load Line 1 may represent a major and heretofore unquantified source release mechanism. Investigation of storm and sanitary lines at other army ammunition plants in load lines similar to Load Line 1 has shown that sewer lines are commonly contaminated with bulk explosives, particularly at load lines that were heavily used. Frequently, camera surveys of such lines reveal cracks or other breaches in the pipe.

Characterization of the sewer systems at the load lines has not heretofore been an objective of RIs at RVAAP. Archived plan drawings indicate that a substantial length of pipe was laid in trenches cut in bedrock at Load Line 1, and that the trenches were backfilled with coarse material. Given these conditions, intrusive sampling of the pipe and trench material is not feasible.

A color video survey of the main sanitary and storm sewer lines at Load Line 1 will be conducted to characterize the extent of explosives contamination in sewer pipe, to assess the integrity of that pipe and its potential for releasing contaminants to the environment, and to provide data for the evaluation of remedial alternatives. The camera survey will be biased to the portions of the system located near the most contaminated areas of the load line, access permitting.

4.6.1.1 Locations

The suitability of sanitary and storm sewer pipes and access points (such as outfalls and catch basins) for a camera survey is largely unknown. Therefore, the scope of the camera survey will be limited to the main lines that represent the collection points for sanitary or storm effluent from the load line. The camera survey will begin at the outfalls and proceed upstream a maximum of 200 feet or until an obstruction prevents further movement. [Figure 4-4](#) shows the planned locations for the camera surveys at Load Line 1. Tentative sewer line video survey locations are shown on [Table 4-3](#). At this writing, it is not known whether all of the proposed entry points are still accessible. Final survey locations will be flagged and mapped in the field.

Table 4-3. Sewer Sampling Locations at Load Line 1

Type Area	Specific Area	Number Surface Samples	Video Survey	Remarks
Storm Sewers				
	Down Grade of LL1sd-46			Confluence of Ditches
	OUTLET A			
	Inlet A2	1 sed	Y-75'	25' to A3.A6, MHA2
	MH A1	1 sed/sw	Y-75'	25' to MHA2, CA7, OUT
	LL1sd-70	1 sed		
	LL1sd-47	1 sed		
	OUTLET B			
	Inlet B6	1 sed		
	Inlet B5A or B5	1sed		
	Inlet B3	1 sed		
	MH B4	1 sed	Y-50'	25' to 1-B2, MH B3
	Inlet B9	1 sed		
	MH B3	1 sed	Y-75'	25' to MHB4, 1-B8, MHB2
	MH B1	1 sed/sw	Y-75'	25' to MHB2, 1-B1, OUT
	LL1sd-39	1 sed		
	OUTLET C			
	Inlet C5	1 sed	Y-50'	25' to 1-C6, CB4A
	Inlet C6	1 sed		
	MH C1	1 sed/sw	Y-100'	25' to 1-C1, C5, C7, OUT
	LL1sd-48	1 sed		
	OUTLET D			
	Inlet D7	1 sed		
	Inlet D9	1 sed	Y-75'	25' to 1-D4, D10, D1
	MH D2	1 sed/sw	Y-50'	25' to 1-D1, MHD2
	LL1sd-49	1 sed		
	OUTLET E			
	Inlet E2	1 sed	Y-75'	25' to 1-E1, D11, E3
	LL1sd-50	1 sed		
	LL1sd-51	1 sed		
Sanitary Sewer				
	MH 203	1 sed		
	MH 204	1 sed		
	MH 205	1 sed		
	MH 206	1 sed	Y-50'	50' to 205'
	MH 207	1 sed	Y-100'	50' to 206,228'
	MH 208	1 sed/sw	Y-100'	50' to 207.220'
	MH 221	1 sed		
	MH 210	1 sed	Y-100'	50' to 209.218
	MH 218	1 sed		
	Ejector Sta 1	1 sed/sw	Y-200'	50' to 210,HD,213,CO
	HD Wall 1 ES 1	1 sed		
	Cleanout MH 1	1 sed/sw		

4.6.2 Procedures

The camera survey of sanitary sewer lines at Load Line 1 will follow the standard operating procedures of the subcontracted video surveyor. The following general procedures will apply.

- The camera shall be moved through the line in either direction at a uniformly slow rate. Precautions shall be taken to minimize the chances of the camera becoming stuck in the pipe.
- A suitable means of communication shall be established between the winches and the monitor control.
- Video operators shall advise the SAIC field manager of suitable locations (if any) for the collection of sediment and surface water samples within the sanitary or storm water sewer system, based upon their observations during the video survey.
- Television inspection of the sewer line shall be color videotaped or recorded on compact disk. When blockages, ruptures, or other significant features are noted, the camera shall be stopped to observe the condition, record the information, and if necessary, take photographs.
- Television logs shall be prepared and shall include identification of the section of pipe and pipe size. Records shall also include locations of reference points, points of entry, observed obstructions, ruptures, cracks, and other evidence of potential problems. These will be brought to the attention of the SAIC field manager while the survey is in progress.

The camera survey subcontractor shall prepare and submit a final report that will include, at a minimum, all field logbooks, a listing of identified or potential problem areas, and a sketch map showing the location of any identified or potential problem areas.

4.6.3 OE screening

Accumulated bulk explosive may be present in sewer pipes at Load Line 1. These compounds represent a substantial hazard to the field team conducting the camera survey and collecting samples of sediment. For this reason, OE support staff will oversee the camera survey. The OE Team Leader will train all field personnel to recognize and avoid contact with suspected bulk explosive in pipe. Safety briefings will also be provided by the OE support team to all site personnel and site visitors during the survey. The OE team will be authorized to stop the advance of the camera if OE is encountered in a given pipe segment. The OE support staff will clearly mark the area on the ground surface that corresponds to a significant obstruction in the pipeline caused by suspected OE Waste.

5.0 SAMPLE CHAIN OF CUSTODY/DOCUMENTATION

5.1 FIELD LOGBOOK

All field logbook information will follow structures identified in Section 5.1 of the Facility-wide SAP. In addition, copies of soil boring logs will be annotated after the conclusion of the field effort to include the following information for each sample in the RI Report:

- Moisture content.
- Estimated USCS classification.
- PID reading.
- Field-determined TNT level.
- Field-determined RDX level.
- Field-determined lead level.

5.2 PHOTOGRAPHS

Information regarding the documentation of photographs for the Phase II RI at Load Line 1 is presented in the SAP Addendum No. 1 for this Phase II RI. Representative photographs of field activities will be included in the Phase II RI Report.

5.3 SAMPLE NUMBERING SYSTEM

The sample numbering system is explained in Section 5.3 of the Facility-Wide SAP. The specific identifying information that will be used to implement this system during the field activities is presented in [Figure 5-1](#). [Tables 5-1](#) through [5-3](#) present the baseline sample identification listing for the Phase II investigation. Samples collected in addition to the baseline sample set will be sequentially identified following the numbering system. If a sample from the baseline set is not collected, a specific reason and notation will be made in the project logbooks.

5.4 SAMPLE DOCUMENTATION

All information in sample labels, logbooks, field records, and field forms will follow structures defined in Section 5.4 of the Facility-Wide SAP.

5.5 DOCUMENTATION PROCEDURES

Documentation and tracking of samples and field information will follow the series of steps identified in Section 5.5 of the Facility-Wide SAP.

5.6 CORRECTIONS TO DOCUMENTATION

Any corrections to documentation will follow guidance established in Section 5.6 of the Facility-Wide SAP.

Sample Station Location Identification: XXXmm-NNN(n)

XXX = Area Designator

Load Line 1 = LL1

mm = Sample Location Type

mw = Groundwater monitoring well

NNN = Sequential Sample Location Number

Unique sequence for each area designator continuing the sequence established by the Phase I RI. Phase I RI sample location number sequence ended at 077.

(n) = Special Identifier (optional)

Sample Identification: XXXmm-NNN(n)-####-tt

= Sequential Sample Number

Unique for the entire project site, continuing the sequence established by the Phase I RI. Phase I RI sample number sequence ended at 0721.

0001–9999

tt = Sample Type

GF = Groundwater Sample (filtered)

GW = Groundwater Sample (unfiltered)

SO = Soil Sample

TB = Trip Blank

FB = Field Blank

ER = Equipment Rinsate

Figure 5-1. Load Line 1 Phase II RI Groundwater Investigation Sample Identification

Table 5-1. Load Line 1 Phase II RI Baseline Soil Sample Identification

Area (No. of Stations)	Depth (ft)	Sample Station ID	Sample ID	Chemical Analyses							Geotechnical Analyses			
				VOCs	SVOCs	PCBs	Explosives	Propellants	Metals	Cyanide	AL	USCS	MC	Grain Size
Soil Samples														
Building CB-17	0-1	LL1-086	LL1ss-086-0722				All samples that test positive in field screening for explosives, and 15% of all samples that test negative in field screening, will be sent to the analytical laboratory for explosives and propellants analysis.		X	X			X	
	0-1	LL1-087	LL1ss-087-0723					X						
	0-1	LL1-088	LL1ss-088-0724					X						
	0-1	LL1-089	LL1ss-089-0726					X						
	0-1	LL1-090	LL1ss-090-0727					X	X					
	0-1	LL1-091	LL1ss-091-0728	X	X	X		X	X					
	1-3	LL1-091	LL1so-091-0729					X	X					
	0-1	LL1-092	LL1ss-092-0730					X						
	0-1	LL1-093	LL1ss-093-0731					X						
	0-1	LL1-094	LL1ss-094-0732	X	X			X	X					
	1-3	LL1-094	LL1so-094-0733					X	X					
	0-1	LL1-095	LL1ss-095-0734					X	X				X	
Bldg. CB-14	0-1	LL1-038	LL1ss-038-0735					X	X					
	1-3	LL1-038	LL1so-038-0736	X	X	X		X						
	0-1	LL1-096	LL1ss-096-0737					X						
	0-1	LL1-097	LL1ss-097-0738					X						
	0-1	LL1-098	LL1ss-098-0739					X	X					
	0-1	LL1-099	LL1ss-099-0740					X						
	0-1	LL1-100	LL1ss-100-0741					X						
	1-3	LL1-100	LL1so-100-0742					X					X	
	0-1	LL1-101	LL1ss-101-0743	X	X	X		X	X					
	0-1	LL1-102	LL1ss-102-0744					X						
	0-1	LL1-103	LL1ss-103-0745	X	X	X		X						
	1-3	LL1-103	LL1so-103-0746					X						
	0-1	LL1-104	LL1ss-104-0747					X						
Bldgs. CB-13, -13B	0-1	LL1-068	LL1ss-068-0748					X	X					
	1-3	LL1-068	LL1so-068-0749					X	X					
	0-1	LL1-105	LL1ss-105-0750					X						
	0-1	LL1-106	LL1ss-106-0751					X						
	0-1	LL1-107	LL1ss-107-0752					X						
	0-1	LL1-108	LL1ss-108-0753	X	X	X		X	X				X	
	1-3	LL1-108	LL1so-108-0754					X	X				X	
	0-1	LL1-109	LL1ss-109-0755					X						
	0-1	LL1-110	LL1ss-110-0756					X						
	0-1	LL1-111	LL1ss-111-0757					X	X					

Table 5-1. Load Line 1 Phase II RI Baseline Soil Sample Identification (continued)

Area (No. of Stations)	Depth (ft)	Sample Station ID	Sample ID	Chemical Analyses							Geotechnical Analyses			
				VOCs	SVOCs	PCBs	Explosives	Propellants	Metals	Cyanide	AL	USCS	MC	Grain Size
	0-1	LL1-112	LL1ss-112-0758						X					
	0-1	LL1-113	LL1ss-113-0759				All samples that test positive in field screening for explosives, and 15% of all samples that test negative in field screening, will be sent to the analytical laboratory for explosives and propellants analysis.		X	X				
	0-1	LL1-114	LL1ss-114-0760						X					
	0-1	LL1-115	LL1ss-115-0761						X	X				
	0-1	LL1-116	LL1ss-116-0762						X					
	0-1	LL1-117	LL1ss-117-0763						X					
	0-1	LL1-118	LL1ss-118-0764						X	X			X	
	0-1	LL1-119	LL1ss-119-0765						X					
Bldg. CB-10	0-1	LL1-034	LL1ss-034-0766						X	X				
	1-3	LL1-034	LL1so-034-0767	X	X				X	X			X	
	3-5	LL1-034	LL1so-034-0768						X	X				
	0-1	LL1-035	LL1ss-035-0769						X	X				
	1-3	LL1-035	LL1so-035-0770						X					
	0-1	LL1-037	LL1ss-037-0771						X	X				
	1-3	LL1-037	LL1so-037-0772						X	X				
	0-1	LL1-120	LL1ss-120-0773	X	X	X			X	X				
	0-1	LL1-121	LL1ss-121-0769						X				X	
	0-1	LL1-122	LL1ss-122-0774						X					
	0-1	LL1-123	LL1ss-123-0775						X	X				
	0-1	LL1-124	LL1ss-124-0776						X					
	0-1	LL1-125	LL1ss-125-0777						X	X				
	1-3	LL1-125	LL1so-125-0778						X					
	0-1	LL1-126	LL1ss-126-0779						X	X				
	0-1	LL1-127	LL1ss-127-0780						X					
	0-1	LL1-128	LL1ss-128-0781						X					
	0-1	LL1-129	LL1ss-129-0782						X					
	0-1	LL1-130	LL1ss-130-0783	X	X	X			X	X				
	0-1	LL1-131	LL1ss-131-0784						X					
	0-1	LL1-132	LL1ss-132-0785						X					
	0-1	LL1-133	LL1ss-133-0786						X					
	0-1	LL1-134	LL1ss-134-0787						X					
Bldg. CA-6	0-1	LL1-023	LL1ss-023-0788						X	X				
	1-3	LL1-023	LL1so-023-0789						X	X				
	0-1	LL1-135	LL1ss-135-0790	X	X	X			X	X				
	0-1	LL1-136	LL1ss-136-0791						X					
	0-1	LL1-137	LL1ss-137-0792						X	X				

Table 5-1. Load Line 1 Phase II RI Baseline Soil Sample Identification (continued)

				Chemical Analyses							Geotechnical Analyses				
Area (No. of Stations)	Depth (ft)	Sample Station ID	Sample ID	VOCs	SVOCs	PCBs	Explosives	Propellants	Metals	Cyanide	AL	USCS	MC	Grain Size	
	0-1	LL1-138	LL1ss-138-0793						X						
	0-1	LL1-139	LL1ss-139-0794				All samples that test positive in field screening for explosives, and 15% of all samples that test negative in field screening, will be sent to the analytical laboratory for explosives and propellants analysis.		X						
	0-1	LL1-140	LL1ss-140-0795						X	X					
	0-1	LL1-141	LL1ss-141-0796						X	X					
	1-3	LL1-141	LL1so-141-0797						X						
	0-1	LL1-142	LL1ss-142-0798						X						
	0-1	LL1-143	LL1ss-143-0799						X	X					
Bldg. CB-4	0-1	LL1-001	LL1ss-001-0800	X	X	X			X	X				X	
	1-3	LL1-001	LL1so-001-0801						X	X					
	3-5	LL1-001	LL1so-001-0802						X						
	0-1	LL1-002	LL1ss-002-0803						X	X			X		
	1-3	LL1-002	LL1so-002-0804						X						
	0-1	LL1-003	LL1ss-003-0805						X	X					
	1-3	LL1-003	LL1so-003-0806						X	X					
	3-5	LL1-003	LL1so-003-0807						X	X					
	0-1	LL1-004	LL1ss-004-0808						X	X					
	1-3	LL1-004	LL1so-004-0809						X	X					
	0-1	LL1-005	LL1ss-005-0810						X	X					
	1-3	LL1-005	LL1so-005-0811						X	X					
	3-5	LL1-005	LL1so-005-0812						X						
	0-1	LL1-006	LL1ss-006-0813						X	X					
	1-3	LL1-006	LL1so-006-0814						X	X					
	0-1	LL1-007	LL1ss-007-0815						X	X					
	1-3	LL1-007	LL1so-007-0816						X						
	0-1	LL1-008	LL1ss-008-0817						X	X					
	1-3	LL1-008	LL1so-008-0818						X						
	0-1	LL1-144	LL1ss-144-0819						X	X					
	0-1	LL1-145	LL1ss-145-0820						X	X					
	0-1	LL1-146	LL1ss-146-0821						X						
	0-1	LL1-147	LL1ss-147-0822						X						
	0-1	LL1-148	LL1ss-148-0823	X	X	X			X	X					
	0-1	LL1-149	LL1ss-149-0824						X						
	0-1	LL1-150	LL1ss-150-0825						X	X					
	0-1	LL1-151	LL1ss-151-0826						X						
	0-1	LL1-152	LL1ss-152-0827						X	X					
	0-1	LL1-153	LL1ss-153-0828						X						
Bldg. CB-4A	0-1	LL1-009	LL1ss-009-0829						X	X					

Table 5-1. Load Line 1 Phase II RI Baseline Soil Sample Identification (continued)

				Chemical Analyses							Geotechnical Analyses			
Area (No. of Stations)	Depth (ft)	Sample Station ID	Sample ID	VOCs	SVOCs	PCBs	Explosives	Propellants	Metals	Cyanide	AL	USCS	MC	Grain Size
	1-3	LL1-009	LL1so-009-0830						X	X				
	3-5	LL1-009	LL1so-009-0831				All samples that test positive in field screening for explosives, and 15% of all samples that test negative in field screening, will be sent to the analytical laboratory for explosives and propellants analysis.		X	X				
	0-1	LL1-010	LL1ss-010-0832						X	X				
	1-3	LL1-010	LL1so-010-0833						X					
	0-1	LL1-013	LL1ss-013-0834						X	X			X	
	1-3	LL1-013	LL1so-013-0835						X	X				
	3-5	LL1-013	LL1so-013-0836						X					
	0-1	LL1-011	LL1ss-011-0837						X	X				
	1-3	LL1-011	LL1so-011-0838						X	X				
	0-1	LL1-014	LL1ss-014-0839	X	X	X			X	X				
	1-3	LL1-014	LL1so-014-0840						X					
	0-1	LL1-015	LL1ss-015-0841						X	X				
	1-3	LL1-015	LL1so-015-0842						X					
	0-1	LL1-154	LL1ss-154-0843						X	X				
	0-1	LL1-155	LL1ss-155-0844						X					
	0-1	LL1-156	LL1ss-156-0845						X					
	0-1	LL1-157	LL1ss-157-0846						X	X				
	0-1	LL1-158	LL1ss-158-0847	X	X	X			X	X				
	1-3	LL1-158	LL1so-158-0848						x					
	0-1	LL1-159	LL1ss-159-0849						X	X				
	0-1	LL1-160	LL1ss-160-0850						X					
	0-1	LL1-161	LL1ss-161-0851						X	X				
	0-1	LL1-162	LL1ss-162-0852						X					
	0-1	LL1-163	LL1ss-163-0853	X	X	X			X	X			X	
	1-3	LL1-163	LL1so-163-0854						x					
	0-1	LL1-164	LL1ss-164-0855						X	X				
	0-1	LL1-165	LL1ss-165-0856						X					
Hill south of CB-4A	0-1	LL1-016	LL1ss-016-0857						X	X				
	1-3	LL1-016	LL1so-016-0858						X	X				
	0-1	LL1-166	LL1ss-166-0859						X	X				
	1-3	LL1-166	LL1so-166-0860						X	X				
	0-1	LL1-167	LL1ss-167-0861						X	X				
	0-1	LL1-168	LL1ss-168-0862	X	X	X			X	X			X	
	1-3	LL1-168	LL1so-168-0863						X	X				
	3-5	LL1-168	LL1so-168-0864						X					
Bldg. CB-3A	0-1	LL1-029	LL1ss-029-0865						X	X				

Table 5-1. Load Line 1 Phase II RI Baseline Soil Sample Identification (continued)

				Chemical Analyses							Geotechnical Analyses			
Area (No. of Stations)	Depth (ft)	Sample Station ID	Sample ID	VOCs	SVOCs	PCBs	Explosives	Propellants	Metals	Cyanide	AL	USCS	MC	Grain Size
	1-3	LL1-029	LL1so-029-0866						X	X				
	0-1	LL1-030	LL1ss-030-0867				All samples that test positive in field screening for explosives, and 15% of all samples that test negative in field screening, will be sent to the analytical laboratory for explosives and propellants analysis.		X	X				
	1-3	LL1-030	LL1so-030-0868	X	X	X			X				X	
	0-1	LL1-169	LL1ss-169-0869	X	X	X			X	X				
	0-1	LL1-170	LL1ss-170-0870						X					
	1-3	LL1-170	LL1so-170-0871						X					
	0-1	LL1-171	LL1ss-171-0872						X				X	
	0-1	LL1-172	LL1ss-172-0873						X					
	0-1	LL1-173	LL1ss-173-0874	X	X	X			X	X				
	1-3	LL1-173	LL1so-173-0875						X					
	0-1	LL1-174	LL1ss-174-0876							X				
	0-1	LL1-175	LL1ss-175-0877						X					
	0-1	LL1-176	LL1ss-176-0878						X	X				
	1-3	LL1-176	LL1so176-0879						X					
	0-1	LL1-177	LL1ss-177-0880						X					
	0-1	LL1-178	LL1ss-178-0881						X					
Bldg. CB-2	0-1	LL1-027	LL1ss-027-0882	X	X	X			X	X			X	
	1-3	LL1-027	LL1so-027-0883						X	X				
	0-1	LL1-179	LL1ss-179-0884	X	X	X			X	X				
	0-1	LL1-180	LL1ss-180-0885						X					
	0-1	LL1-181	LL1ss-181-0886	X	X	X			X	X				
	1-3	LL1-181	LL1so-181-0887	X	X				X	X				
	0-1	LL1-182	LL1ss-182-0888						X					
	0-1	LL1-183	LL1ss-183-0889						X					
	0-1	LL1-184	LL1ss-184-0890						X					
	0-1	LL1-185	LL1ss-185-0891	X	X	X			X	X				
	1-3	LL1-185	LL1so-185-0892						X					
	0-1	LL1-186	LL1ss-186-0893						X				X	
	0-1	LL1-187	LL1ss-187-0894						X					
Settling Basins N of Melt/Pour Bldgs.	0-1	LL1-024	LL1ss-024-0981	X	X	X			X	X				
	0-1	LL1-254	LL1ss-254-0982						X					
	0-1	LL1-255	LL1ss-255-0983						X					
	0-1	LL1-256	LL1ss-256-0984	X	X	X			X	X				
	0-1	LL1-257	LL1ss-257-0985						X					
	0-1	LL1-258	LL1ss-258-0986						X					

Table 5-1. Load Line 1 Phase II RI Baseline Soil Sample Identification (continued)

				Chemical Analyses							Geotechnical Analyses			
Area (No. of Stations)	Depth (ft)	Sample Station ID	Sample ID	VOCs	SVOCs	PCBs	Explosives	Propellants	Metals	Cyanide	AL	USCS	MC	Grain Size
	0-1	LL1-259	LL1ss-259-0987						X					
	0-1	LL1-260	LL1ss-260-0988				All samples that test positive in field screening for explosives, and 15% of all samples that test negative in field screening, will be sent to the analytical laboratory for explosives and propellants analysis.		X					
	0-1	LL1-261	LL1ss-261-0989						X	X				
	0-1	LL1-262	LL1ss-262-0990						X					
	0-1	LL1-263	LL1ss-263-0991						X					
	0-1	LL1-264	LL1ss-264-0992						X	X				
	0-1	LL1-265	LL1ss-265-0993						X					
	0-1	LL1-266	LL1ss-266-0994						X	X				
	0-1	LL1-267	LL1ss-267-0995						X					
	0-1	LL1-268	LL1ss-268-0996						X					
	0-1	LL1-269	LL1ss-269-0997						X					
	0-1	LL1-270	LL1ss-270-0998						X	X				
	0-1	LL1-271	LL1ss-271-0999						X					
	0-1	LL1-272	LL1ss-272-1000						X					
	0-1	LL1-273	LL1ss-273-1001						X					
CA-6A Ditch	0-1	LL1-274	LL1ss-274-1002						X	X			X	
	0-1	LL1-275	LL1ss-275-1003						X					
	0-1	LL1-276	LL1ss-276-1004						X					
	0-1	LL1-277	LL1ss-277-1005						X	X				
	0-1	LL1-278	LL1ss-278-1006						X					
	0-1	LL1-279	LL1ss-279-1007						X					
	0-1	LL1-280	LL1ss-280-1008						X					
	0-1	LL1-281	LL1ss-281-1009						X					
	0-1	LL1-282	LL1ss-282-1010						X					
	0-1	LL1-283	LL1ss-283-1011						X	X				
	0-1	LL1-284	LL1ss-284-1012						X		X	X		
	0-1	LL1-285	LL1ss-285-1013						X		X	X		
Random grid samples	0-1	LL1-188	LL1ss-188-0895						X	X			X	
	0-1	LL1-189	LL1ss-189-0896						X	X				
	0-1	LL1-190	LL1ss-190-0897						X	X				
	0-1	LL1-191	LL1ss-191-0898						X	X				
	1-3	LL1-191	LL1so-191-0899						X	X				
	0-1	LL1-192	LL1ss-191-0900						X	X				
	0-1	LL1-193	LL1ss-193-0901	X	X	X			X	X				

Table 5-1. Load Line 1 Phase II RI Baseline Soil Sample Identification (continued)

				Chemical Analyses							Geotechnical Analyses			
Area (No. of Stations)	Depth (ft)	Sample Station ID	Sample ID	VOCs	SVOCs	PCBs	Explosives	Propellants	Metals	Cyanide	AL	USCS	MC	Grain Size
	0-1	LL1-194	LL1ss-194-0902						X	X				
	0-1	LL1-195	LL1ss-195-0903				All samples that test positive in field screening for explosives, and 15% of all samples that test negative in field screening, will be sent to the analytical laboratory for explosives and propellants analysis.		X	X				
	1-3	LL1-195	LL1so-195-0904						X	X				
	0-1	LL1-196	LL1ss-196-0905						X	X				
	0-1	LL1-197	LL1ss-197-0906	X	X	X			X	X				
	0-1	LL1-198	LL1ss-198-0907						X	X				
	0-1	LL1-199	LL1ss-199-0908						X	X				
	1-3	LL1-199	LL1so-199-0909						X	X				
	0-1	LL1-200	LL1ss-200-0910						X					
	0-1	LL1-201	LL1ss-201-0911						X	X				
	0-1	LL1-202	LL1ss-202-0912	X	X	X			X				X	
	0-1	LL1-203	LL1ss-203-0913						X	X				
	0-1	LL1-204	LL1ss-204-0914						X					
	0-1	LL1-205	LL1ss-205-0915						X	X				
	1-3	LL1-205	LL1so-205-0916						X					
	0-1	LL1-206	LL1ss-206-0917						X	X				
	0-1	LL1-207	LL1ss-207-0918						X					
	0-1	LL1-208	LL1ss-208-0919						X	X				
	0-1	LL1-209	LL1ss-209-0920						X					
	0-1	LL1-210	LL1ss-210-0921						X	X				
	1-3	LL-210	LL1ss-210-0922						X					
	3-5	LL1210	LL1so-210-0923						X	X				
	0-1	LL1-211	LL1ss-211-0924						X	X				
	0-1	LL1-212	LL1ss-212-0925						X					
	0-1	LL1-213	LL1ss-213-0926						X	X				
	0-1	LL1-214	LL1ss-214-0927						X					
	0-1	LL1-215	LL1ss-215-0928						X	X				
	0-1	LL1-216	LL1ss-216-0929						X					
	0-1	LL1-217	LL1ss-217-0930						X	X				
Water Tower	0-1	LL1-218	LL1ss-218-0931			X			X					
	0-1	LL1-219	LL1ss-219-0932			X			X					
	0-1	LL1-220	LL1ss-220-0933			X			X					
Floor slab- CB-13	0-1	LL1-221	LL1ss-221-0934						X	X				
	1-3	LL1-221	LL1so-221-0935						X	X			X	
	0-1	LL1-222	LL1ss-222-0936	X	X	X			X	X				

Table 5-1. Load Line 1 Phase II RI Baseline Soil Sample Identification (continued)

				Chemical Analyses							Geotechnical Analyses			
Area (No. of Stations)	Depth (ft)	Sample Station ID	Sample ID	VOCs	SVOCs	PCBs	Explosives	Propellants	Metals	Cyanide	AL	USCS	MC	Grain Size
	1-3	LL1-222	LL1so-222-0937						X					
	0-1	LL1-223	LL1ss-223-0938				All samples that test positive in field screening for explosives, and 15% of all samples that test negative in field screening, will be sent to the analytical laboratory for explosives and propellants analysis.		X	X				
Floor slab- CB-10	0-1	LL1-224	LL1ss-224-0939						X					
	0-1	LL1-225	LL1ss-225-0940						X	X				
	1-3	LL1-225	LL1so-225-0941						X					
	0-1	LL1-226	LL1ss-226-0942	X	X	X			X	X				
	1-3	LL1-226	LL1so-226-0943						X					
Floor slab-CB-4	0-1	LL1-227	LL1ss-227-0944	X	X	X			x	X				
	1-3	LL1-227	LL1so-227-0945						X	X				
	0-1	LL1-228	LL1ss-228-0946						X					
	1-3	LL1-228	LL1so-228-0947						X					
	0-1	LL1-229	LL1ss-229-0948						X	X				
Floor slab- CB-4A	0-1	LL1-230	LL1ss-230-0949						X					
	0-1	LL1-231	LL1ss-231-0950	X	X	X			X	X				
	1-3	LL1-231	LL1so-231-0951						X	X				
	0-1	LL1-232	LL1ss-232-0952						X					
	1-3	LL1-232	LL1so-232-0953						X					
Floor slab-CA-6	0-1	LL1-233	LL1ss-233-0954	X	X	X			X	X				
	1-3	LL1-233	LL1so-233-0955						x					
	0-1	LL1-234	LL1ss-234-0956						X					
Floor slab- CA-6A	0-1	LL1-235	LL1ss-235-0957	X	X	X			X	X				
	1-3	LL1-235	LL1so-235-0958						X					
	0-1	LL1-236	LL1ss-236-0959						X					
Track CB	0-1	LL1-237	LL1ss-237-0960	X					X					
	0-1	LL1-238	LL1ss-238-0961						X					
	0-1	LL1-239	LL1ss-239-0962	X					X	X				
	1-3	LL1-239	LL1so-239-0963	X					X	X				
	0-1	LL1-240	LL1ss-240-0964	X					X					
	0-1	LL1-241	LL1ss-241-0965						X					
	0-1	LL1-242	LL1ss-242-0966	X					X	X				
	1-3	LL1-242	LL1so-242-0967	X					X					
	0-1	LL1-243	LL1ss-243-0968	X					X					
	0-1	LL1-244	LL1ss-244-0969						X	X				
	0-1	LL1-245	LL1ss-245-0970	X					X					

Table 5-1. Load Line 1 Phase II RI Baseline Soil Sample Identification (continued)

				Chemical Analyses							Geotechnical Analyses			
Area (No. of Stations)	Depth (ft)	Sample Station ID	Sample ID	VOCs	SVOCs	PCBs	Explosives	Propellants	Metals	Cyanide	AL	USCS	MC	Grain Size
	0-1	LL1-246	LL1ss-246-0971	X	X				X					
Scraped soils from Change House Demo.	0-1	LL1-247	LL1ss-247-0972				All samples that test positive in field screening for explosives, and 15% of all samples that test negative in field screening, will be sent to the analytical laboratory for explosives and propellants analysis.		X	X				
	0-1	LL1-248	LL1ss-248-0973						X	X				
	0-1	LL1-249	LL1ss-249-0974						X	X				
Sites east of CA-6	0-1	LL1-039	LL1ss-039-0975						X	X				
	1-3	LL1-039	LL1so-039-0976						X					
	0-1	LL1-250	LL1ss-250-0977						X	X				
	0-1	LL1-251	LL1ss-251-0978						X					
Bldg. CA-6A	0-1	LL1-324	LL1-ss-324-0979	X	X	X			X	X				
	0-3	LL1-324	LL1-so-324-0980						X					
	0-1	LL1-325	LL1-ss-324-0981						X	X				
	0-1	LL1-326	LL1-ss-324-0982						X					
	0-1	LL1-327	LL1-ss-324-0983						X	X				
	0-1	LL1-328	LL1-ss-324-0984						X					
	0-1	LL1-329	LL1-ss-324-0985						X	X				
	0-1	LL1-330	LL1-ss-324-0986						X					
	0-1	LL1-331	LL1-ss-324-0987						X	X				
	0-1	LL1-332	LL1-ss-324-0988						X					
	0-1	LL1-333	LL1-ss-324-0989						X	X				
	0-1	LL1-334	LL1-ss-324-0990						X					
	0-1	LL1-335	LL1-ss-324-0991						X	X				
	0-3	LL1-335	LL1-so-324-0992						X					

5.7 MONTHLY REPORTS

Monthly reports will be submitted to USACE during the performance of the field investigation, data evaluation, and report preparation for this Phase II RI.

Table 5-2. Load Line 1 Phase II RI Baseline Sediment and Surface Water Sample Identification

Area (No. of Stations)	Depth (ft)	Sample Station ID	Sample ID	Chemical Analyses								
				VOCs	SVOCs	PCBs	Explosives	Propellants	Metals	Cyanide	TOC	Grain Size
Sediments												
Ditch N of CB-13B	0-0.5	LL1-252	LL1sd-252-0979						X		X	X
Ditch at Inlet A14	0-0.5	LL1-253	LL1sd-253-0980				All samples that test positive in field screening for explosives, and 15% of all samples that test negative in field screening, will be sent to the analytical laboratory for explosives and propellants analysis.		X		X	X
Ditch to Charlies' Pond	0-0.5	LL1-048	LL1sd-048-1014						X		X	X
	0-0.5	LL1-077	LL1sd-077-1015	X	X	X			X	X	X	X
	0-0.5	LL1-286	LL1sd-286-1016						X		X	X
	0-0.5	LL1-287	LL1sd-287-1017						X		X	X
	0-0.5	LL1-288	LL1sd-288-1018						X		X	X
	0-0.5	LL1-289	LL1sd-289-1019						X		X	X
Sanitary Sewer Lines – 203	0.5	LL1-290	LL1sd-290-1020						X		X	X
MH-204	0.5	LL1-291	LL1sd-291-1021						X		X	X
MH-205	0.5	LL1-292	LL1sd-292-1022						X		X	X
MH-206	0.5	LL1-293	LL1sd-293-1023						X		X	X
MH-207	0.5	LL1-294	LL1sd-294-1024						X		X	X
MH-208	0.5	LL1-295	LL1sd-295-1025						X		X	X
MH-210	0.5	LL1-296	LL1sd-296-1026						X		X	X
ES-1	0.5	LL1-297	LL1sd-297-1027						X		X	X
MH-221	0.5	LL1-298	LL1sd-298-1028						X		X	X
MH-218	0.5	LL1-299	LL1sd-299-1029						X		X	X
Headwall	0.5	LL1-300	LL1sd-300-1030						X		X	X
Cleanout	0.5	LL1-301	LL1sd-301-1031						X		X	X
Storm Sewer Lines - B3	0-0.5	LL1-302	LL1sd-302-1032						X		X	X
MH-B4	0-0.5	LL1-303	LL1sd-303-1033						X		X	X
MH-213	0-0.5	LL1-304	LL1sd-304-1034	X	X	X			X	X	X	X
MH-B3	0-0.5	LL1-305	LL1sd-305-1035						X		X	X
B8	0-0.5	LL1-306	LL1sd-306-1036						X		X	X
C5	0-0.5	LL1-307	LL1sd-307-1037						X		X	X
C6	0-0.5	LL1-308	LL1sd-308-1038						X		X	X
MH-B1	0-0.5	LL1-309	LL1sd-309-1039	X	X	X			X	X	X	X
D7	0-0.5	LL1-310	LL1sd-310-1040						X		X	X

Table 5-2. Load Line 1 Phase II RI Baseline Sediment and Surface Water Sample Identification (continued)

Area (No. of Stations)	Depth (ft)	Sample Station ID	Sample ID	Chemical Analyses								
				VOCs	SVOCs	PCBs	Explosives	Propellants	Metals	Cyanide	TOC	Grain Size
D9	0-0.5	LL1-311	LL1sd-311-1041						X		X	X
MH-D2	0-0.5	LL1-312	LL1sd-312-1042				All samples that test positive in field screening for explosives, and 15% of all samples that test negative in field screening, will be sent to the analytical laboratory for explosives and propellants analysis.		X		X	X
B6	0-0.5	LL1-313	LL1sd-313-1042						X		X	X
B5	0-0.5	LL1-314	LL1sd-314-1044						X		X	X
A2	0-0.5	LL1-315	LL1sd-315-1045						X		X	X
MH-C1	0-0.5	LL1-316	LL1sd-316-1046	X	X	X			X	X	X	X
E2	0-0.5	LL1-317	LL1sd-317-1047						X		X	X
Phase I	0-0.5	LL1-046	LL1sd-046-1048						X		X	X
Phase I	0-0.5	LL1-047	LL1sd-047-1049						X		X	X
Phase I	0-0.5	LL1-048	LL1sd-048-1050	X	X	X			X	X	X	X
Phase I	0-0.5	LL1-049	LL1sd-049-1051						X		X	X
Phase I	0-0.5	LL1-050	LL1sd-050-1052						X		X	X
Phase I	0-0.5	LL1-051	LL1sd-051-1053						X		X	X
Phase I	0-0.5	LL1-070	LL1sd-070-1054						X		X	X
Ditches from Charlie's Pond	0-0.5	LL1-060	LL1sd-060-1055						X		X	X
	0-0.5	LL1-061	LL1sd-061-1056								X	X
Off-AOC streams, 1 st round	0-0.5	LL1-318	LL1sd-318-1057	X	X	X			X	X	X	X
	0-0.5	LL1-319	LL1sd-319-1058						X		X	X
	0-0.5	LL1-320	LL1sd-320-1059						X		X	X
	0-0.5	LL1-321	LL1sd-321-1060						X		X	X
	0-0.5	LL1-322	LL1sd-322-1061						X		X	X
	0-0.5	LL1-323	LL1sd-323-1062						X		X	X
2 nd round	0-0.5	LL1-318	LL1sd-318-1098						X		X	X
	0-0.5	LL1-319	LL1sd-319-1099						X		X	X
	0-0.5	LL1-320	LL1sd-320-1100						X		X	X
	0-0.5	LL1-321	LL1sd-321-1101						X		X	X
	0-0.5	LL1-322	LL1sd-322-1102						X	X	X	X
	0-0.5	LL1-323	LL1sd-323-1103	X	X	X			X		X	X
TOTALS		84 STATIONS	90 SAMPLES									
Surface Water												
Storm Sewers	NA	LL1-304	LL1sw-304-1063	X	X	X			X	X		
	NA	LL1-309	LL1sw-309-1064	X	X	X			X	X		
	NA	LL1-316	LL1sw-316-1065	X	X	X			X	X		
	NA	LL1-312	LL1sw-312-1066	X	X	X			X	X		

Table 5-2. Load Line 1 Phase II RI Baseline Sediment and Surface Water Sample Identification (continued)

Area (No. of Stations)	Depth (ft)	Sample Station ID	Sample ID	Chemical Analyses								Grain Size
				VOCs	SVOCs	PCBs	Explosives	Propellants	Metals	Cyanide	TOC	
Sanitary Sewers	NA	LL1-295	LL1sw-295-1067	X	X	X			X	X		
	NA	LL1-297	LL1sw-297-1068	X	X	X			X	X		
	NA	LL1-301	LL1sw-301-1069	X	X	X			X	X		
Charlie's Pond	NA	LL1-059	LL1sw-059-1070						X	X		
Griggy's Pond	NA	LL1-055	LL1sw-055-1071						X	X		
Off-AOC Streams, 1 st round	NA	LL1-318	LL1sw-320-1072						X	X		
	NA	LL1-319	LL1sw-319-1073						X	X		
	NA	LL1-320	LL1sw-320-1074						X	X		
	NA	LL1-321	LL1sw-321-1075						X	X		
	NA	LL1-322	LL1sw-322-1076						X	X		
	NA	LL1-323	LL1sw-323-1077	X	X	X			X	X		
2 nd round	NA	LL1-318	LL1sw-318-1092						X	X		
	NA	LL1-319	LL1sw-319-1093						X	X		
	NA	LL1-320	LL1sw-320-1094						X	X		
	NA	LL1-321	LL1sw-321-1095						X	X		
	NA	LL1-322	LL1sw-322-1096						X	X		
	NA	LL1-323	LL1sw-323-1097	X	X	X			X	X		
TOTALS		15 STATIONS	21 SAMPLES									

Table 5-3. Load Line 1 Phase II RI Baseline Groundwater Sample Identification

Sample Station ID	Sample ID	VOCs	SVOCs	PCBs	Explosives	Propellants	Filtered Metals	Cyanide
<i>Primary Samples</i>								
LL1mw-059	LL2mw-059-1078-GW	X	X	X	X	X		X
LL1mw-060	LL1mw-060-1079-GW	X	X	X	X	X		X
LL1mw-063	LL1mw-063-1080-GW	X	X	X	X	X		X
LL1mw-064	LL1mw-064-1081-GW	X	X	X	X	X		X
LL1mw-065	LL1mw-065-1082-GW	X	X	X	X	X		X
LL1mw-067	LL1mw-067-1083-GW	X	X	X	X	X		X
LL1mw-078	LL1mw-078-1084-GW	X	X	X	X	X		X
LL1mw-079	LL1mw-079-1085-GW	X	X	X	X	X		X
LL1mw-080	LL1mw-080-1086-GW	X	X	X	X	X		X
LL1mw-081	LL1mw-081-1087-GW	X	X	X	X	X		X
LL1mw-082	LL1mw-082-1088-GW	X	X	X	X	X		X
LL1mw-083	LL1mw-083-1089-GW	X	X	X	X	X		X
LL1mw-084	LL1mw-084-1090-GW	X	X	X	X	X		X
LL1mw-085	LL1mw-085-1091-GW	X	X	X	X	X		X
TOTALS	14 stations, 14 samples	14	14	14	14	14	14	14
Field Duplicates		1	1	1	2	2	1	2
USACE QA Split Samples			1	1	1	1	1	1
Trip Blanks		1						
Source Blanks		1	1	1	2	2	1	2
Equipment Rinsates		1	1	1	2	2	1	2

6.0 SAMPLE PACKAGING AND SHIPPING REQUIREMENTS

Sample packaging and shipping will generally follow the protocols in Section 6.0 of the Facility-Wide SAP. Because the analytical laboratory is located less than 80 km (50 miles) from RVAAP, the contract laboratory will provide pickup of sample coolers. This courier service will reduce some of the packaging and labeling requirements described in the Facility-Wide SAP, which are intended for air-shipped coolers. Specifically:

- Chain-of-custody forms can be hand-carried by the courier to the laboratory.
- No airbills will be attached to coolers shipped by courier.
- “THIS END UP” and “FRAGILE” stickers will not be required for containers transported by courier.

An additional consideration is that the time from sample collection in the field to cooler receipt at the laboratory may be short when courier service is used. Samples may have insufficient time to reach the required temperature in transit to the laboratory. The Sample Manager will make a notation on the change-of-custody form to this effect, to alert the laboratory to the potential for a temperature deviation.

Sample coolers shipped to the USACE independent contract laboratory will be prepared and shipped in accordance with the Facility-Wide SAP.

Geotechnical samples do not require refrigeration or other preservation, and will be shipped to the contract laboratory at the conclusion of the field sampling effort.

7.0 INVESTIGATION-DERIVED WASTE

All investigation-derived waste (IDW), including auger cuttings, personal protective equipment, disposable sampling equipment, and decontamination fluids will be properly handled, labeled, characterized, and managed in accordance with Section 7.0 of the Facility-Wide SAP. At the conclusion of the field activities, a letter report will be submitted documenting the characterization and classification of wastes. All solid and liquid IDW will be removed from the site and disposed of by a licensed waste disposal contractor. All shipments of IDW off site will be approved via manifests signed by the RVAAP Environmental Coordinator.

The following types of IDW are expected to be created in the course of the Phase II RI. Each type will be containerized as a separate waste stream.

- Solid unsaturated drill cuttings (hand and power augers; concrete cutting devices) – up to 10 55-gallon drums.
- Decontamination solutions and reagents from field colorimetry lab - up to 1 drum each.
- Personal protective equipment – up to two 55-gallon drums.
- IDW water (purge water, concrete coring fluids) – up to four drums.
- Decontamination fluids – up to two drums.
- IDW Solid Waste (expendables) – up to two drums.

At locations where soil sampling is performed, any holes or openings in the ground will be filled with bentonite chips or granules to the ground surface, to prevent vertical migration of any potential contamination. Any excess soil not used for samples will be placed in 55-gallon drums. The disposition of the drummed soils will be based on up to 10 Toxicity Characteristic Leaching Procedure (TCLP) samples collected from the drums.

At locations where sediment sampling results in a hole that remains open, bentonite granules will be used to fill the hole to the ground surface. If the hole collapses or is underwater, no additional measures will be taken. Any excess sediment not used for samples will be placed in a 55-gallon drum. The disposition of the drummed sediment will be based on TCLP analysis of a composite sample.

Excess water generated during monitoring well purging and sampling will be commingled in 55-gallon drums because the volume from any single well is expected to be minimal. The management of this water will be based on TCLP analysis of composite water samples. Decontamination fluids disposition will be based on collection and analysis of a single TCLP sample.

Drummed IDW will be staged at Building 1036 and, if necessary, placed on a secondary containment platform. IDW management and disposition will be carried out in such a manner that the potential for freezing and rupturing of drums is minimized.

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APPENDIX A

STANDARD OPERATING PROCEDURE FOR FIELD COLORIMETRIC ANALYSIS OF EXPLOSIVES FOR RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO

STANDARD OPERATING PROCEDURE FOR FIELD COLORIMETRIC ANALYSIS OF EXPLOSIVES FOR RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide directions for in the field chemical determination of the presence of 2,4,6-trinitrotoluene (TNT) and Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) in soil and sediment. This procedure will allow the quantification of these two compounds using a battery operated spectrophotometer by experienced analytical personnel.

The resulting data is intended to provide information that meets DQOs for field screening for the purpose of expedient field operation decisions. The resulting data will not meet DQOs necessary for risk assessment nor be stand-alone for feasibility studies.

2.0 METHOD SUMMARY

A 20 gram aliquot of undried sample is placed in an appropriate size container and extracted with 100 ml of acetone. After filtration and color development the background and developed color is measured at the appropriate wavelength on the spectrophotometer. After subtraction of the background color the concentration of the target compound is determined based on the absorbance measurement from the spectrophotometer.

Two separate color developments and absorbance measurements are required for the determination of TNT and RDX by this procedure. TNT detection and quantification is based on the spectrophotometric measurement at 540 nm of the red color complex resulting from the addition of potassium hydroxide (KOH) and sodium sulfite (Na_2SO_3) to the filtered acetone extract. RDX detection and quantification is based on the spectrophotometric measurement at 507 nm the red color complex resulting from the derivitization of the acetone extract with acetic acid and zinc and subsequent color development with commercially available HACH NitroVer 3 reagent.

The method concentration range for the compounds is typically 1 – 30 ppm for TNT and 2.5 – 35 ppm for RDX, wet weight. The actual range found will be dependent on the individual instrumentation and the cuvet diameter. The actual reportable concentration range needs to be determined on a project by project basis.

3.0 REFERENCES

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- 3.2** RVAAP Site Wide SAP, July 2000
- 3.3** RVAAP Site Wide QAPP, July 2000
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- 3.4** Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual, U.S. EPA, Region IV Environmental Services Division, February, 1991.
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- 3.5** Jenkins, T.F., and Walsh, M.E. (1993). “Determination of TNT/RDX in Soils Using Colorimetry”, U.S. Cold Regions Research and Engineering Laboratory.

4.0 RESPONSIBILITIES

4.1 Contractor Program Manager

The Program Manager is responsible for approving this procedure.

4.2 Contractor Quality Assurance/Quality Control (QA/QC) Officer

The QA/QC Officer is responsible for approving this procedure and verifying that this procedure is being implemented.

4.3 Contractor Health and Safety (H&S) Officer

The H&S Officer is responsible for ensuring that appropriate and contractual H&S policies and procedures are in effect and verify enforcement of same by line management.

4.4 Contractor Program or Project Manager

The Program or Project Manager is responsible for:

- designating a qualified person to train personnel who will be using this procedure
- ensuring that this and all appropriate procedures are followed
- the interpretation of these operating instructions
- verifying that the appropriate training records are submitted to the Central Records Facility

4.5 Contractor Field Sampling Team Leader

The Field Sampling Team Leader is responsible for:

- assigning field sampling team members
- coordinating and preparing for field sampling and field analytical activities by ensuring compliance with the SAP and field procedures (including operating instructions)

- ensuring that the field sampling team members and the field analysts are appropriately trained and the training is properly documented
- overall management of field activities.

4.6 Contractor Field Sampling Team Members

The field sampling team members are responsible for:

- assisting the field sampling team leader in selecting locations and intervals for sampling as identified in the SAP
- collecting the required field samples, appropriately documenting sample collection activities, properly labeling samples, and delivering samples to the field analysts

4.7 Contractor Field Analysts

The field analysts are responsible for:

- implementation of and adherence to this field analytical procedure
- performing appropriate calibrations
- analyzing samples
- performing QC analysis
- maintaining analytical equipment
- documenting information according to the steps defined in this procedure.

5.0 GENERAL INFORMATION

- 5.1** Any deviation from this procedure's requirements will be justified to and authorized by the Contractor Project Manager or Program Manager.
- 5.2** Deviations from this procedure's requirements must be sufficiently documented to allow re-creation of the modified process.
- 5.3** Refer to and implement the site- or project-specific H&S Plan for relevant H&S requirements.
- 5.4** Refer to and implement the project-specific SAP for relevant sampling and analysis requirements.
- 5.5** It is RVAAP policy to maintain an effective program to control employee exposure to chemical, radiological, and physical stress which is consistent with U.S. Occupational Safety and Health Administration (OSHA) established standards and requirements.
- 5.6** Refer to and implement the site- or project-specific Waste Management Plan for relevant waste and waste disposal requirements.
- 5.7** Subcontractor personnel who implement this procedure must provide documented evidence of having been trained in the procedure to the Program Manager of Project Manager in accordance with subsection 4.5.

- 5.8** Data Quality Objectives (DQOs) for field analyses should be identified in project-specific documents (WP, SAP, QAPjP). As presented, this procedure provides appropriate guidance to produce quantitative screening data. QC includes multi-level calibration, method blank information, and control sample analysis. Duplicate analytical information is optional.
- 5.9** Sample analytical reports and QC information will be provided to the Sampling Team Leader daily. In addition, sample results may be requested as determined by the Sampling Team Leader.
- 5.10** Upon completion of a project, final data packages will be assembled including but not limited to; analytical results, QC data, calibration information, and a written summary of each day's activities.
- 5.11** For additional information regarding instrument calibration, adjustment, maintenance, or replacement components, consult the manufacturer's instruction and operational manuals.
- 5.12** Sampling equipment needed for the collection of soils and sediments will vary depending on project requirements and will be identified in the project-specific SAP.
- 5.13** The analyst must be capable of making judgment calls and technical decisions based upon a clear understanding of Beer Lambert's Law, dilutions; along with the ability to execute proper analytical measurement techniques.

6.0 INTERFERENCES

- 6.1** Several other nitroaromatic compounds have been investigated which develop a visible color when processed through the procedure and measured at 540 nm; Tetryl (orange), TNB (red), DNB (purple) and 2,4,6-DNT (pink). These compounds, if present, may contribute to the sample absorbance and be calculated as TNT.
- 6.2** Similar color development was not observed for other nitroaromatics, e.g., RDX, HMX, nitrobenzene o-nitrotoluene, m-nitrotoluene, p-nitrotoluene, nitroglycerine, 4-amino-2,6-dinitrotoluene or 2-amino-4,6-dinitrotoluene, with the TNT method. These compounds, if present, would not contribute to the color intensity at 540 nm.
- 6.3** Humic organic matter in soil is extracted to some degree with the TNT method and yields a yellow color that becomes darker upon addition of the procedure's reagents. The contribution of this interference is estimated and accounted for with the background correction step outlined in this procedure.
- 6.4** Percentage of H₂O (ice and water) in soil samples can alter the color development time. In addition, results should be noted as wet weight.
- 6.5** The Griess Reaction that produces the red azo dye in the RDX determination will also produce similarly-colored products if HMX, nitroglycerine, nitrocellulose, PETN, or nitroguanidine are present in the soil. This reaction keys on the presence of organo-nitrates and may give false positive results for RDX in samples from areas where destruction of explosives has occurred as a result of detonation or burning.

- 6.6** Humic substances that produce a background yellow color in the acetone extract are removed when the extract is acidified with acetic acid and filtered prior to RDX determination. Therefore, there is no requirement to obtain and subtract an initial absorbance from the final absorbance after color development.

7.0 SAFETY INFORMATION

- 7.1** Normal safety precautions associated with laboratory use of a flammable organic solvent should be employed.
- 7.2** Acetone and acetone solutions spilled on skin should be rapidly rinsed off with water.
- 7.3** Organic solvents and solvent wastes must be stored separately from strong oxidizers (e.g., nitric acid) and never mixed with them.
- 7.4** Flammable materials must be stored in approved containers and locations.
- 7.5** Eye protection must be worn at all times and by all individuals entering the field laboratory area.

8.0 INSTRUMENTS AND SUPPLIES

8.1 Instrumentation

- 8.1.1** Spectrophotometer – Fixed wavelength, battery-operated (e.g., HACH DR 2000) or for standard 110 v electrical if available at the project. Need a measurement path width of 25 mm (1 in.) for maximum sensitivity.
- 8.1.2** Balance – Accurate to 0.1 gram or better. Electrical (e.g., 110 v plug in) or battery-operated preferred. Mechanical is acceptable, but calibration check needs to be performed more frequently.

8.2 Chemicals and Reagents

- 8.2.1** TNT – Traceable to a known quality SARM, provided commercially as a certified grade neat material, or standard of known concentration in a known solvent. (Typically from commercial standards preparation as 1,000 ppm in acetone or methanol. Prefer 5,000 to 10,000 ppm if available.)
- 8.2.2** RDX – Traceable to a known quality SARM, provided commercially as a certified grade neat material, or standard of known concentration in a known compatible solvent. (Typically available as 1,000 ppm in acetonitrile; prefer as 5,000 or 10,000 ppm in acetone or methanol.)
- 8.2.3** Acetone – Commercially available as reagent grade from chemical suppliers. Also available off-the-shelf from local hardware or paint stores.

Caution – Acetone is a volatile solvent and must be used only in a well ventilated temperature controlled environment.

Caution – Acetone is often a site contaminant of concern. As such, both analyst and sampling personnel must be aware of its presence and potential impact for cross contamination of samples destined for volatile organic analyses.

8.2.4 Glacial Acetic Acid – Reagent grade from chemical supplier.

8.2.5 Potassium Hydroxide – Reagent grade pellets

8.2.6 Sodium Sulfite – Granular, reagent grade.

8.2.7 Zinc – Metal powder, reagent grade. Note: Must be kept dry in a dessicator.

8.2.8 Clean Sand – Sand being used for well construction or commercially available play sand that has been acetone washed.

8.2.9 Water Deionized – Commercially available from chemical supplier or off-the-shelf from local drug or food stores.

8.2.10 HACH NitroVer 3 Powder Pillow.

8.3 Supplies

Caution – Acetone is a strong solvent that readily dissolves a majority of plastics. If substitutions are made to the following items, be sure they are compatible with acetone (i.e., polypropylene, nylon, glass, or Teflon) and do not attribute any color, turbidity or organo-nitrate materials.

8.3.1 Bottles

- 250-ml polypropylene bottles with screw top caps.
- 30-ml polypropylene bottle and screw cap.

8.3.2 Squeeze wash bottles with hazard label:

- 1 liter deionized water
- 1 liter acetone

8.3.3 Serological Pipettes

- 2 ml
- 10 ml

8.3.4 Pipette Bulbs – Safety pipette filters

8.3.5 Transfer Pipettes and Tips

- 10 ml repipet sampling pipettes
- 10 ml repipet sampling Pipettes Tip pkg 100

8.3.6 Volumetric Flasks

- 50 ml polypropylene
- 100 ml polypropylene

- 25 ml glass

8.3.7 Graduated Cylinders

- 10 ml polypropylene
- 50 ml polypropylene
- 100 ml polypropylene

8.3.8 Syringes

- 0.250 ml Hamilton Gastight fixed needle
- 2.50 ml Hamilton Gastight fixed needed
- 60 ml; Luer-Lock disposable syringes

8.3.9 Syringe Filters

- 25 mm; 0.45 nm nylon filters in polypropylene housing; Luer Lock fitting (Milex SR; Whatman GD/X or equivalent)

8.3.10 Spectrophotometer Cuvetts

- 3 – matched pairs; 25 mm path length compatible with spectrophotometer

8.3.11 Tongue Depressors

- 1 box

8.3.12 Desiccant system

- 1 small desiccator cabinet
- 2 silica gel desiccant cans

8.3.13 Alumina A Cartridge

- Alumina A ion exchange cartridge, 6 ml capacity

8.3.14 1000 ml Polypropylene beaker

9.0 METHOD CALIBRATION

9.1 Standards Preparation

Four types of standards are prepared for each of the two analytical parameters. Actual concentrations and transfer volumes will be dependent on the stock solution concentration being used. The four standards to be prepared are the: working stock, calibration, Laboratory Control Sample (LCS) spiking, and Continuous Calibration Verification (CCV).

9.1.1 Working Stock Standards

SARM Source

Dry to a consistent weight over night in a desiccator. Weigh ~0.5 g on a 4 place balance, transfer and dilute to volume in a 100 ml volumetric flask with acetone. This gives ~5,000 ppm stock solution. Store in either a sealed serum vial or tightly capped 20 ml polypropylene or glass bottle with minimal headspace that has been blackened to keep light out.

Working Stock Solution 40 ppm

Source Concentration (ppm)	Transfer Volume ¹ (ml)	Final Volume (ml acetone)	Final Concentration (ppm)
10,000 ²	0.20	50	40
5,000 ^{2,3}	0.40	50	40
1,000 ²	1.00	25	40

¹Transfer using the 2.5 ml gastight syringe.

²Commercially prepared standard source.

³Prepared source from either a SARM or available solid material source of known purity.

9.1.2 Calibration Standards

TNT Calibration Standards

Working Stock (ppm)	Transfer ¹ Volume (ml)	Final ² Volume (ml acetone)	Water ³ Volume (ml)	Final Conc. (ppm)
40	0.5	100	3	0.2
40	1.0	100	3	0.4
40	2.0	100	3	0.8
40	5.0	50	1.5	4.0
40	10.0	50	1.5	8.0

¹Transfer using to deliver serological pipettes.

²Bring up to final volume in volumetric flask with Acetone.

³Add defined water to volumetric flask after bringing to volume and prior to mixing, essentially giving a final volume of 103 & 51.5 ml.

RDX Calibration Standards

Working Stock (ppm)	Transfer ¹ Volume (ml)	Final ² Volume (ml acetone)	Water ³ Volume (ml)	Final Conc. (ppm)
40	1.2	100	3	0.48
40	2.5	100	3	1.0
40	2.5	50	1.5	2.0
40	5	50	1.5	4.0
40	9	50	1.5	7.2

¹Transfer using to deliver serological pipettes.

²Bring up to final volume in volumetric flask with Acetone.

³Add defined water to volumetric flask after bringing to volume and prior to mixing, essentially giving a final volume of 103 & 51.5 ml.

9.1.3 Continuing Calibration Verification Standards

TNT 0.8 ppm

Working Stock (ppm)	Transfer ¹ Volume (ml)	Final ² Volume (ml acetone)	Water ³ Volume (ml)	Final Conc. (ppm)
40	2.0	100	3	0.8

¹Transfer using serological pipettes.

²Bring up to final volume in volumetric flask with Acetone.

³Add defined water to volumetric flask after bringing to volume and prior to mixing, essentially giving a final volume of 103 ml.

RDX 2.0 ppm

Working Stock (ppm)	Transfer ¹ Volume (ml)	Final ² Volume (ml acetone)	Water ³ Volume (ml)	Final Conc. (ppm)
40	5.0	100	3	2.0

¹Transfer using serological pipettes.

²Bring up to final volume in volumetric flask with Acetone.

³Add defined water to volumetric flask after bringing to volume and prior to mixing, essentially giving a final volume of 103 ml.

9.1.4 Laboratory Control Standards

The RDX and TNT LCS are prepared at the same time on the same aliquot of clean sand.

Sand Weight (g)	RDX Transfer Volume/Conc. (ml/ppm)	TNT Transfer Volume/Conc. (ml/ppm)	Water Volume (ml)	Acetone Volume (ml)	Final TNT/RDX Conc. PRM
20	5.0/40	2.0/40	3	93	0.8/2.0

Note: Typically the LCS is allowed to stand 1 hour after standard spiking and prior to water and solvent addition to allow the solvent to evaporate and the compound to come into contact with the soil. However, this is not done in this procedure due to large volume of spiking solutions being added.

9.2 Calibration

9.2.1 TNT Calibration

1. Zero spectrophotometer reading with an acetone blank.
2. Place a 25 ml aliquot of each prepared standard in a 30-ml bottle.
3. Add 4-5 KOH pellets and 0.5 g (excess) of Na₂SO₃ to each standard.
4. Cap bottle, shake, and allow a minimum of 10 minutes for color development.
5. Filter through syringe filter into cuvet and read absorbance at 540 nm.

9.2.2 RDX

1. To a measured 20 ml aliquot of each prepared standard in a 30 ml bottle, add 2 ml of acetic acid (using 10 ml sampling pipetor set to 2ml), mix and transfer to a prepared 60 ml syringe and filter unit containing ~0.3g of zinc powder.

2. Twelve seconds after pouring the standard solution into the syringe, insert the plunger and begin filtering the derivitized extract through the filter back into the original 30 ml container. Filtration must be continuous once initiated and at a rate that does not allow the extract to be in contact with the zinc for more than 25 seconds total.
3. Measure and transfer 5 ml of the filtered extract (using a 10 ml sampling pipetor set to 5ml) to a second 30 ml bottle containing 20 ml of DI water (measure and transfer using a 10 ml sampling pipetor).
4. Add content of one NitroVer 3 powder pillow.
5. Cap, shake, and allow a minimum of 15 minutes for color development.
6. Zero the spectrophotometer with DI water.
7. Measure absorbance of each standard at 507 nm.

9.3 Calculations and Acceptance Criteria

9.3.1 Response Factor

$$RF = \frac{CONC_{STD}}{ASB_{STD}}$$

where

- RF = Response factor for a given standard as mg/l compound per absorbance unit,
 CONC_{STD} = Concentration of measured standard as mg/l,
 ASB_{STD} = Absorbance reading of spectrophotometer for measured standard.

9.3.2 Relative Standard Deviation (% RSD)

$$\%RSD = \frac{RF_{SO}}{RF_{AVG}} \times 100$$

where

- %RSD = Relative standard deviation as a percentage,
 RF_{SO} = The standard deviation of all the RFs used in the calibration curve, (N is equal to 5 if all points are used or 4 if one point is eliminated)
 RF_{AVG} = Average response factor for all the RFs used in the calibration curve.

9.3.3 Calibration Criteria

The calibration curve is acceptable if the % RSD is < 25%. Note the use of all 5 points is preferable; however, the elimination of one point and use of 4 points is acceptable.

9.4 Continuing Calibration Verification (CCV)

9.4.1 A CCV needs to be analyzed under the following circumstances:

- Start and end of each days work for each compound
- At the completion of a compound's analytical sequence prior to changing the spectrophotometer wavelength setting

- Prior to the start of the compound's analysis sequence after changing the spectrophotometer wavelength setting.

9.4.2 CCV Analysis

The CCV standard will be prepared as defined in Section 9.1.3 for the applicable compound. The CCV standard will be developed according to the steps defined in Section 9.2.1 for TNT and 9.2.2 for RDX.

9.4.3 CCV Calculations and Acceptance Criteria

Acceptance that the derivitization, color development, and spectrophotometric system is in control is based on the comparability of the found CCV concentration to the expected CCV concentration, (i.e., percent recovery; %R).

$$\%R = \frac{CCV_{MES}}{CCV_{EXP}} \times 100$$

where

- %R = Percent recovered,
- CCV_{MES} = Measured concentration of CCV using the RF from the applicable, calibration curve,
- CCV_{RXP} = Concentration of the prepared standard used for the CCV.

A %R of 75-125% is acceptable and the system has been demonstrated to be in control. Recoveries outside this range will require appropriate corrective action and evaluation of results for affected samples.

10.0 SAMPLE PREPARATION AND ANALYSIS

10.1 Expendable Materials

The following expendable materials are needed for the analysis of a sample for both TNT and RDX.

- 1 – 250 ml polypropylene bottle with screw cap
- 3 – 60 ml syringes with fitted filters
- 3 – syringe filters
- 3 – 30 ml polypropylene bottles with screw cap
- KOH pellets
- Sodium sulfite
- Zinc powder
- 1-HACH NitroVer 3 powder pillow

10.2 Sample Extraction

10.2.1 LCS and Method Blank

Weigh two 20 g aliquots of clean sand into two separate 250 ml bottles. Mark one bottle as the method blank and leave unspiked adding only 3 ml water and 100 ml acetone. Mark the second bottle as the LCS and prepare as defined in Section 9.1.4.

10.2.2 Sample Preparation

To an appropriate marked 250 ml bottle, weigh $20 \text{ g} \pm 0.5 \text{ g}$ of soil/sediment sample and record to the nearest 0.1 g. Measure and add 100 ml of acetone to the soil cap and shake for a minimum of 3 minutes. Allow the bottle to set a reasonable amount of time and let the soil/sediment settle out.

For the TNT background color measurement and RDX analysis, pull 40 ml of acetone from above the sediment up through the filter into Syringe 1.

10.3 TNT Analysis

10.3.1 Color Development

For TNT analysis, remove the syringe plunger from Syringe 2 and place 4 to 5 KOH pellets and $\sim 0.5 \text{ g}$ of Na_2SO_3 into the syringe barrel and replace the plunger. Place the tip of the syringe filter into the acetone extract above the sediment and pull 25 ml of extract into the syringe. Shake and allow a minimum of 10 minutes for color development. (Note: color development rate can be temperature dependent; therefore, it may be necessary to allow more development time during cold weather.)

10.3.2 Background Measurement

Remove the filter from Syringe 1 (Section 10.2.2), and fill the 10 ml cuvet $\frac{3}{4}$ full. Measure the absorbance of the sample's background color at 540 nm on the spectrophotometer. Record the absorbance in the appropriate logbook form column.

10.3.3 TNT Color Measurement

After the color development time has elapsed, change the filter on the TNT color syringe (Syringe 2). Filter the colored extract into the 10 ml cuvet until it is $\frac{3}{4}$ full. Measure the absorbance of the sample at 540 nm on the spectrophotometer. Record the absorbance in the logbook.

Calculate the TNT concentration based on the formula in Section 11.1 and the applicable Average Response Factor from the applicable calibration curve.

10.4 RDX Analysis

10.4.1 Ion Exchange

Remove the filter from Syringe 1 (Section 10.2.2) and use the extract to fill the reservoir above the solid phase in the Supelco Alumina-A ion exchange tube. (Note: Flow of the extract through the ion column should not exceed 5 ml/min. For the defined tubes, the acetone extract typically has a flow rate of 2 to 3 mls/min (an occasional check of the flow rate is recommended).)

Discard the first 2 to 3 ml that passed through the column. Collect the next 20 ml of extract that passes through the column. Pour a measured 20 ml of the ion exchanged extract into a 30 ml bottle.

10.4.2 Derivatization

Add 2 ml of glacial acetic acid to the 20 mls of ion exchanged extract, using a preset and dedicated 10 ml sampling pipetor. (Note: In cold weather temperature <40°F arrangements need to be made to keep the acetic acid warm to keep it from crystallizing.) Transfer the entire contents of the 30 ml bottle to a prepared syringe containing ~0.3 g of dry zinc powder. Pour it into the barrel through the top with the plunger removed. After 12 seconds, replace the syringe plunger and begin to filter the derivitized extract back into the 30 ml bottle. The filtration needs to be consistent in starting at 12 seconds and not taking more than 10 to 15 seconds to complete.

10.4.3 RDX Color Development and Measurement

Measure and transfer 5 ml of the derivitized extract, using a dedicated preset sampling pipetor, to a second 30 ml bottle with 20 ml of DI water. Add the contents of one NitroVer 3 powder pillow, cap, mix, and allow 15 minutes for color development. (Note: set the remaining derivitized sample aside for re-analysis or dilutions, if necessary.)

After the color has developed, measure the absorbance at 507 nm on the spectrophotometer. Calculate the RDX concentration based on the Average Response Factor for the applicable calibration curve using the calculations found in Section 11.2.

11.0 CALCULATIONS

11.1 TNT Concentration

$$TNT_{CONC} = \frac{(ABS_{SMP} - 2XABS_{BKG}) \times RF_{AVG} \times DF}{WGT_{SMP}}$$

Where

TNT_{CONC} = Concentration of TNT in sample as ppm wet weight

ASB_{SMP} = Absorbance reading for the color developed sample extract

ASB_{BKG} = Absorbance reading for the background or non-color developed sample extract
 RF_{AVG} = Average response factor for applicable calibration curve
 DF = Dilution factor (when applicable)
 WGT_{SMP} = Weight of sample aliquot used for extraction and analysis.

11.2 RDX Concentration

$$RDX_{CONC} = \frac{ASB_{SMP} \times RF_{AVG} \times DF}{WGT_{SMP}}$$

Where

RDX_{CONC} = Concentration of RDX in the sample as ppm wet weight
 ASB_{SMP} = Absorbance reading for the color developed sample extract
 RF_{AVG} = Average response factor for applicable calibration curve
 DF = Dilution factor (when applicable)
 WGT_{SMP} = Weight of sample aliquot used for extraction and analysis.

12.0 QUALITY CONTROL

12.1 Method Blank (MB)

Prepared as defined in Section 10.2.1. A MB is analyzed daily with first batch of samples processed and at a frequency of 1 per 20 samples, thereafter. The method blank is acceptable when the calculated concentration does not exceed 1.0 ppm for TNT or 2.0 ppm for RDX.

12.2 Laboratory Control Sample (LCS)

Prepared as defined in Section 10.2.2. The LCS is analyzed daily with first batch of samples processed and at a frequency of 1 per 20 samples thereafter. Acceptable if %R is 60-140%.

12.3 Duplicate Analysis (DUP)

One laboratory duplicate analysis is performed for every 20 field samples analyzed. Samples for duplicate analysis can be selected at a later time based on samples having a positive result. Acceptable if RPD values are <50% for samples with concentrations >10 ppm and <90% for sample concentrations <10 ppm. (Note: Method resolution needs to be taken into consideration before accepting or rejecting duplicate analysis.)

12.4 Reporting Limit

The lower reporting limit is calculated based on the concentration of the lowest standard used in the applicable calibration curve adjusted for the extraction volume and sample weight.

12.5 QC Summary

QC Parameter	Frequency	Acceptance criteria
Calibration curve	Start of project; major change to instrument or procedure; failure of CCV	% RSD < 25%
CCV	Start of day End of day Before and after changing spectrophotometer wavelength	%R 75 ± 125%
Method blank	1 per day and as needed to achieve 1 per 20 ratio	< 1 ppm TNT < 2 ppm RDX
LCS	1 per day and as needed to achieve 1 per 20 ratio	%R 60-140%
Analytical duplicate	1 per 20 samples; preferable on samples with positive hits	Concentrations > 10 ppm RPD < 50% Concentrations < 10 ppm RPD < 90%

13.0 ANALYTICAL WASTE

The major waste generated during the implementation of this procedure will be extract solutions and colored complex solutions. These solutions are caustic flammable solvent wastes and should be handled as such. These wastes must be properly containerized and labeled. Coordination must be established with the site waste manager, and disposal must be in accordance with the site Waste Management Plan.

Other general waste generated during the analysis should not represent a chemical or biological hazard, however, proper site handling and disposal procedures should be implemented.

14.0 EQUIPMENT AND SUPPLIES

14.1 Nonexpendable

Item	Supplier	Catalog No.	Units	Order
DR2010 Spectrophotometer	HACH	DR2010	ea	1
10 ml DR2010 matched cuvetts	HACH	24954-02	pair	3
Top-loading balance	Cole Palmer	E11300-06	ea	1
10 ml Polypropylene serological pipets	Fisher	13-662-12D	ea	2
Pipet safety bulb	Fisher	13-681-51	ea	3
10 ml Sampling respirator	Fisher	13-689-26	ea	3
10 ml Polypropylene graduated cylinder	Fisher	08-572A	ea	8
50 ml Polypropylene graduated cylinder	Fisher	08-572C	ea	3
100 ml Polypropylene graduated cylinder	Fisher	08-572D	ea	3
Dessicator Cabinet	Fisher	08-647-20	ea	1
Desiccant Cans	Fisher	01-952-5	ea	2
50 ml Propylene volumetric flask	Fisher	10-198-50A	ea	5
100 ml Propylene volumetric flask	Fisher	10-198-50B	ea	5
25 ml glass volumetric flask	Fisher	10-200A	ea	3
Acetone washbottle	Fisher	03-409-23A	pkg/6	1
Water washbottle	Fisher	03-409-23G	pkg/6	1
0.250 ml Hamilton gastight syringe	Fisher	13-684-102	ea	2
2.5 ml Hamilton gastight syringe	Fisher	13-684-110	ea	3

14.2 Expendable

Item	Supplier	Catalog No.	Units	Order
60 ml disposable syringe Luer lock	Fisher	14-823-2D	Case/120	3
25 mm; 0.45 nylon; polypropylene housing syringe filters	Fisher	09-740-35Q	case/300	2
Acetone	local paint or hardware supplier		gal.	3
Zinc powder technical grade	Fisher	25-500	500g	1
DI water	Fisher	W2-4	Ll	2
Sodium sulfide technical; granular	Fisher	5447-500	500 g	1
Potassium hydroxide technical; pellets	Fisher	P250-500	500 g	1
Acetic acid glacial	Fisher	A385-500	500 ml	1
Polypropylene bottles 250 ml	Fisher	03-083-52	case/72	1
Polypropylene bottles 30 ml	Fisher	03-083-49	case/72	1
Alumina A SPME column	Supeko	5-70834	30/pkg	4
25 ml NitroVer3 powder pillow	HACH	14034-99	100/pkg	2
Sampling respirator tips	Fisher	D7-101	100/pkg	2
RDX standard 1,000 ppm in acetonitrile	Accustandard		ea	4
TNT standard 1,000 ppm in methanol	Accustandard		ea	4
Tongue depressors	Fisher	01-346	1200/box	1
100 ml Tripour polypropylene beaker	Fisher	02-593-50F	pkg/100	1

APPENDIX B

QUALITY ASSURANCE PROJECT PLAN

FINAL

**QUALITY ASSURANCE PROJECT PLAN ADDENDUM NO. 2
FOR THE PHASE II REMEDIAL INVESTIGATION
OF LOAD LINE 1
AT THE RAVENNA ARMY AMMUNITION PLANT,
RAVENNA, OHIO**

Prepared for

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Prepared by

Science Applications International Corporation
800 Oak Ridge Turnpike, P.O. Box 2502
Oak Ridge, Tennessee 37831

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ABBREVIATIONS

COC	chain of custody
CX	Center of Expertise
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
HTRW	Hazardous, Toxic, and Radioactive Waste
LCS	laboratory control sample
MS	matrix spike
MSD	matrix spike duplicate
PCB	polychlorinated biphenyl
QA	quality assurance
QC	quality control
QAMP	Quality Assurance Management Plan
QAPP	Quality Assurance Project Plan
RI	remedial investigation
RVAAP	Ravenna Army Ammunition Plant
SAP	Sampling and Analysis Plan
SOP	standard operating procedure
TAL	Target Analyte List
TCL	Target Compound List
USACE	U.S. Army Corps of Engineers

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INTRODUCTION

This Quality Assurance Project Plan (QAPP) addendum addresses supplemental project-specific information in relation to the facility-wide QAPP for the Ravenna Army Ammunition Plant (RVAAP), Ravenna, Ohio. Each QAPP section is presented documenting adherence to the facility-wide QAPP or stipulating project-specific addendum requirements.

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1.0 PROJECT DESCRIPTION

1.1 SITE HISTORY/BACKGROUND INFORMATION

This information is contained in Section 1.1 of the Load Line 1 Phase II Remedial Investigation (RI) Sampling and Analysis Plan (SAP) Addendum No. 2.

1.2 PAST DATA COLLECTION ACTIVITY/CURRENT STATUS

This information is contained in Section 1.2 of the Load Line 1 Phase II RI SAP Addendum No. 2.

1.3 PROJECT OBJECTIVES AND SCOPE

This information is contained in Chapter 3.0 of the Load Line 1 Phase II RI SAP Addendum No. 2.

1.4 SAMPLE NETWORK DESIGN AND RATIONALE

This information is contained in Chapter 4.0 of the Load Line 1 Phase II RI SAP Addendum No. 2.

1.5 PARAMETERS TO BE TESTED AND FREQUENCY

Sample matrix types, analytical parameters, and analytical methods are discussed in Chapter 4.0 of the Load Line 1 Phase II RI SAP Addendum No. 2. These are summarized in Table 1-1 of this QAPP addendum, in conjunction with anticipated sample numbers, quality assurance (QA) sample frequencies, and field quality control (QC) sample frequencies.

1.6 PROJECT SCHEDULE

The Load Line 1 Phase II RI project schedule is discussed in Chapter 2.0 of the SAP Addendum No. 2.

Table 1-1. Phase II RI of Load Line 1, RVAAP – Sampling and Analytical Requirements

Parameter	Methods	Field Samples	Field Duplicate Samples	Site Source Water ^a	Sampler Rinsates	Trip Blanks	Total A-E Samples	USACE QA Split Samples	USACE Trip Blanks
<i>Soils/Sediments</i>									
Field TNT/RDX Screening	RVAAP SOP 2000	345	35	-	-	-	380	-	-
Field Metals Screening	SW-846, 6200	345	35	-	-	-	380	-	-
Volatile Organics, TCL	SW-846, 5030/8260B	41	4	-	-	-	45	4	-
Semivolatile Organics, TCL	SW-846, 3540/8270C	41	4	-	-	-	45	4	-
Pesticides, TCL	SW-846, 3540/8081A	41	4				45	4	
PCBs, TCL	SW-846, 3540/8082	41	4	-	-	-	45	4	-
Explosives	SW-846, 8330	163	16	-	-	-	179	16	-
Propellants	SW-846, 8330	163	16	-	-	-	179	16	-
Metals, TAL	SW-846, 6010B/7471	345	35	-	-	-	380	35	-
Cyanide	SW-846, 9011/9010	172	17	-	-	-	189	17	-
Grain Size	ASTM D422	60	-	-	-	-	60	-	-
TOC	SW846, 9060	50	-	-	-	-	50	-	-
Moisture Content	ASTM D2216	20	-	-	-	-	347	-	-
Atterberg Limits	ASTM D4318	10	-	-	-	-	10	-	-
USGS Classification	N/A	10	-	-	-	-	10	-	-
Bulk Density	ASTM D4531	2	-	-	-	-	2	-	-
Porosity	EM1110-2-1906	2	-	-	-	-	2	-	-
Hydraulic Cond.	ASTM D5084	2	-	-	-	-	2	-	-
Specific Gravity	ASTM D854	2	-	-	-	-	2	-	-
pH	SW-846 9045	2	-	-	-	-	2	-	-
<i>Contingency Soils/Sediments</i>									
Field TNT/RDX Screening	RVAAP SOP 2000	69	7	-	-	-	76	-	-
Field Metals Screening	SW-846, 6200	69	7	-	-	-	76	-	-
Volatile Organics, TCL	SW-846, 5030/8260B	8	1	-	-	-	9	1	-
Semivolatile Organics, TCL	SW-846, 3540/8270C	8	1	-	-	-	9	1	-
Pesticides, TCL	SW-846, 3540/8081A	8	1				9	1	
PCBs	SW-846, 3540/8082	8	1	-	-	-	9	1	-
Explosives	SW-846, 8330	30	3	-	-	-	33	3	-
Propellants	SW-846, 8330	30	3	-	-	-	33	3	-
Metals, TAL	SW-846, 6010B/7471	69	7	-	-	-	76	7	-
Cyanide	SW-846, 9011/9010	35	4	-	-	-	35	4	-
Moisture Content	ASTM D2216	69	-	-	-	-	69	-	-

Table 1-1 (continued)

Parameter	Methods	Field Samples	Field Duplicate Samples	Site Source Water ^a	Sampler Rinsates	Trip Blanks	Total A-E Samples	USACE QA Split Samples	USACE Trip Blanks
<i>Surface Waters/Groundwaters</i>									
Volatile Organics, TCL	SW-846, 5030/8260B	11	1	-	1	2	15	1	1
Semivolatile Organics, TCL	SW-846, 3520/8270C	11	1	-	1	-	13	1	-
Pesticides, TCL	SW-846, 3520/8081A	11	1	-	1	-	13	1	
PCBs, TCL	SW-846, 3520/8082	11	1	-	1	-	13	1	-
Explosives	SW-846, 8330	33	4	-	1	-	38	4	-
Propellants	SW-846, 8330	33	4	-	1	-	38	4	-
Metals (total), TAL	SW-846, 6010A/7470	47*	6	-	1	-	54	6	-
Cyanide	SW-846, 9010	33	4	-	1	-	38	4	-

^aSource waters = one potable water source and one ASTM water supply lot for the project.

*Fourteen ground water samples will be analyzed for both total and dissolved metal content.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITY

The functional project organization and responsibilities are described in Chapter 2.0 of the facility-wide SAP and the Load Line 1 Phase II RI SAP Addendum No. 2.

Analytical support for this work has been assigned to Severn Trent Laboratories, Inc. [(STL), formerly Quanterra]. The majority of analysis will be completed by STL's North Canton, Ohio facility, with explosive determinations being performed by the Knoxville, Tennessee facility and nitrocellulose/nitroguanidine analyses being performed by the Sacramento, California facility. These laboratories have been validated by the U.S. Army Corp of Engineers (USACE) Hazardous, Toxic, and Radioactive Waste (HTRW) Center of Expertise (CX), Omaha, Nebraska. Severn Trent Laboratories' Quality Assurance Management Plan (QAMP), Revision 3, November 1998, is available for review upon request. The laboratory's organizational structure, roles, and responsibilities are identified in Section 1 of their QAMP and facility-specific appendices. Addresses and telephone numbers for each of the STL facilities are as follows:

Analytical Facilities

Severn Trent Laboratories, Inc. – general analytical services:

North Canton, OH
4101 Shuffel Drive, N.W.
North Canton, OH 44720

Tel: (330) 497-9396
Fax: (330) 497-0772

Severn Trent Laboratories, Inc. – explosives analyses:

Knoxville, TN
5815 Middlebrook Pike
Knoxville, TN 37921

Tel: (423) 588-6401
Fax: (423) 584-4315

Severn Trent Laboratories, Inc. – nitrocellulose/nitroguanidine analyses:

Sacramento, CA
880 Riverside Parkway
West Sacramento, CA 95605

Tel: (916) 373-5600
Fax: (916) 372-1059

3.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT

3.1 DATA QUALITY OBJECTIVES

Data quality objectives (DQO) summaries for this investigation will follow Tables 3-1 and 3-2 in the facility-wide QAPP. All QC parameters stated in the specific U.S. Environmental Protection Agency (EPA) SW-846 methods will be adhered to for each chemical listed. SW-846 Method references found in the facility-wide QAPP have been revised to the Update III Methods (i.e., 8260A is now 8260B, 8270B is now 8270C, etc.). Laboratories are required to comply with all methods as written; recommendations are considered requirements. Concurrence with the USACE Shell Document for Analytical Chemistry Requirements, version 1.0, 2 Nov 98 and Environmental Data Assurance Guideline, USACE-Louisville, May 2000 is expected.

3.2 LEVEL OF QUALITY CONTROL EFFORT

QC efforts will follow Section 3.2 of the facility-wide QAPP. Field QC measurements will include field source water blanks, trip blanks, field duplicates, and equipment rinsate blanks. Laboratory QC measurements will include method blanks, laboratory control samples (LCSs), laboratory duplicates, and matrix spike/matrix spike duplicate (MS/MSD) samples.

3.3 ACCURACY, PRECISION, AND SENSITIVITY OF ANALYSIS

Accuracy, precision, and sensitivity goals identified in Section 3.3 and Tables 3-1 through 3-9 of the facility-wide QAPP will be imposed for this investigation.

3.4 COMPLETENESS, REPRESENTATIVENESS, AND COMPARABILITY

Completeness, representativeness, and comparability goals identified in Section 3.4 and Tables 3-1 and 3-2 of the facility-wide QAPP will be imposed for this investigation.

4.0 SAMPLING PROCEDURES

Sampling procedures are discussed in Chapter 4.0 of the facility-wide SAP and SAP Addendum for the Phase II RI at Load Line 1.

Table 4-1 summarizes sample container, preservation, and holding time requirements for the soil, sediment, and water matrices for this investigation. The number of containers required is estimated in this table.

Table 4-1. Container Requirements for Water, Soil, and Sediment Samples for the Load Line 1 Phase II RI at Ravenna Army Ammunition Plant^a

Analyte Group	Approx. No. of Containers incl. Field QC	Container	Minimum Sample Size	Preservative	Holding Time
<i>Groundwater and Surface Water</i>					
Volatile Organic Compounds	51	Three, 40-mL glass vials with Teflon®-lined septum (no headspace)	80 mL	HCl to pH <2 Cool, 4°C	14 d
Semivolatile Organic Compounds	28	Two, 1-L amber glass bottles with Teflon®-lined lid	1000 mL	Cool, 4°C	7 d (extraction) 40 d (analysis)
Pesticide Compounds	28	Two, 1-L amber glass bottles with Teflon®-lined lid	1000 mL	Cool, 4°C	7 d (extraction) 40 d (analysis)
PCB Compounds	28	Two, 1-L amber glass bottles with Teflon®-lined lid	1000 mL	Cool, 4°C	7 d (extraction) 40 d (analysis)
Explosive Compounds	84	Two, 1-L amber glass bottles with Teflon®-lined lid	1000 mL	Cool, 4°C	7 d (extraction) 40 d (analysis)
Propellant Compounds	84	Two, 1-L amber glass bottles with Teflon®-lined lid	1000 mL	Cool, 4°C	7 d (extraction) 40 d (analysis)
Metals (total and dissolved)	60	1-L polybottle	500 mL	HNO ₃ to pH <2 Cool, 4°C	180 d
Cyanide	42	1-L polybottle	500 mL	NaOH to pH >12 Cool, 4°C	14 d
<i>Soils and Sediments</i>					
Volatile Organic Compounds	60	One 2-oz. Glass jar with Teflon-lined cap (no headspace)	20 grams	Cool, 4°C	14 d
Semivolatile Organic Compounds	60	One 4-ounce glass jar with Teflon-lined cap	100 grams	Cool, 4°C	14 days (extraction) 40 days (analysis)
Pesticide Compounds	–	One 4-ounce glass jar with Teflon-lined cap Use same container as SVOC.	100 grams	Cool, 4°C	14 days (extraction) 40 days (analysis)
PCB Compounds	–	Use same container as SVOC.	100 grams	Cool, 4°C	14 days (extraction) 40 days (analysis)
Explosive Compounds	210	One 4-ounce glass jar with Teflon-lined cap	100 grams	Cool, 4°C	14 days (extraction) 40 days (analysis)
Propellant Compounds	210	One 4-ounce glass jar with Teflon-lined cap	100 grams	Cool, 4°C	14 days (extraction) 40 days (analysis)
Metals	500	One 4-ounce wide-mouth poly bottle	50 grams	Cool, 4°C	180 d
Cyanide	–	Use same container as metals	25 grams	Cool, 4°C	14 d
Geotechnical Parameters	10	Shelby Tube or 32-ounce wide-mouth container	1000 grams	None	None

^aOne sample will be tripled in volume for the laboratory to perform appropriate laboratory quality control analysis.

PCB = polychlorinated biphenyl

QC = quality control

5.0 SAMPLE CUSTODY

5.1 FIELD CHAIN-OF-CUSTODY PROCEDURES

Sample handling, packaging, and shipment procedures will follow those identified in Section 5.1 of the facility-wide QAPP.

5.2 LABORATORY CHAIN-OF-CUSTODY PROCEDURES

Laboratory chain of custody (COC) will follow handling and custody procedures identified in Section 8.5.3 of the STL QAMP.

5.3 FINAL EVIDENCE FILES CUSTODY PROCEDURES

Custody of evidence files will follow those criteria defined in Section 5.3 of the facility-wide QAPP.

6.0 CALIBRATION PROCEDURES AND FREQUENCY

6.1 FIELD INSTRUMENTS/EQUIPMENT

Field instruments and equipment calibrations will follow those identified in Section 6.1 of the facility-wide QAPP.

6.2 LABORATORY INSTRUMENTS

Calibration of laboratory equipment will follow procedures identified in Section 8.5.4 of the STL QAMP, corporate, and facility-specific operating procedures.

7.0 ANALYTICAL PROCEDURES

7.1 LABORATORY ANALYSIS

Analytical methods, parameters and quantitation or detection limits are those listed in Tables 3-3 through 3-9 of the facility-wide QAPP.

STL's QAMP Section 8.0 and the facility-specific addenda for the North Canton, Knoxville, and Sacramento facilities will be followed during the analysis of these samples. The following laboratory Standard Operating Procedures (SOPs) will implement the defined EPA methods.

- GC/MS Volatile Organics Analysis Based on Methods 8240B and 8260B, SW-846, CORP-MS-0002, rev 2, 12/15/97.
- GC/MS Semivolatile Analysis Based on Methods 8270C, SW-846, CORP-MS-0001, Rev. 2, 12/15/97.
- Gas Chromatographic Analysis Based on Method 8000A, 8010B, 8020A, 8021A, 8080A, 8081, 8082, 8150B, and 8051, SW-846, CORP-GC-0001, Rev. 5.1, 3/30/99.
- Extraction and Cleanup of Organic Compounds from Waters and Soils, Based on SW-846 3500 Series, 3600 Series, 8150, 8151, and 600 Series Methods, CORP-OP-0001, Rev. 3.4, 4/15/99.
- Analysis of Nitroaromatic and Nitramine Explosives by HPLC, KNOX-LC-0001, Rev. 1, 4/28/97.
- Total Organic Carbon and Total Inorganic Carbon, NC-WC-0017, Rev. 2, 2/15/99.
- Inductively Coupled Plasma-Atomic Emission Spectroscopy, Spectrometric Method for Trace Element Analysis, Methods 6010B and 200.7, CORP-MT-0001, Rev. 2, 12/15/97.
- Graphite Furnace Atomic Absorption Spectroscopy, SW-846 Methods 7000A and MCAWW 200 series methods, CORP-MT-0003, Rev. 1, 08/22/95.
- Mercury in Aqueous Samples by Cold Vapor Atomic Absorption, SW-846 7470A and MCAWW 245.1, CORP-MT-0005NC, Rev. 1.1, 04/19/97.
- Mercury in Solid Samples by Cold Vapor Atomic Absorption, SW846 7471A and McAWW 245.5, CORP-MT-0005NC, Rev. 1.1, 04/19/97.
- Preparation and analysis of Nitrocellulose in Aqueous, Soil, and Sediments by Colorimetric Autoanalyzer, SAC-WC-0050, Rev. 0.
- Determination of nitroaromatics, nitramines, and specialty explosives in water and soil by high performance liquid chromatography/ultraviolet detector (HPLC/UV) and liquid chromatography/thermospray/mass spectrometry (LC/TSP/MS), SAC-LC-0001, Rev. 5.0.

STL facilities will at all times maintain a safe and contaminant free environment for the analysis of samples. The laboratories will demonstrate, through instrument blanks, holding blanks, and analytical method blanks, that the laboratory environment and procedures will not and do not impact analytical results.

STL facilities will also implement all reasonable procedures to maintain project reporting levels for all sample analyses. Where contaminant and sample matrix analytical interferences impact the laboratory's ability to obtain project reporting levels, the laboratory will institute sample clean-up processes, minimize dilutions, adjust instrument operational parameters, or propose alternative analytical methods or procedures. Elevated reporting levels will be kept to a minimum throughout the execution of this work.

7.2 FIELD SCREENING ANALYTICAL PROTOCOLS

Procedures for field analysis are identified in Chapter 6.0 of the facility-wide SAP and in Chapter 4.0 of the Load Line 1 Phase II RI SAP Addendum No. 2.

Field screening analysis for 2,4,6-trinitrotoluene (2,4,6-TNT) and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) will be performed using the RVAAP Standard Operating Procedure "Field Method for Determination of 2,4,6-TNT and RDX in Soil and Sediment." This SOP is a formal attachment to the facility-wide QAPP.

Field screening analysis for metals will be performed using the SW846 Method 6200 "Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment."

8.0 INTERNAL QUALITY CONTROL CHECKS

8.1 FIELD SAMPLE COLLECTION

Field QC sample types, numbers, and frequencies are identified in Chapter 4.0 of the Load Line 1 Phase II RI SAP Addendum No. 2. In general, field duplicates will be collected at a frequency of 10 percent, field equipment rinsates and blanks will be collected at a frequency of 10 percent for samples collected with non-dedicated equipment, and volatile organic trip blanks will accompany all shipments containing volatile organic water samples.

8.2 FIELD MEASUREMENT

Refer to Chapter 4.0 of the Load Line 1 Phase II RI SAP Addendum No. 2 for details regarding these measurements. In addition, refer to the field screening methods for TNT, RDX, and metals.

8.3 LABORATORY ANALYSIS

Analytical QC procedures will follow those identified in the referenced EPA methodologies. These will include method blanks, LCS, MS, MSD, laboratory duplicate analysis, calibration standards, internal standards, surrogate standards, and calibration check standards.

STL facilities will conform to their QAMP, facility-specific appendices, and implement their established SOPs to perform the various analytical methods required by the project. QC frequencies will follow those identified in Section 8.3 of the facility-wide QAPP.

Analyses will also be consistent with direction provided by the USACE Shell Document for Analytical Chemistry Requirements and the Environmental Data Assurance Guideline of USACE-Louisville.

9.0 DATA REDUCTION, VALIDATION, AND REPORTING

9.1 DATA REDUCTION

Sample collection and field measurements will follow the established protocols defined in the facility-wide QAPP, facility-wide SAP, and Load Line 1 Phase II RI SAP Addendum No. 2. Laboratory data reduction will follow STL's QAMP (Section 8.6) guidance and conform to general direction provided by the facility-wide QAPP, the USACE Shell Document, and the Environmental Data Assurance Guideline of USACE-Louisville.

9.2 DATA VALIDATION

Data validation of 10% of the data will follow the direction provided in the facility-wide QAPP and the Environmental Data Assurance Guideline of USACE-Louisville. An independent data validation subcontractor qualified by USACE Louisville District will perform this data validation.

All data will be reviewed and verified by SAIC according to the facility-wide QAPP.

9.3 DATA REPORTING

Analytical data reports will follow the direction provided in the facility-wide QAPP.

10.0 PERFORMANCE AND SYSTEM AUDITS

10.1 FIELD AUDITS

A minimum of one field surveillance for the investigation will be performed by the SAIC QA Officer and/or the SAIC Field Team Leader. This audit will encompass the sampling of groundwater, surface water, soil, and sediment from the wells, ditches, ponds, land areas, and storm and sanitary sewers. Surveillances will follow SAIC QAPP No. 18.3.

USACE, EPA Region 5, or Ohio EPA audits may be conducted at the discretion of the respective agency.

10.2 LABORATORY AUDITS

Routine USACE HTRW CX on-site laboratory audits will be conducted by the USACE. EPA Region 5 or Ohio EPA audits may be conducted at the discretion of the respective agency.

Internal performance and systems audits will be conducted by STL's QA staff as defined in the laboratory QAMP, Section 9.2.

11.0 PREVENTIVE MAINTENANCE PROCEDURES

11.1 FIELD INSTRUMENTS AND EQUIPMENT

Maintenance of all field analytical and sampling equipment will follow direction provided in Section 11.1 of the facility-wide QAPP.

11.2 LABORATORY INSTRUMENTS

Routine and preventive maintenance for all laboratory instruments and equipment will follow the direction of Section 8.11 of STL's QAMP.

12.0 SPECIFIC ROUTINE PROCEDURES TO ASSESS DATA PRECISION, ACCURACY, AND COMPLETENESS

12.1 FIELD MEASUREMENTS DATA

Field data will be assessed as outlined in Section 12.1 of the facility-wide QAPP.

12.2 LABORATORY DATA

Laboratory data will be assessed as outlined in Section 12.2 of the facility-wide QAPP.

13.0 CORRECTIVE ACTIONS

13.1 SAMPLE COLLECTION/FIELD MEASUREMENTS

Field activity corrective action protocol will follow directions provided in Section 13.1 of the facility-wide QAPP.

13.2 LABORATORY ANALYSES

Laboratory activity corrective action protocol will follow directions provided in Section 13.2 of the facility-wide QAPP and Section 9.1 of STL's QAMP.

14.0 QA REPORTS TO MANAGEMENT

Procedures and reports will follow the protocol identified in Section 14 of the facility-wide QAPP and those directed by Section 9.4 of STL's QAMP.

15.0 REFERENCES

Additional references to the facility-wide QAPP are:

STL (Previously Quanterra Environmental Services, Inc.) 1998. *Quality Assurance Management Plan*, Revision 3, November 2, 1998.

GC/MS Volatile Organics Analysis Based on Methods 8240B and 8260B, SW-846, CORP-MS-0002, rev 2, 12/15/97.

GC/MS Semivolatile Analysis Based on Methods 8270C, SW-846, CORP-MS-0001, Rev. 2, 12/15/97.

Gas Chromatographic Analysis Based on Method 8000A, 8010B, 8020A, 8021A, 8080A, 8081, 8082, 8150B, and 8051, SW-846, CORP-GC-0001, Rev. 5.1, 3/30/99.

Extraction and Cleanup of Organic Compounds from Waters and Soils, Based on SW-846 3500 Series, 3600 Series, 8150, 8151, and 600 Series Methods, CORP-OP-0001, Rev. 3.4, 4/15/99.

Analysis of Nitroaromatic and Nitramine Explosives by HPLC, KNOX-LC-0001, Rev. 1, 4/28/97.

Total Organic Carbon and Total Inorganic Carbon, NC-WC-0017, Rev. 2, 2/15/99.

Inductively Coupled Plasma-Atomic Emission Spectroscopy, Spectrometric Method for Trace Element Analysis, Methods 6010B and 200.7, CORP-MT-0001, Rev. 2, 12/15/97.

Graphite Furnace Atomic Absorption Spectroscopy, SW-846 Methods 7000A and MCAWW 200 series methods, CORP-MT-0003, Rev. 1, 08/22/95.

Mercury in Aqueous Samples by Cold Vapor Atomic Absorption, SW-846 7470A and MCAWW 245.1, CORP-MT-0005NC, Rev. 1.1, 04/19/97.

Mercury in Solid Samples by Cold Vapor Atomic Absorption, SW-846 7471A and MCAWW 245.5, CORP-MT-0007NC, Rev. 1.1, 04/17/97.

Analysis of Nitroaromatic and Nitramine Explosives by High Performance Liquid Chromatography, KNOX-LC-0001, Rev. 1, 04/28/97.

Preparation and Analysis of Nitrocellulose in Aqueous, Soil, and Sediments by Colorimetric Autoanalyzer, SAC-WC-0500, Rev. 0.0.

Determination of nitroaromatics, nitramines, and specialty explosives in water and soil by high performance liquid chromatography/ultraviolet detector (HPLC/UV) and liquid chromatography/thermospray/mass spectrometry (LC/TSP/MS), SAC-LC-0001, Rev. 5.0.

APPENDIX C

HUMAN HEALTH RISK ASSESSMENT ALGORITHMS

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HUMAN HEALTH RISK ASSESSMENT ALGORITHMS

Appendix C contains the equations used to estimate risk to human receptor populations. Risk estimation is conducted in several steps including estimation of exposure concentration, calculation of intake and dose, toxicity assessment, and risk characterization. The methods and equations used in each step are described in the sections below.

C.1 ESTIMATION OF EXPOSURE CONCENTRATION

Exposure concentrations are medium-specific contaminant concentrations a potential receptor is expected to encounter. Exposure concentrations from direct contact with environmental media (soils, sediment, groundwater, surface water) are based on the sampling results of the media. Exposure concentrations for contaminants that have migrated into secondary media (beef, milk, venison, fish, and vegetables) are modeled from the equations presented in the following sections.

Chemical Concentration in Beef. Concentrations in beef cattle are calculated from the concentration in the cattle's food sources due to soil and water contamination. The contaminant levels in pasture are estimated by the equation:

$$C_p = C_s \times (R_{upp} + R_{es}),$$

where:

- C_p = concentration of contaminant in pasture (mg/kg, calculated),
- C_s = concentration of contaminant in soil (mg/kg),
- R_{upp} = multiplier for dry root uptake for pasture (unitless),
- R_{es} = resuspension multiplier (unitless).

The multiplier for dry root uptake for pasture, R_{upp} , is estimated as:

$$R_{upp} = Bv_{dry},$$

where:

- R_{upp} = multiplier for dry root uptake for pasture (unitless),
- Bv_{dry} = soil-to-plant uptake, dry weight (kg/kg, chemical-specific, or $38 \times K_{ow}^{-0.58}$),
- K_{ow} = octanol-water partitioning coefficient (unitless, chemical-specific).

The resuspension multiplier is estimated as:

$$R_{es} = MLF,$$

where:

- R_{es} = resuspension multiplier (unitless),
- MLF = plant mass loading factor (unitless, 0.25 for pasture).

The concentration of contaminants in beef cattle from ingestion of contaminated pasture, soil, and water is estimated using the following equation:

$$C_b = BTF_{\text{beef}} \times [(C_p \times Q_{pb} \times f_{pb} \times f_{sb}) + (C_s \times Q_{sb} \times f_{pb}) + (C_w \times Q_{wb})],$$

where:

C_b	=	concentration of contaminant in beef (mg/kg dry weight),
BTF_{beef}	=	beef transfer coefficient (day/kg, chemical-specific, or $2.5 \times 10^{-8} \times K_{ow}$),
K_{ow}	=	octanol-water partitioning coefficient (unitless, chemical-specific),
C_p	=	concentration of contaminant in pasture (mg/kg, calculated),
Q_{pb}	=	quantity of pasture ingested by beef cattle (kg/day),
f_{pb}	=	fraction of year beef cattle is on-site (kg/day),
f_{sb}	=	fraction of beef cattle's food that is from the site (kg/day),
C_s	=	concentration of contaminant in soil (mg/kg),
Q_{sb}	=	quantity of soil ingested by beef cattle (kg/day),
C_w	=	concentration of contaminant in water (mg/L),
Q_{wb}	=	quantity of water ingested by beef cattle (L/day).

Chemical Concentration in Milk. Milk concentrations from dairy cattle are calculated from the concentration in the cattle's food sources due to soil and water contamination. The contaminant levels in pasture are estimated in the same fashion as for beef cattle (see above).

The concentration of contaminants in dairy cattle's milk, from ingestion of contaminated pasture, soil, and water is estimated using the following equation:

$$C_m = BTF_{\text{milk}} \times [(C_p \times Q_{pd} \times f_{pd} \times f_{sd}) + (C_s \times Q_{sd} \times f_{pd}) + (C_w \times Q_{wd})],$$

where:

C_m	=	concentration of contaminant in milk (mg/kg),
BTF_{milk}	=	milk transfer coefficient (day/kg, chemical-specific, or $7.9 \times 10^{-9} \times K_{ow}$),
K_{ow}	=	octanol-water partitioning coefficient (unitless, chemical-specific),
C_p	=	concentration of contaminant in pasture (mg/kg, calculated),
Q_{pd}	=	quantity of pasture ingested by dairy cattle (kg/day),
f_{pd}	=	fraction of year dairy cattle is on-site (kg/day),
f_{sd}	=	fraction of dairy cattle's food that is from the site (kg/day),
C_s	=	concentration of contaminant in soil (mg/kg),
Q_{sd}	=	quantity of soil ingested by dairy cattle (kg/day),
C_w	=	concentration of contaminant in water (mg/L),
Q_{wd}	=	quantity of water ingested by dairy cattle (L/day).

Chemical Concentration in Venison. Concentrations in venison are estimated by calculating the concentration in venison food sources due to soil contamination. The contaminant levels in forage are estimated by the following:

$$C_p = (CF)(C_s)(B_p),$$

where:

- C_p = concentration of contaminant in forage (mg/kg dry weight),
 CF = conversion factor to adjust for soil containing 20 percent moisture (1.25 unitless),
 C_s = concentration of contaminant in soil (mg/kg),
 B_p = soil-to-forage biotransfer factor (mg chemical per kg of dry plant/mg of chemical per kg or dry soil)(chemical specific).

The B_p for metals is taken from the available literature. The B_p for semivolatile organics are calculated using the following formulas:

$$\log B_p = 1.588 - 0.578 \log K_{ow},$$

where:

- $\log B_p$ = soil-to-forage biotransfer factor (mg chemical per kg of dry plant/mg of chemical per kg or dry soil)(chemical-specific),
 K_{ow} = octanol-water partitioning coefficient (unitless, chemical-specific).

A B_p is not estimated for VOCs, because these chemicals are expected to volatilize rapidly from soils and plants and thus are insignificant in food chain pathways.

The concentration of contaminants in venison from ingestion of contaminated forage is estimated using the following equation:

$$C_v = (Q_p)(C_p)(FI_e)(B_v),$$

where:

- C_v = contaminant concentration in venison (mg/kg),
 Q_p = browse ingestion rate (0.87 kg dry weight/day),
 C_p = contaminant concentration in browse (mg/kg dry weight),
 FI_e = fraction browse ingested from the contaminated site (site area/home range),
 B_v = biotransfer factor for venison (days/kg).

The B_v for beef is used for deer due to a lack of available literature values for deer. Both of these animals are ruminants; therefore, the uptake and bioaccumulation of contaminants is likely to be similar. The meat of deer contains less fat than commercial beef, 14.4 percent fat for beef as compared to 2.9 percent for venison. Organic chemicals have a greater affinity to fat and thus would not accumulate as much in venison. Therefore, the beef biotransfer factors for organics are adjusted by 2.9/14.4 (0.20) to reflect this lower accumulation rate.

The B_v values for metals are taken from the published literature. The B_v values for organics are calculated as follows:

$$B_v = R_f \times 10^{-7.6 + \log K_{ow}},$$

where:

- B_v = biotransfer factor for venison (days/kg),
 R_f = ratio of the fat content in venison to the fat content of beef (0.20),
 K_{ow} = octanol-water partitioning coefficient (unitless, chemical-specific)

Chemical Concentrations in Fish. Fish may bioconcentrate contaminants from water and sediment. The contaminant concentration in fish due to bioconcentrating contaminants from surface water is estimated using the following equation:

$$C_{fw} = (C_w)(BCF),$$

where:

- C_{fw} = contaminant concentration in fish from surface water (mg/kg),
 C_w = contaminant concentration in water (mg/L),
 BCF = fish bioconcentration factor (L/kg).

Many BCF factors for fish are available from the literature. In the absence of a BCF literature value for an organic, the value is estimated using the following equation:

$$\log BCF = 0.76 \times K_{ow} - 0.23,$$

where:

- BCF = fish bioconcentration factor (L/kg),
 K_{ow} = octanol-water partitioning coefficient (unitless, chemical-specific).

Ingestion of Homegrown Vegetables. The model to estimate the chemical concentration in homegrown vegetables is comprised of contributions from irrigation and soil resuspension.

The root uptake from irrigation component is estimated by the equation:

$$Irr_{rup} = (Ir \times F \times Bv_{wet} \times [1 - e^{(-\lambda_B \times t_b)}] / (P \times \lambda_B),$$

where:

- Irr_{rup} = multiplier in vegetable equation for root uptake from irrigation (L/kg),
 Ir = irrigation rate (L/m²-day),
 F = irrigation period as a fraction (unitless),
 Bv_{wet} = soil-to-plant uptake factor, wet weight (kg/kg),
 λ_B = effective rate for removal (1/day, calculated as $\lambda_i + \lambda_{HL}$),
 λ_i = decay rate (1/day, assume 0 for chemicals),
 λ_{HL} = soil leaching rate (1/day),
 t_b = long-term deposition and buildup (days),
 P = area density for root zone (kg/m²).

The resuspension from irrigation component is estimated by the equation:

$$Irr_{res} = (Ir \times F \times MLF \times [1 - e^{(-\lambda_B \times t_b)}] / (P \times \lambda_B),$$

where:

Irr_{res}	=	multiplier in vegetable equation for resuspension from irrigation (L/kg),
Ir	=	irrigation rate (L/m ² -day),
F	=	irrigation period as a fraction (unitless),
MLF	=	plant mass loading factor (unitless, 0.26 for vegetables),
λ_B	=	effective rate for removal (1/day, calculated as $\lambda_i + \lambda_{HL}$),
λ_i	=	decay rate (1/day, assume 0 for chemicals),
λ_{HL}	=	soil leaching rate (1/day),
t_b	=	long-term deposition and buildup (days),
P	=	area density for root zone (kg/m ²).

The aerial deposition from irrigation component is estimated by the equation:

$$Irr_{dep} = (Ir \times F \times I_f \times T \times [1 - e^{(-\lambda_E \times t_v)}] / (Y_v \times \lambda_E),$$

where:

Irr_{dep}	=	multiplier in vegetable equation for aerial deposition from irrigation (L/kg),
Ir	=	irrigation rate (L/m ² -day),
F	=	irrigation period as a fraction (unitless),
I_f	=	interception fraction (unitless),
T	=	translocation factor (unitless),
λ_E	=	decay for removal on produce (1/day, calculated as $\lambda_i + 0.693/t_w$),
λ_i	=	decay rate (1/day, assume 0 for chemicals),
t_w	=	weathering half-life (days),
t_v	=	above ground exposure time (days),
Y_v	=	plant yield (wet) (kg/m ²).

The chemical concentration in homegrown vegetables is estimated with the equation:

$$C_{veg} = C_w \times (Irr_{rup} + Irr_{res} + Irr_{dep}) + C_s \times (Bv_{wet} + MLF),$$

where:

C_w	=	concentration of contaminant in water (mg/L),
Irr_{rup}	=	multiplier in vegetable equation for root uptake from irrigation (L/kg),
Irr_{res}	=	multiplier in vegetable equation for resuspension from irrigation (L/kg),
Irr_{dep}	=	multiplier in vegetable equation for aerial deposition from irrigation (L/kg),
C_s	=	concentration of contaminant in soil (mg/kg),
Bv_{wet}	=	soil-to-plant uptake, wet weight (kg/kg, chemical-specific, or $7.7 \times K_{ow}^{-0.58}$),
K_{ow}	=	octanol-water partitioning coefficient (unitless, chemical-specific),
MLF	=	plant mass loading factor (unitless, 0.26 for vegetables).

C.2 ESTIMATION OF INTAKE AND DOSE

The quantification of exposure to receptors from contact with chemicals in different media involves estimating the amount of contaminant that is taken into the body via various routes of exposures. This section describes the models used to quantify doses or intakes of contaminants by exposure pathways identified for a site. The intake of contaminants from environmental media (soils, groundwater, and

surface water) and secondary sources (deer, fish, beef, milk, and vegetables) are discussed below. Exposure parameters used for evaluating each receptor are provided in Table C-1.

Estimated Intakes and Doses from Soils and Sediment.

Potential exposure pathways for soils include incidental ingestion, inhalation of fugitive dust and VOCs, and dermal contact with soils. The equations used to estimate potential intakes and doses from these exposure pathways are discussed below.

Incidental Ingestion. The intake of chemicals from incidental ingestion of soils and sediments is estimated using the following equation:

$$I_s = (C_s)(IR_s)(FI_s)EF_T(ED) / [(BW)(AT)],$$

where:

I_s	=	ingested soil or sediment intake (mg/kg-day, calculated),
C_s	=	concentration in soil or sediment (mg/kg),
IR_s	=	ingestion rate of soil or sediment (kg/day),
FI_s	=	fraction of exposure attributed to site soil (unitless),
EF_T	=	exposure frequency (days/year),
ED	=	exposure duration (years),
BW	=	body weight (kg),
AT	=	averaging time (days).

Inhalation of VOCs and Dust. The following equation is used to estimate the inhalation intake of contaminants in air from airborne dust and VOCs:

$$I_a = (C_s)(IR_a)(PEF^{-1} + VF^{-1})(FI_a)(Et_a)(EF_T)(ED) / [(BW)(AT)],$$

where:

I_a	=	inhaled intake of COPC (mg/kg-day, calculated),
C_s	=	concentration of COPC in soil (mg/kg),
IR_a	=	inhalation rate (m ³ /hour),
PEF	=	particulate emission factor (9.24E+08 m ³ /kg, site-specific),
VF	=	chemical-from-soil volatilization factor (m ³ /kg, chemical-specific),
FI_a	=	fraction of exposure attributed to the media (unitless),
ET_a	=	exposure time (hours/day),
EF_T	=	exposure frequency (days/year),
ED	=	exposure duration (years),
BW	=	body weight (kg),
AT	=	averaging time (days).

The particulate emission factor (PEF) is used to evaluate the fugitive dust contribution to the inhalation of soils pathway, while the volatilization factor (VF) is used to evaluate chemicals that volatilize from soils (volatile organic compounds only). The PEF and VF factors are calculated per EPA's Soil Screening Guidance (EPA 1996), using site specific factors for Cleveland Ohio, the city nearest Ravenna for which EPA has provided parameters to estimate PEF and VF values. Specific equations for PEF and VF are provided below. For the National Guard receptor, whose activities generate more dust than activities of

other receptors, a dust-loading factor of 600 µg/m³ is applied, resulting in a PEF of 1.67E+06 m³/kg for this receptor.

The PEF for non-National Guard receptors is calculated by the following equation:

$$PEF = \frac{LS \times V \times DH \times 3600s/hr}{A} \times \frac{1000g/kg}{0.036 \times (1 - G) \times (U_m / U_t)^3 \times F(x)},$$

where:

PEF	=	particulate emission factor (m ³ /kg),
LS	=	width of contaminated area (m),
V	=	wind speed in mixing zone (m/s),
DH	=	diffusion height (m),
A	=	area of contamination (m ²),
0.036	=	respirable fraction (g/m ² -hr),
G	=	fraction of surface covered with vegetation (unitless),
U _m	=	mean annual wind speed (m/sec),
U _t	=	equivalent threshold value of wind speed at 10 m (m/sec),
F(x)	=	function dependent on U _m /U _t (unitless).

The chemical-from-soil volatilization factor is calculated as follows:

$$VF = \frac{(LS \times V \times DH)}{A} \times \frac{(3.14 \times \alpha T)^{1/2}}{(2 \times D_{ei} \times E \times K_{as} \times 10^{-3} kg/g)},$$

where:

VF	=	chemical-from-soil volatilization factor (m ³ /kg, chemical-specific),
LS	=	width of contaminated area (m),
V	=	wind speed in mixing zone (m/s),
DH	=	diffusion height (m),
A	=	area of contamination (m ²),
D _{ei}	=	effective diffusivity (cm ² /s), calculated from D _i x E ^{0.33} ,
D _i	=	molecular diffusivity (cm ² /s),
E	=	true soil porosity (unitless),
K _{as}	=	soil/air partitioning coefficient (g soil/cm ³ air), calculated from H/K _d ,
H	=	Henry's law constant (atm-m ³ /mol),
K _d	=	soil/water partitioning coefficient (cm ³ /g),
T	=	exposure interval (seconds),
α	=	is defined by the equation:

$$\alpha = (D_{ei} \times E) / [E + (\rho_s)(1 - E) / K_{as}]$$

where:

ρ _s	=	true soil density or particulate density (g/cm ³).
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Dermal Contact with COPCs in Soil. The dermal dose of a contaminant is estimated from the equation:

$$DAD = (C_s)(FI_s)(CF)(AF)(ABS)(SAS)(EF_T)(ED) / [(BW)(AT)],$$

where:

DAD	=	average dermally absorbed dose of the COPC (mg/kg-day, calculated),
C _s	=	concentration of COPC in soil (mg/kg),
FI _s	=	fraction of exposure attributed to site soil or sediment (unitless),
CF	=	conversion factor (10 ⁻⁶ kg/mg x 10 ⁴ cm ² /m ²),
AF	=	soil-to-skin adherence factor (mg/cm ²),
ABS	=	absorption fraction (unitless, chemical-specific)
SAS	=	surface area of the skin available for contact with contaminated medium (m ² /day),
EF _T	=	exposure frequency (days/year),
ED	=	exposure duration (years),
BW	=	body weight (kg),
AT	=	averaging time (days).

ABS values have been empirically determined for very few chemicals. EPA (1992) discussed the available empirical data, as well as several predictive approaches for estimating ABS, but refrains from recommending any single approach. EPA (1995) recommends reasonable default values of 0.1% for inorganic chemicals and 1% for organic chemicals, to reflect the matrix effect (i.e., binding to organic matter in soil). Chemical-specific ABS values available from EPA Region V will be used whenever possible. When chemical-specific values are not available EPA Region V recommends a default ABS of 0.1 for SVOCs (USACE 2000b). For LL1, default values of 0.1% for inorganics (EPA 1995), 10% for SVOCs (USACE 2000b), and 1% for other organics (i.e., VOCs) EPA 1995) will be used when chemical-specific data are not available.

Estimated Intakes and Doses from Groundwater and Surface Water

Potential exposure pathways for groundwater and surface water include ingestion, inhalation of VOCs, and dermal contact. The equations used to estimate potential intakes and doses from these exposure pathways are described below.

Ingestion Drinking Water. Ingestion of groundwater or surface water used as a potable water source is quantified with the following equation:

$$I_w = (C_w)(IR_w)(FI_w)(EF_T)(ED) / [(BW)(AT)],$$

where:

I _w	=	ingested intake of COPC in drinking water (mg/kg-day),
C _w	=	concentration of COPC in drinking water (mg/L),
IR _w	=	drinking water ingestion rate (L/day),
FI _w	=	fraction of exposure attributed to site medium (unitless),
EF _T	=	exposure frequency (days/year),
ED	=	exposure duration (years),
BW	=	body weight (kg),
AT	=	averaging time (days).

Incidental Ingestion while Swimming. Incidental ingestion of surface water while swimming is quantified with the following equation:

$$I_{\text{swim}} = (C_w)(IR_w)(ET_w)(EF_T)(ED) / [(BW)(AT)],$$

where:

I_{swim}	=	incidental ingestion intake (mg/kg-day),
C_w	=	concentration in surface water (mg/L),
IR_w	=	incidental ingestion rate while swimming (L/hour),
ET_w	=	exposure time (hours/day)
EF_T	=	exposure frequency (days/year),
ED	=	exposure duration (years),
BW	=	body weight (kg),
AT	=	averaging time (days).

Inhalation of VOCs in Groundwater or Surface Water. The daily intake from the inhalation of VOCs for water use (e.g., showering) may be evaluated using the following equation (EPA 1991b):

$$I_s = (C_w)(IR)(ET)(K)(EF_T)(ED) / [(BW)(AT)],$$

where:

I_s	=	estimated inhalation exposure during water use (mg/day),
C_w	=	concentration in groundwater or surface water (chemical-specific; mg/L),
IR	=	inhalation rate (m ³ /hour),
ET	=	exposure time to water (hour/day),
K	=	volatilization factor (0.0005 x 1000 L/m ³),
EF_T	=	exposure frequency (days/year),
ED	=	exposure duration (years),
BW	=	body weight (kg),
AT	=	averaging time (days).

Dermal Contact. The dermal dose is estimated as the dose that crosses the skin and is systematically absorbed. The dermal dose is estimated from the equation:

$$DAD = (C_w)(PC)(ET_w)(CF)(SAS)(EF_T)(ED) / [(BW)(AT)],$$

where:

DAD	=	average dermally absorbed dose of the COPC (mg/kg-day, calculated),
C_w	=	concentration of chemicals of concern (COC) in water (mg/L),
PC	=	permeability coefficient (cm/hour, chemical-specific),
ET_w	=	time of exposure (hours/event),
CF	=	conversion factor (0.01 m/cm x 1000 L/m ³)
SAS	=	surface area of the skin available for contact with contaminated medium (m ²),
EF_T	=	exposure frequency (events/year),
ED	=	exposure duration (years),
BW	=	body weight (kg),
AT	=	averaging time (days).

The permeability coefficient (PC) describes the rate of movement of a constituent from water across the dermal barrier to the systemic circulation. The PC has been determined for very few inorganic

compounds. For those inorganic compounds for which empirical data are not available, EPA (1992) recommends a default of 10^{-3} cm/hour.

The PC for organic chemicals varies by several orders of magnitude (EPA 1992). The PC for organic chemicals is highly dependent on lipophilicity, expressed as a function of the octanol/water partition coefficient (K_{ow}). Because the stratum corneum (the outer skin layer) is rich in lipid content, it may act as a sink, initially reducing the transport of chemical to the systemic circulation. When possible, values for PC are taken from EPA (1992). If PC values are not available, they may be calculated from the formula:

$$\log(PC) = 2.72 + 0.71 \log(K_{ow}) - 0.0061 MW,$$

where:

PC = permeability coefficient (cm/hour, calculated),
 K_{ow} = octanol/water partition coefficient (unitless),
 MW = molecular weight.

Estimation of Intakes from Consumption of Game

The intake from ingestion of venison and fish by the sportsman is estimated from the equation:

$$I_g = [(C_v)(IR_v)(FI_v) + (C_f)(IR_f)(FI_f)] \frac{(EF_G)(ED)}{(BW)(AT)},$$

where:

I_g = ingested intake in game (venison and fish) (mg/kg-day, calculated),
 C_v = concentration in venison (mg/kg),
 IR_v = ingestion rate of venison (kg/day),
 FI_v = fraction of daily intake of venison from contaminated sources (unitless),
 C_f = concentration in fish (mg/kg),
 IR_f = ingestion rate of fish (kg/day),
 FI_f = fraction of daily intake of fish from contaminated sources (unitless),
 EF_G = exposure frequency (days/year),
 ED = exposure duration (years),
 BW = body weight (kg),
 AT = averaging time (days).

Estimation of Intakes from Consumption of Beef

The intake from ingestion of beef by the residential farmer is estimated from the equation:

$$I_b = (C_b)(IR_b)(FI_b)(EF_B)(ED) / [(BW)(AT)],$$

where:

I_b = ingested intake of beef (mg/kg-day, calculated),
 C_b = concentration in beef (mg/kg),
 IR_b = ingestion rate of beef (kg/day),
 FI_b = fraction of daily intake of beef from contaminated sources (unitless),
 EF_B = exposure frequency (days/year),
 ED = exposure duration (years),

BW = body weight (kg),
 AT = averaging time (days).

Estimation of Intakes from Consumption of Milk

The intake from ingestion of milk by the residential farmer is estimated from the equation:

$$I_m = (C_m)(IR_m)(FI_m)(EF_M)(ED) / [(BW)(AT)],$$

where:

I_m = ingested intake of milk (mg/kg-day, calculated),
 C_m = concentration in milk (mg/kg),
 IR_m = ingestion rate of milk (kg/day),
 FI_m = fraction of daily intake of milk from contaminated sources (unitless),
 EF_M = exposure frequency (days/year),
 ED = exposure duration (years),
 BW = body weight (kg),
 AT = averaging time (days).

Estimation of Intakes from Consumption of Homegrown Vegetables

The intake from ingestion of homegrown vegetables by the residential farmer is estimated from the equation:

$$I_{veg} = (C_{veg})(IR_{veg})(FI_{veg})(EF_{VEG})(ED) / [(BW)(AT)],$$

where:

I_{veg} = ingested intake of vegetables (mg/kg-day, calculated),
 C_{veg} = concentration in vegetables (mg/kg),
 IR_{veg} = ingestion rate of vegetables (kg/day),
 FI_{veg} = fraction of daily intake of vegetables from contaminated sources (unitless),
 EF_{VEG} = exposure frequency (days/year),
 ED = exposure duration (years),
 BW = body weight (kg),
 AT = averaging time (days).

C.3 TOXICITY ASSESSMENT

To understand the potential health risk associated with a potentially hazardous chemical, information on chemical-specific toxicity is required. Toxicity information is used in conjunction with the results of the exposure assessment to characterize potential health risks. The toxic mechanisms for chemicals are divided into two categories, carcinogenicity and systemic toxicity (noncancer effects).

Assessment of Chemical Carcinogens

Although few chemicals are known human carcinogens, many chemicals are suspected to be human carcinogens based on the results of animal studies. The evaluation of the potential carcinogenicity of a chemical includes both a qualitative and a quantitative aspect (EPA 1989). The qualitative aspect is a

weight-of-evidence evaluation of likelihood that a chemical might induce cancer in humans. The EPA recognizes six weight-of-evidence group classifications for carcinogenicity:

Group A – Human Carcinogen. Data for humans are sufficient to identify the chemical as a human carcinogen.

Group B1 – Probable Human Carcinogen. Human data indicate a causal association is credible, but alternative explanations cannot be dismissed.

Group B2 – Probable Human Carcinogen. Human data are insufficient to support a causal association, but testing data support a causal association in animals.

Group C – Possible Human Carcinogen. Human data are inadequate or lacking, but animal data suggest a causal association, although the studies have deficiencies that limit interpretation.

Group D – Not Classifiable as to Human Carcinogenicity. Human and animal data are lacking or inadequate.

Group E – Evidence of Noncarcinogenicity to Humans. Data for humans show negative results or are lacking, and adequate animal data indicate no association with cancer.

The quantitative evaluation is an estimate of carcinogenic potency. Potency estimates are developed only for chemicals in Groups A, B1, B2, and C. The potency estimates are statistically derived from the dose-response curve from the best human or animal study or studies available for a given chemical. In the case of animal studies, pharmacokinetic data or principles are used to estimate an equivalent human dose. The potency estimates are referred to as the cancer slope factor (CSF), and are expressed as risk per unit dose (per mg/kg-day). In order to be appropriately conservative, the CSF is usually the 95 percent upper bound on the slope of the dose-response curve extrapolated from high (experimental) doses to the low-dose range expected in environmental exposure scenarios. It is assumed that there is no threshold for carcinogens (e.g., a dose below which exposure is safe), and, therefore, any exposure represents some quantifiable risk. The discussion of chemical carcinogenicity includes the EPA's classification of carcinogenicity and the CSF recommended by the EPA. The CSF used in evaluating the carcinogenic risks associated with exposure to each COPC will be obtained from the Integrated Risk Information Service (IRIS) computer database or the most recent Health Effects Assessment Summary Tables (HEAST). Separate CSFs are available for oral and inhalation exposures.

Toxicity values for inhalation are presented as unit risk factors [i.e., risk per ($\mu\text{g}/\text{m}^3$)]. This value is converted to a CSF [i.e., risk per (mg/kg-day)] by dividing the unit risk factor by the average respiration rate of an adult ($20 \text{ m}^3/\text{day}$) and multiplying it by the average body weight (70 kg) and by 1,000 to convert micrograms to milligrams.

Evaluation of Polycyclic Aromatic Hydrocarbons (PAHs). Seven PAHs [benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene] are considered to be potentially carcinogenic. Adequate toxicity data are available to determine a CSF only for benzo(a)pyrene, therefore, risks from the other potentially carcinogenic PAHs will be estimated using a toxicity equivalency approach. This approach assigns a relative toxicity, reported as a relative potency factors (RPFs) to each of the seven potentially carcinogenic PAHs. Exposure concentrations are converted to equivalent concentrations of benzo(a)pyrene by multiplying the concentration by the appropriate RPF. This results in Benzo(a)pyrene equivalent concentration for each of the other PAHs. The CSF for benzo(a)pyrene is used to evaluate risk from the total benzo(a)pyrene equivalent concentration. RPFs developed by EPA (1993) are listed below:

Compound	RPF
Benzo(a)pyrene	1.0
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenz(a,h) anthracene	1.0
Indeno(1,2,3-cd)pyrene	0.1

Noncancer Effects

Many chemicals pose a potential health effect other than cancer. The range of potential noncancer effects is great (e.g., ranging from liver damage to dental fluorosis). The evaluation of noncancer effects (EPA 1989) involves:

- Identification of the critical effect (or threshold effect) for each duration of exposure [i.e., the adverse effect that occurs at the lowest dose (e.g., if liver damage occurs at 20 mg/kg-day, and mortality occurs at 100 mg/kg-day, liver damage is the critical effect].
- Quantification of the threshold dose for the critical effect for each duration of exposure (i.e., the dose at or above which the effect occurs, and below which the effect does not occur).
- Development of an uncertainty factor (i.e., quantification of the uncertainty associated with interspecies extrapolation, intraspecies variation in sensitivity, severity of the critical effect and slope of the dose-response curve, and deficiencies in the database) in regard to developing a reference dose (RfD) for human exposure.
- Identification of the target organ(s) for the critical effect for each route of exposure.

The information described above is used to derive reference doses (RfDs), expressed as mg/kg-day, which is considered to be the dose to humans at which adverse effects are not expected to occur. Because it is assumed that there is a threshold (e.g., a safe dose for noncarcinogens), the RfD is a non-probabilistic expression of the likelihood that an adverse effect might occur. RfDs are derived separately for oral and inhalation exposure pathways because of possible differences in the rate of absorption, target organs, and mechanisms of toxicity.

The inhalation toxicity is generally expressed as the reference concentration (i.e., that concentration of a chemical in air that is not likely to have an adverse effect upon human receptors). The reference concentration is converted to an RfD by multiplying the reference concentration ($\mu\text{g}/\text{m}^3$) by the average respiration rate of an adult (20 m^3/day) and dividing by the average body weight (70 kg). The final RfD value is converted from micrograms to milligrams by dividing by 1,000.

Chronic exposure is generally defined as an exposure equal to or greater than 7 years. Some receptors (i.e., construction workers and on-site child residents) have a subchronic exposure. As a conservative measure, chronic RfDs, may be used to evaluate the potential adverse health effects associated with subchronic exposure to chemicals.

Evaluation of Lead. No suitable dose-response values exist for assessing the risks associated with exposure to lead. The EPA has developed an Adult lead model for evaluating lead exposure. This model will be used if necessary to evaluate lead at Load Line 1.

Evaluation of Copper. No RfD is available for elemental copper. However, EPA established an action level of 1300 µg/L for drinking water. This is converted to an RfD of 0.037 mg/kg-day by multiplying by a standard drinking water ingestion rate of 2 L/day and dividing by an average adult body weight of 70 kg and a conversion factor of 1000 µg/mg.

Dermal Evaluation of Chemicals

Methodologies for estimating inhaled or ingested intake of a chemical account for the amount of chemical presented to the barrier membrane of the pulmonary or gastrointestinal mucosa, respectively. However, the dermal dose is estimated as the dose that crosses the skin and is systematically absorbed. For this reason, dermal toxicity values must be based on absorbed dose.

Dermal RfD and CSF values may be derived from the corresponding oral values. In the derivation of a dermal RfD, the oral RfD is multiplied by a gastrointestinal absorption factor (GAF), expressed as a unitless fraction. The resulting dermal RfD is an RfD based on absorbed dose, which is the appropriate value with which to compare dermal doses because dermal doses are expressed as absorbed rather than exposure doses. In a similar manner, and for the same reasons, a dermal CSF is derived by dividing the oral cancer slope factor by the GAF.

Chemical-specific GAF values available from EPA Region V (USACE 2000b) will be used whenever possible.

Not all COPCs have specific GAF values. When quantitative data are insufficient, a default GAF is used. A default value of 1.0 for organic chemicals will be used (USACE 2000, personal communication between D. Brancato, USACE, and S. Robers, SAIC).

C.4 RISK CHARACTERIZATION

Risk characterization is the final step during which exposure and toxicity information are integrated to qualitatively or quantitatively evaluate the potential health risks associated with exposure to contaminants. Quantitative estimates of both carcinogenic and noncarcinogenic risks are calculated for each contaminant and each potentially complete exposure pathway.

Methodology for Carcinogens

The risk attributed to exposure to chemical carcinogens is estimated as the probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. At low doses, the risk of developing cancer is determined as follows (EPA 1989):

$$Risk = (CDI)(SF),$$

where:

- Risk = risk of cancer incidence, expressed as a unitless probability,
- CDI = chronic daily intake averaged over 70 years (mg/kg-day),
- SF = slope factor (mg/kg-day)⁻¹.

For a given pathway with simultaneous exposure of a receptor to several carcinogens, the following equation is used to sum cancer risks:

$$Risk_{total} = Risk(chem_1) + Risk(chem_2) + \dots + Risk(chem_i),$$

where:

Risk = total risk of cancer incidence,
chem_i = individual carcinogenic chemical.

Contaminants contributing significantly to the total risk associated with a site are identified as contaminants of concern (COC).

Methodology for Noncarcinogens

The risks associated with the effects of noncarcinogenic hazardous chemicals are evaluated by comparing an exposure level or intake to a reference dose. The ratio of intake over the reference dose is termed the Hazard Quotient (HQ) (EPA 1989) and is defined as:

$$HQ = I/RfD,$$

where:

HQ = hazard quotient (unitless),
I = intake of a chemical (mg/kg-day),
RfD = reference dose (mg/kg-day).

When using this equation to estimate potential risk, both the intake and the RfD must refer to exposures of equivalent duration (i.e., sub-chronic, chronic, or less than two weeks). Chemical exposures are evaluated in all cases on a chronic basis, using chronic RfD values.

This approach is different from the probabilistic approach used to evaluate carcinogens. An HQ of 0.01 does not imply a 1 in 100 chance of an adverse effect, but indicates only that the estimated intake is 100 times less than the reference dose. An HQ of unity (1) indicates that the exposure intake is equal to the RfD. If the HQ is greater than 1, or above unity, there may be concern for potential health effects.

In the case of simultaneous exposure of a receptor to several chemicals, a Hazard Index (HI) is calculated as the sum of the Hazard Quotients by:

$$HI = I_1/RfD_1 + I_2/RfD_2 + \dots I_i/RfD_i,$$

where:

I_i = intake for the ith toxicant, where i = 1, 2, 3
RfD_i = reference dose for the ith toxicant, where i = 1, 2, 3

Hazard indices are determined by assuming dose additivity for those chemicals acting by the same mechanism and inducing the same effects (EPA 1989). Initially all of the chemicals are assumed to have the same mechanism of toxicity. If the HI is below 1, then the target organ specific HIs will also be below 1.0. If the HI exceeds 1.0, then HIs are calculated for each target organ. This provides a more accurate estimation of the potential systemic toxicity associated with exposure to a chemical mixture.

Uncertainty

There are uncertainties associated with all phases of the Human Health Risk Assessment (HHRA), including collection and laboratory analysis of the samples, exposure assessment, toxicity assessment, and risk characterization. Site-specific uncertainties will be discussed as part of the risk assessment and the impact of the uncertainties will be qualitatively addressed.

Uncertainty in Exposure Assessment

Three major types of uncertainties should be considered when reviewing the results of the exposure assessment: (1) uncertainties associated with predicting future land use, (2) uncertainties associated with estimating chemical concentrations at receptor locations, and (3) uncertainties associated with assumptions used in the exposure models.

Physiological values (e.g., body weight, inhalation rates) and behavioral values (e.g., average time spent in one place, amount of soil ingested) used to model the RME are a combination of average and upper-bound levels taken from reliable sources. The use of upper-bound estimates will tend to overestimate exposure for the RME. Therefore, the predicted risks are likely to be greater than the actual risks. This provides a conservative, health-protective approach for the risk assessment.

Uncertainty in Toxicity Assessment

The toxicological parameters used to quantify potential risk to a receptor include CSFs and RfDs. These values are often derived from laboratory animal studies. The following overriding uncertainties associated with the use of laboratory animal studies are:

- The extrapolation of toxic effects observed at the high dose necessary to conduct animal studies to effects that might occur at the much lower, environmentally relevant doses.
- The extrapolation from toxic effects in animals to toxic effects in man (i.e., the potential for animal responses to differ from responses of man).

The EPA has derived CSFs using a weight-of-evidence approach from studies in the scientific literature. The CSFs represent the upper 95% confidence limits on the slope of the dose response curve for carcinogenic responses. Because CSFs represent the near upper limits of the slope of the line, the use of the CSF is more likely to overestimate the actual risk than under estimate it.

Uncertainties also arise in the development of the RfDs used to characterize noncarcinogenic effects. These reference values are derived using studies in humans or animals by identifying the lowest-observed-adverse-effect level (LOAEL) or no-observed-adverse-effect level (NOAEL). Two basic types of uncertainty arise. The first is related to the extrapolation from toxic effects seen at high dose to predict effects at the low dose usually encountered in the environment. The second involves extrapolation from effects in animals to effects in man. Each of these is offset by an uncertainty factor that is actually a product of as many as five separate factors, each intended to account for one type of uncertainty (EPA 1989). The LOAEL and NOAEL are divided by this composite uncertainty factor. The uncertainty factors usually range from 10 to 10,000. The five types of uncertainty (each representing an uncertainty factor of 5 to 10) included in the assignment of the uncertainty factor are:

- sensitive subpopulations in the general population,
- extrapolation from animals to humans,

- extrapolation from a subchronic study to a chronic estimate,
- extrapolation from a LOAEL to a NOAEL, and
- additional uncertainties in the critical study used in setting the RfD or reference concentration.

In addition, the absence of established toxicity criteria for some COPCs may result in an underestimation of risks.

Uncertainty in Risk Characterization

The risk characterization evaluates the potential risks associated with exposure to numerous chemicals via multiple pathways. There is uncertainty associated with exposure to chemical mixtures because chemicals may have synergistic or antagonistic effects on other chemicals. It is assumed that all chemicals have additive toxicity and that the potential health effects would be equal to the sum of each of the individual chemical actions for chemicals that act upon the same target organ. This may result in the overestimation or underestimation of certain risks.

In general, sources of uncertainty may be categorized into site-specific factors (e.g., variability in analytical data, modeling results, and exposure parameter assumptions) and toxicity factors. The use of conservative assumptions in the risk assessment is believed to result in an overestimate of risk. Actual site risks are likely to be lower.

C.5 REFERENCES

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Table C-1. Parameters Used to Quantify Exposures for Each Medium and Receptor

Parameter	Units	Security Guard/ Maintenance Worker (1)	Hunter/ Trapper (2)	Child Trespasser (3)	National Guard Trainee (4)	Open Recreator (5)	Open Industrial Worker (6)	Resident Farmer (child/adult) (7)
Pathway								
<i>Surface Soil</i>								
Incidental ingestion								
Soil ingestion rate (Adult)	kg/day	0.000 ^a	0.0001 ^a	NA	0.0001 ^a	0.0001 ^a	0.0001 ^a	0.0001 ^a
Soil ingestion rate (Child)	kg/day	NA	NA	0.0002 ^a	NA	NA	NA	0.0002 ^a
Exposure time	hours/day	1 ^b	2 ^b	2 ^q	8 ^b	1 ^b	NA	NA
Exposure frequency	days/year	250 ^a	90 ^b	50 ^q	180 ^b	75 ^b	250 ^a	350 ^a
Exposure duration (Adult)	years	25 ^a	30 ^b	NA	25 ^b	30 ^a	25 ^a	24 ^a
Exposure duration (Child)	years	NA	NA	10 ^q	NA	NA	NA	6 ^a
Body weight (Adult)	kg	70 ^a	70 ^a	NA	70 ^a	70 ^a	70 ^a	70 ^a
Body weight (Child)	kg	NA	NA	45 ^r	NA	NA	NA	15 ^a
Carcinogen averaging time	days	25550 ^a	25550 ^a	25550 ^a	25550 ^a	25550 ^a	25550 ^a	25550 ^a
Noncarcinogen averaging time (Adult)	days	9125 ^a	10950 ^a	NA	9125 ^a	10950 ^a	9125 ^a	8760 ^a
Noncarcinogen averaging time (Child)	days	NA	NA	3650 ^a	NA	NA	NA	2190 ^a
Fraction Ingested	unitless	1 ^b	1 ^b	1 ^b	1 ^b	1 ^b	1 ^b	1 ^b
Conversion Factor	days/hour	0.042	0.042	0.042	0.042	0.042	NA	NA
Dermal contact								
Skin area	m ² /event	0.33 ^d	0.57 ^d	0.815 ^c	0.33 ^d	0.57 ^d	0.33 ^d	0.57 ^d
Adherence factor	mg/cm ²	0.7 ^c	0.7 ^c	0.2 ^c	0.3 ^c	0.07 ^c	0.2 ^c	0.4 ^c
Exposure frequency	events/year	250 ^a	90 ^b	50 ^q	180 ^b	75 ^c	250 ^a	350 ^a
Exposure duration	years	25 ^a	30 ^b	10 ^q	25 ^b	30 ^a	25 ^a	30 ^a
Body weight	kg	70 ^a	70 ^a	45 ^r	70 ^a	70 ^a	70 ^a	70 ^a
Carcinogen averaging time	days	25550 ^a	25550 ^a	25550 ^a	25550 ^a	25550 ^a	25550 ^a	25550 ^a
Noncarcinogen averaging time	days	9125 ^a	10950 ^a	3650 ^a	9125 ^a	10950 ^a	9125 ^a	10950 ^a
Conversion Factor	(kg-cm ²)/(mg-m ²)	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Table C-1. Parameters Used to Quantify Exposures for Each Medium and Receptor (continued)

Parameter	Units	Security Guard/ Maintenance Worker (1)	Hunter/ Trapper (2)	Child Trespasser (3)	National Guard Trainee (4)	Open Recreator (5)	Open Industrial Worker (6)	Resident Farmer (7)
Inhalation of VOCs and dust								
Inhalation rate	m ³ /day	20 ^a	20 ^a	20 ^a	20 ^a	20 ^a	20 ^a	20 ^a
Exposure time	hours/day	1 ^b	2 ^b	2 ^q	8 ^b	1 ^b	NA	NA
Exposure frequency	days/year	250 ^a	90 ^b	50 ^q	180 ^b	75 ^c	250 ^a	350 ^a
Exposure duration	years	25 ^a	30 ^b	10 ^q	25 ^b	30 ^a	25 ^a	30 ^a
Body weight	kg	70 ^a	70 ^a	45 ^r	70 ^a	70 ^a	70 ^a	70 ^a
Carcinogen averaging time	days	25550 ^a	25550 ^a	25550 ^a	25550 ^a	25550 ^a	25550 ^a	25550 ^a
Noncarcinogen averaging time	days	9125 ^a	10950 ^a	3650 ^a	9125 ^a	10950 ^a	9125 ^a	10950 ^a
Conversion Factor	days/hour	0.042	0.042	0.042	0.042	0.042	NA	NA
<i>Subsurface Soil</i>								
Incidental ingestion								
Soil ingestion rate (Adult)	kg/day	NA	NA	NA	0.0001 ^a	NA	0.0001 ^a	0.0001 ^a
Soil ingestion rate (Child)	kg/day	NA	NA	NA	NA	NA	NA	0.0002 ^a
Exposure time	hours/day	NA	NA	NA	8 ^b	NA	NA	NA
Exposure frequency	days/year	NA	NA	NA	28 ^b	NA	250 ^a	350 ^a
Exposure duration (Adult)	years	NA	NA	NA	25 ^b	NA	25 ^a	24 ^a
Exposure duration (Child)	years	NA	NA	NA	NA	NA	NA	6 ^a
Body weight (Adult)	kg	NA	NA	NA	70 ^a	NA	70 ^a	70 ^a
Body weight (Child)	kg	NA	NA	NA	NA	NA	NA	15 ^a
Carcinogen averaging time	days	NA	NA	NA	25550 ^a	NA	25550 ^a	25550 ^a
Noncarcinogen averaging time (Adult)	days	NA	NA	NA	9125 ^a	NA	9125 ^a	8760 ^a
Noncarcinogen averaging time (Child)	days	NA	NA	NA	NA	NA	NA	2190 ^a
Fraction Ingested	unitless	NA	NA	NA	1 ^b	NA	1 ^b	1 ^b
Conversion Factor	days/hour	NA	NA	NA	0.042	NA	NA	NA
Dermal contact								
Skin area	m ² /event	NA	NA	NA	0.316 ^d	NA	0.316 ^d	0.53 ^e
Adherence factor	mg/cm ²	NA	NA	NA	1 ^c	NA	1 ^c	1 ^c
Exposure frequency	events/year	NA	NA	NA	28 ^b	NA	250 ^a	350 ^a

Table C-1. Parameters Used to Quantify Exposures for Each Medium and Receptor (continued)

Parameter	Units	Security Guard/ Maintenance Worker (1)	Hunter/ Trapper (2)	Child Trespasser (3)	National Guard Trainee (4)	Open Recreator (5)	Open Industrial Worker (6)	Resident Farmer (7)
Exposure duration	years	NA	NA	NA	25 ^b	NA	25 ^a	30 ^a
Body weight	kg	NA	NA	NA	70 ^a	NA	70 ^a	70 ^a
Carcinogen averaging time	days	NA	NA	NA	25550 ^a	NA	25550 ^a	25550 ^a
Noncarcinogen averaging time	days	NA	NA	NA	9125 ^a	NA	9125 ^a	10950 ^a
Conversion Factor	(kg-cm ²)/(mg-m ²)	NA	NA	NA	0.01	NA	0.01	0.01
Inhalation of VOCs and dust								
Inhalation rate	m ³ /day	NA	NA	NA	20 ^a	NA	20 ^a	20 ^a
Exposure time	hours/day	NA	NA	NA	8 ^b	NA	NA	NA
Exposure frequency	days/year	NA	NA	NA	28 ^b	NA	250 ^a	350 ^a
Exposure duration	years	NA	NA	NA	25 ^b	NA	25 ^a	30 ^a
Body weight	kg	NA	NA	NA	70 ^a	NA	70 ^a	70 ^a
Carcinogen averaging time	days	NA	NA	NA	25550 ^a	NA	25550 ^a	25550 ^a
Noncarcinogen averaging time	days	NA	NA	NA	9125 ^a	NA	9125 ^a	10950 ^a
Conversion Factor	days/hour	NA	NA	NA	0.042	NA	NA	NA
<i>Sediment</i>								
Incidental ingestion								
Soil ingestion rate (Adult)	kg/day	NA	0.0001 ^a	NA	0.0001 ^a	0.0001 ^a	NA	0.0001 ^a
Soil ingestion rate (Child)	kg/day	NA	NA	0.0002 ^a	NA	NA	NA	0.0002 ^a
Exposure time	hours/day	NA	2 ^b	2 ^q	8 ^b	1 ^b	NA	NA
Exposure frequency	days/year	NA	90 ^b	50 ^q	28 ^b	75 ^c	NA	350 ^a
Exposure duration (Adult)	years	NA	30 ^b	NA	25 ^b	30 ^a	NA	24 ^a
Exposure duration (Child)	years	NA	NA	10 ^q	NA	NA	NA	6 ^a
Body weight (Adult)	kg	NA	70 ^a	NA	70 ^a	70 ^a	NA	70 ^a
Body weight (Child)	kg	NA	NA	45 ^r	NA	NA	NA	15 ^a
Carcinogen averaging time	days	NA	25550 ^a	25550 ^a	25550 ^a	25550 ^a	NA	25550 ^a
Noncarcinogen averaging time (Adult)	days	NA	10950 ^a	NA	9125 ^a	10950 ^a	NA	8760 ^a
Noncarcinogen averaging time (Child)	days	NA	NA	3650 ^a	NA	NA	NA	2190 ^a

Table C-1. Parameters Used to Quantify Exposures for Each Medium and Receptor (continued)

Parameter	Units	Security Guard/ Maintenance Worker (1)	Hunter/ Trapper (2)	Child Trespasser (3)	National Guard Trainee (4)	Open Recreator (5)	Open Industrial Worker (6)	Resident Farmer (7)
Fraction Ingested	unitless	NA	1 ^b	1 ^b	1 ^b	1 ^b	NA	1 ^b
Conversion Factor	days/hour	NA	0.042	0.042	0.042	0.042	NA	NA
Dermal contact								
Skin area	m ² /event	NA	0.53 ^e	0.815 ^f	0.316 ^d	0.53 ^e	NA	0.53 ^e
Adherence factor	mg/cm ²	NA	1 ^c	0.2 ^c	1 ^c	1 ^c	NA	1 ^c
Exposure frequency	events/year	NA	90 ^b	50 ^q	28 ^b	75 ^c	NA	350 ^a
Exposure duration	years	NA	30 ^b	10 ^q	25 ^b	30 ^a	NA	30 ^a
Body weight	kg	NA	70 ^a	45 ^r	70 ^a	70 ^a	NA	70 ^a
Carcinogen averaging time	days	NA	25550 ^a	25550 ^a	25550 ^a	25550 ^a	NA	25550 ^a
Noncarcinogen averaging time	days	NA	10950 ^a	3650 ^a	9125 ^a	10950 ^a	NA	10950 ^a
Conversion Factor	(kg-cm ²)/(mg-m ²)	NA	0.01	0.01	0.01	0.01	NA	0.01
Inhalation of VOCs and dust								
Inhalation rate	m ³ /day	NA	20 ^a	20 ^a	20 ^a	20 ^a	NA	20 ^a
Exposure time	hours/day	NA	2 ^b	2 ^q	8 ^b	1 ^b	NA	NA
Exposure frequency	days/year	NA	90 ^b	50 ^q	28 ^b	75 ^c	NA	350 ^a
Exposure duration	years	NA	30 ^b	10 ^q	25 ^b	30 ^a	NA	30 ^a
Body weight	kg	NA	70 ^a	45 ^r	70 ^a	70 ^a	NA	70 ^a
Carcinogen averaging time	days	NA	25550 ^a	25550 ^a	25550 ^a	25550 ^a	NA	25550 ^a
Noncarcinogen averaging time	days	NA	10950 ^a	3650 ^a	9125 ^a	10950 ^a	NA	10950 ^a
Conversion Factor	days/hour	NA	0.042	0.042	0.042	0.042	NA	NA
<i>Surface Water</i>								
Incidental ingestion while swimming/wading/showering								
Drinking water ingestion rate	L/day	NA	NA	NA	NA	NA	NA	2 ^a
Incidental water ingestion rate	L/hour	NA	0.05 ^g	0.05 ^g	0.05 ^g	0.05 ^g	NA	NA
Exposure time	hours/day	NA	2 ^b	2 ^q	8 ^b	1 ^b	NA	NA
Exposure frequency	days/year	NA	90 ^b	50 ^q	28 ^b	45 ^b	NA	350 ^a
Exposure duration	years	NA	30 ^b	10 ^q	25 ^b	30 ^a	NA	30 ^a
Body weight	kg	NA	70 ^a	45 ^r	70 ^a	70 ^a	NA	70 ^a

Table C-1. Parameters Used to Quantify Exposures for Each Medium and Receptor (continued)

Parameter	Units	Security Guard/ Maintenance Worker (1)	Hunter/ Trapper (2)	Child Trespasser (3)	National Guard Trainee (4)	Open Recreator (5)	Open Industrial Worker (6)	Resident Farmer (7)
Carcinogen averaging time	days	NA	25550 ^a	25550 ^a	25550 ^a	25550 ^a	NA	25550 ^a
Noncarcinogen averaging time	days	NA	10950 ^a	3650 ^a	9125 ^a	10950 ^a	NA	10950 ^a
Dermal contact while swimming/wading/showering								
Skin area	m ²	NA	0.53 ^e	1.733 ⁱ	0.53 ^e	1.94 ^c	NA	1.94 ^c
Exposure time	hours/day	NA	2 ^b	2 ^q	8 ^b	1 ^b	NA	0.25 ^c
Exposure frequency	days/year	NA	90 ^b	50 ^q	28 ^b	45 ^b	NA	350 ^a
Exposure duration	years	NA	30 ^b	10 ^q	25 ^b	30 ^a	NA	30 ^a
Body weight	kg	NA	70 ^a	45 ^r	70 ^a	70 ^a	NA	70 ^a
Carcinogen averaging time	days	NA	25550 ^a	25550 ^a	25550 ^a	25550 ^a	NA	25550 ^a
Noncarcinogen averaging time	days	NA	10950 ^a	3650 ^a	9125 ^a	10950 ^a	NA	10950 ^a
Conversion Factor	(m/cm)(L/m ³)	NA	10	10	10	10	NA	10
Inhalation of VOCs								
Inhalation rate	m ³ /day	NA	20 ^a	20 ^a	20 ^a	20 ^a	NA	20 ^a
Exposure time	hours/day	NA	2 ^b	2 ^q	8 ^b	1 ^b	NA	NA
Exposure frequency	days/year	NA	90 ^b	50 ^q	28 ^b	45 ^b	NA	350 ^a
Exposure duration	years	NA	30 ^b	10 ^q	25 ^b	30 ^a	NA	30 ^a
Body weight	kg	NA	70 ^a	45 ^r	70 ^a	70 ^a	NA	70 ^a
Carcinogen averaging time	days	NA	25550 ^a	25550 ^a	25550 ^a	25550 ^a	NA	25550 ^a
Noncarcinogen averaging time	days	NA	10950 ^a	3650 ^a	9125 ^a	10950 ^a	NA	10950 ^a
Conversion Factor	days/hour	NA	0.042	0.042	0.042	0.042	NA	NA
Volatilization factor	L/m ³	NA	0.5 ^a	0.5 ^a	0.5 ^a	0.5 ^a	NA	0.5 ^a
<i>Groundwater</i>								
Drinking water ingestion								
Drinking water ingestion rate	L/day	NA	NA	NA	1 ^a	NA	NA	2 ^a
Exposure frequency	days/year	NA	NA	NA	180 ^b	NA	NA	350 ^a
Exposure duration	years	NA	NA	NA	25 ^b	NA	NA	30 ^a
Body weight	kg	NA	NA	NA	70 ^a	NA	NA	70 ^a
Carcinogen averaging time	days	NA	NA	NA	25550 ^a	NA	NA	25550 ^a
Noncarcinogen averaging time	days	NA	NA	NA	9125 ^a	NA	NA	10950 ^a

Table C-1. Parameters Used to Quantify Exposures for Each Medium and Receptor (continued)

Parameter	Units	Security Guard/ Maintenance Worker (1)	Hunter/ Trapper (2)	Child Trespasser (3)	National Guard Trainee (4)	Open Recreator (5)	Open Industrial Worker (6)	Resident Farmer (7)
Dermal contact while showering								
Skin area	m ²	NA	NA	NA	1.94 ^h	NA	NA	1.94 ^h
Exposure time	hours/day	NA	NA	NA	0.25 ^c	NA	NA	0.25 ^c
Exposure frequency	days/year	NA	NA	NA	180 ^b	NA	NA	350 ^a
Exposure duration	years	NA	NA	NA	25 ^b	NA	NA	30 ^a
Body weight	kg	NA	NA	NA	70 ^a	NA	NA	70 ^a
Carcinogen averaging time	days	NA	NA	NA	25550 ^a	NA	NA	25550 ^a
Noncarcinogen averaging time	days	NA	NA	NA	9125 ^a	NA	NA	10950 ^a
Conversion Factor	(m/cm)(L/m ³)	NA	NA	NA	10	NA	NA	10
Inhalation of VOCs during household water use								
Inhalation rate	m ³ /day	NA	NA	NA	20 ^a	NA	NA	20 ^a
Exposure frequency	days/year	NA	NA	NA	180 ^b	NA	NA	350 ^a
Exposure duration	years	NA	NA	NA	25 ^b	NA	NA	30 ^a
Body weight	kg	NA	NA	NA	70 ^a	NA	NA	70 ^a
Carcinogen averaging time	days	NA	NA	NA	25550 ^a	NA	NA	25550 ^a
Noncarcinogen averaging time	days	NA	NA	NA	9125 ^a	NA	NA	10950 ^a
Volatilization factor	L/m ³	NA	NA	NA	0.5 ^a	NA	NA	0.5 ^a
<i>Foodstuffs</i>								
Ingestion of venison								
Conversion factor	unitless	NA	1.25	NA	NA	NA	NA	1.25
Browse ingestion rate	kg dry weight/day	NA	0.87 ^b	NA	NA	NA	NA	0.87 ^b
Fraction browse ingested from site	unitless	NA	0.46 ^b	NA	NA	NA	NA	0.46 ^b
Fat ratio (venison to beef)	unitless	NA	0.20	NA	NA	NA	NA	0.20
Venison ingestion rate	kg/day	NA	0.03 ^b	NA	NA	NA	NA	0.03 ^b
Fraction ingested	unitless	NA	1 ^b	NA	NA	NA	NA	1 ^b
Exposure frequency	days/year	NA	365 ^b	NA	NA	NA	NA	365 ^b
Exposure duration	years	NA	30 ^b	NA	NA	NA	NA	30 ^a
Body weight	kg	NA	70 ^a	NA	NA	NA	NA	70 ^a

Table C-1. Parameters Used to Quantify Exposures for Each Medium and Receptor (continued)

Parameter	Units	Security Guard/ Maintenance Worker (1)	Hunter/ Trapper (2)	Child Trespasser (3)	National Guard Trainee (4)	Open Recreator (5)	Open Industrial Worker (6)	Resident Farmer (7)
Carcinogen averaging time	days	NA	25550 ^a	NA	NA	NA	NA	25550 ^a
Noncarcinogen averaging time	days	NA	10950 ^a	NA	NA	NA	NA	10950 ^a
Ingestion of beef, pork								
Resuspension multiplier	unitless	NA	NA	NA	NA	NA	NA	0.25 ^j
Quantity of pasture ingested	kg dry weight/day	NA	NA	NA	NA	NA	NA	7.2 ^k
Fraction of year cow is on-site	unitless	NA	NA	NA	NA	NA	NA	1 ^b
Fraction of cow's food from on-site	unitless	NA	NA	NA	NA	NA	NA	0.9 ^b
Quantity of soil ingested by cow	kg/day	NA	NA	NA	NA	NA	NA	1 ^l
Beef ingestion rate	kg/day	NA	NA	NA	NA	NA	NA	0.075 ^m
Fraction ingested	unitless	NA	NA	NA	NA	NA	NA	1 ^b
Exposure frequency	days/year	NA	NA	NA	NA	NA	NA	365 ^b
Exposure duration	years	NA	NA	NA	NA	NA	NA	30 ^a
Body weight	kg	NA	NA	NA	NA	NA	NA	70 ^a
Carcinogen averaging time	days	NA	NA	NA	NA	NA	NA	25550 ^a
Noncarcinogen averaging time	days	NA	NA	NA	NA	NA	NA	10950 ^a
Ingestion of milk products								
Resuspension multiplier	unitless	NA	NA	NA	NA	NA	NA	0.25 ^j
Quantity of pasture ingested	kg dry weight/day	NA	NA	NA	NA	NA	NA	16.1 ^k
Fraction of year cow is on-site	unitless	NA	NA	NA	NA	NA	NA	1 ^b
Fraction of cow's food from on-site	unitless	NA	NA	NA	NA	NA	NA	0.6 ^b
Quantity of soil ingested by cow	kg/day	NA	NA	NA	NA	NA	NA	1 ^l
Milk ingestion rate (Adult)	kg/day	NA	NA	NA	NA	NA	NA	0.305 ^m
Milk ingestion rate (Child)	kg/day	NA	NA	NA	NA	NA	NA	0.509 ⁿ
Fraction ingested	unitless	NA	NA	NA	NA	NA	NA	1 ^b
Exposure frequency	days/year	NA	NA	NA	NA	NA	NA	365 ^b
Exposure duration (Adult)	years	NA	NA	NA	NA	NA	NA	24 ^a
Exposure duration (Child)	years	NA	NA	NA	NA	NA	NA	6 ^a
Body weight (Adult)	kg	NA	NA	NA	NA	NA	NA	70 ^a
Body weight (Child)	kg	NA	NA	NA	NA	NA	NA	15 ^a

Table C-1. Parameters Used to Quantify Exposures for Each Medium and Receptor (continued)

Parameter	Units	Security Guard/ Maintenance Worker (1)	Hunter/ Trapper (2)	Child Trespasser (3)	National Guard Trainee (4)	Open Recreator (5)	Open Industrial Worker (6)	Resident Farmer (7)
Carcinogen averaging time	days	NA	NA	NA	NA	NA	NA	25550 ^a
Noncarcinogen averaging time (Adult)	days	NA	NA	NA	NA	NA	NA	8760 ^a
Noncarcinogen averaging time (Child)	days	NA	NA	NA	NA	NA	NA	2190 ^a
Ingestion of vegetables								
Resuspension multiplier	unitless	NA	NA	NA	NA	NA	NA	0.26 ^o
Vegetable ingestion rate	kg/day	NA	NA	NA	NA	NA	NA	0.2 ^m
Fraction ingested	unitless	NA	NA	NA	NA	NA	NA	0.4 ^m
Exposure frequency	days/year	NA	NA	NA	NA	NA	NA	365 ^b
Exposure duration	years	NA	NA	NA	NA	NA	NA	30 ^a
Body weight	kg	NA	NA	NA	NA	NA	NA	70 ^a
Carcinogen averaging time	days	NA	NA	NA	NA	NA	NA	25550 ^a
Noncarcinogen averaging time	days	NA	NA	NA	NA	NA	NA	10950 ^a
Ingestion of fish								
Fish ingestion rate	kg/day	NA	0.054 ^p	NA	NA	NA	NA	0.054 ^p
Fraction ingested	unitless	NA	1 ^b	NA	NA	NA	NA	1 ^b
Exposure frequency	days/year	NA	365 ^b	NA	NA	NA	NA	365 ^b
Exposure duration	years	NA	30 ^b	NA	NA	NA	NA	30 ^a
Body weight	kg	NA	70 ^a	NA	NA	NA	NA	70 ^a
Carcinogen averaging time	days	NA	25550 ^a	NA	NA	NA	NA	25550 ^a
Noncarcinogen averaging time	days	NA	10950 ^a	NA	NA	NA	NA	10950 ^a

Table C-1. Parameters Used to Quantify Exposures for Each Medium and Receptor (continued)

NA = not applicable for this scenario.

^a RAGS, Part B (EPA 1991c).

^b Site-specific (value assumed for site or value obtained from site personnel).

^c USACE 2000b

Security guard/maintenance worker = adult groundskeeper (95th percentile)

Hunter/trapper = residential default

Child trespasser = child default and teen soccer (95th percentile)

National guard trainee = construction worker (95th percentile)

Open recreator = adult soccer (95th percentile)

Open industrial worker = industrial default

Residential farmer = adult farmer (95th percentile)

^d USACE 2000b

Security guard/maintenance worker, national guard training, and open industrial = industrial default

Hunter/trapper, open recreator, and resident farmer = adult residential default.

^e Average surface area for head, hands, forearms and lower legs for an adult (EPA 1992b).

^f Average surface area for head, hands, forearms, torso, and lower legs for a child (EPA 1992b).

^g RAGS, Part A (EPA 1989c).

^h Average total body surface area for an adult (EPA 1992b).

ⁱ Average total body surface area for a child (EPA 1992b).

^j Plant mass loading factor for pasture (Hinton 1992).

^k International Atomic Energy agency 1994.

^l Soil ingestion by dairy cattle (Darwin 1990).

^m Exposure Factors Handbook (EPA 1989d).

ⁿ Pao, et al., 1982.

^o Plant mass loading factor for vegetables (Pinder 1989).

^p Standard default Exposure Factors (EPA 1991b).

^q OEPA personal communication, June 1999, assumes exposure age 8-18.

^r Average body weight for child age 8-18 (EPA, 1992b)

FINAL

**SITE SAFETY AND HEALTH PLAN
ADDENDUM NO. 1**

FOR THE

**PHASE II REMEDIAL INVESTIGATION OF
LOAD LINE 1 AT THE RAVENNA ARMY
AMMUNITION PLAN, RAVENNA, OHIO**

PREPARED FOR



**US Army Corps
of Engineers®**

**LOUISVILLE DISTRICT
CONTRACT No. DACA27-97-D-0025**

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SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

contributed to the preparation of this document and should not
be considered an eligible contractor for its review.

FINAL

**SITE SAFETY AND HEALTH PLAN ADDENDUM NO. 1
FOR THE
PHASE II REMEDIAL INVESTIGATION
OF THE
LOAD LINE 1
AT THE
RAVENNA ARMY AMMUNITION PLANT,
RAVENNA, OHIO**

Prepared for

U.S. Army Corps of Engineers
Louisville District
Louisville, Kentucky 40201
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Prepared by

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
800 Oak Ridge Turnpike, P.O. Box 2502
Oak Ridge, Tennessee 37831

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APPROVALS

**SITE SAFETY AND HEALTH PLAN ADDENDUM NO. 1
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PHASE II REMEDIAL INVESTIGATION
OF THE
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RAVENNA, OHIO**

Stephen B. Selecman, SAIC Project Manager

Date

Stephen L. Davis, CIH, CSP, SAIC Health and Safety Manager

Date

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ACRONYMS

CIH	Certified Industrial Hygienist
CPR	cardiopulmonary resuscitation
CSP	Certified Safety Personnel
D&D	decontamination and decommissioning
DNT	dinitrotoluene
FP	flash point
FSHP	Facility-wide Safety and Health Plan
H&S	health and safety
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
IDLH	immediately dangerous to life and health
IP	ionization potential
MSDS	Material Safety Data Sheet
NA	not available
NIOSH	National Institute for Occupational Safety and Health
OE	ordnance and explosives
PEL	permissible exposure limit
PID	photoionization detector
PPE	personal protective equipment
ppm	parts per million
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RI	Remedial Investigation
RVAAP	Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
STEL	short-term exposure limit
SVOC	semivolatile organic compound
TNT	trinitrotoluene
TLV	threshold limit value
TWA	time-weighted average
USGS	U.S. Geological Survey
VP	vapor pressure

INTRODUCTION

Science Applications International Corporation's (SAIC's) formal policy, as stated in the Environmental Compliance and Health and Safety Program manual, is to take every reasonable precaution to protect the health and safety of our employees, the public, and the environment. To this end, the Ravenna Army Ammunition Plant Facility-wide Safety and Health Plan (FSHP) and this Site Safety and Health Plan (SSHP) Addendum collectively set forth the specific procedures required to protect SAIC and SAIC subcontractor personnel involved in the field activities. All field personnel are required to comply with the requirements of these plans. In addition, subcontractors are responsible for providing their employees with a safe workplace, and nothing in these plans relieves such subcontractors of this responsibility. If the requirements of these plans are not sufficient to protect the employees of a subcontractor, then the subcontractor is required to supplement this information with work practices and procedures that will ensure the safety of its personnel.

The FSHP addresses program issues and hazards and hazard controls common to the entire installation. This SSHP Addendum to the FSHP serves as the lower-tier document addressing the hazards and controls specific to this project. Copies of the FSHP and this SSHP Addendum will be present at the work site.

SAIC will perform a Phase II Remedial Investigation (RI) at the Load Line 1 location. From 1941 to 1971, this area of concern produced large volumes of process effluent (pink water) resulting from the loading, packing, and assembly of munitions. The wastewater passed through concrete sumps and sawdust filtration units prior to entering a settling pond via unlined ditches. The unlined settling pond received washdown water and wastewater from the load line operations. Building washdown water was also swept through doorways onto the ground surrounding load line buildings. Potential contaminants of concern identified in the Phase I RI include ordnance and explosives (OE); explosives residues; metals (arsenic, lead, chromium, and mercury); and semivolatile organic compounds (SVOCs) (USACE 1998). Low levels of polychlorinated biphenyls and pesticides were observed in seven samples collected during the Phase I RI.

Environmental characterization will be conducted incrementally during the Phase II RI under the auspices of the sequential Sampling and Analysis Plan Addenda. Groundwater will be the first environmental medium characterized, followed by soil, sediment, and surface water. This SSHP Addendum addresses all planned characterization activities.

The following are tasks to be performed as part of this project:

- collect 350 samples using hand augers or trowels;
- collect 175 subsurface soil samples from 2- to 4-foot depths using hand augers and hand-held power augers and 88 samples from 4- to 6-foot depths using hand-held power augers;
- drill and install eight new wells using NX coring and subsequent overdrilling with a 4-inch air rotary bit;
- develop the eight new wells;
- perform slug testing in the eight new wells;
- perform groundwater sampling using low-flow purging techniques for eight new wells and six existing wells;

- perform field analyses for trinitrotoluene (TNT) and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) using on-site colorimetric analyses and metals using X-ray fluorescence; and
- decontaminate sampling equipment.

Potential hazards posed by the tasks planned at these locations include OE, moving equipment (power auger and drill rig), hand-held power tools and hand tools for brush clearing, fuel or decontamination solvent fires, chemical exposure, temperature extremes, noise, stinging/biting insects, poisonous plants, and snakes. These hazards will be minimized through the application of various control measures, such as area clearance by OE specialists, exclusion zones around heavy equipment, protective clothing, etc. These controls are detailed elsewhere in this document.

The potential for chemical overexposure appears to be low given the nature of the planned tasks. All of the expected contaminants have low vapor pressures, making overexposure through vapor inhalation very unlikely. All of the planned tasks, with the exception of air rotary drilling, pose a minimal potential for creating airborne particulates. Potable water will be used as needed to manage dust generation. Air rotary drill discharge will not be routed through a particulate control system to minimize airborne particulates unless other measures fail to perform adequately. There is some potential for adverse effects due to dermal contact with contaminated soil. The crew will use protective gloves to handle potentially contaminated materials and, if necessary, the Site Safety and Health Officer (SSHO) will upgrade the required personal protective equipment (PPE) to prevent dermal contact with potentially contaminated materials. The SSHO will observe all site tasks during daily safety inspections and will use professional judgment, coupled with instrument readings, to determine if upgrading of PPE is required. A detailed analysis of these hazards and specific appropriate controls is presented in Chapter 2, [Table 2-2](#).

This investigation will be performed in Level D PPE, plus chemical-resistant gloves will be used when handling potentially contaminated materials, unless one of several action levels is exceeded, or the potential for increased risk becomes apparent during the investigation. Protective procedures, including protective clothing, will be upgraded as necessary by the SSHO based on established action levels or judgment.

1.0 SITE DESCRIPTION AND CONTAMINATION CHARACTERIZATION

1.1 SITE DESCRIPTION

The Ravenna Army Ammunition Plant (RVAAP) is located in northeastern Ohio within Portage and Trumbull Counties, approximately 4.8 km (3 miles) northeast of the town of Ravenna. The installation consists of 8,668 hectares (21,419 acres) in a 17.7-km (11-mile)-long, 5.6-km (3.5-mile)-wide tract bordered by a sparsely inhabited private residential area. The site is an inactive government-owned armament, munitions, and chemical command facility maintained by a contracted caretaker, R&R International, Inc.

The installation was active from 1941 to 1992. Activities included loading, assembling, storing, and packing military ammunition; demilitarization of munitions; production of ammonium nitrate fertilizer; and disposal of “off-spec” munitions. Munitions handled on the installation included artillery rounds of 90 mm or more and 2000-lb bombs.

The buildings associated with Load Line 1 are currently undergoing decontamination and decommissioning (D&D). These activities will be in progress during the Phase II Remedial Investigation (RI) groundwater investigation, but are expected to be completed before the RI characterization of soil, sediment, and surface is initiated.

1.2 CONTAMINANTS

The Phase I RI (USACE 1998) detected a number of contaminants at this location. Explosives residues were the most notable contaminants. Explosives residues were detected in 29 of the 46 soil samples analyzed. The maximum concentration of trinitrotoluene (TNT) was 5800 mg/kg. See [Tables 1-1](#) and [1-2](#) for detailed sampling results. Inclusion in this table indicates the presence of a contaminant but does not necessarily indicate that the contaminant is present in sufficient quantity to pose a health risk to project workers.

Table 1-1. Load Line 1 Phase I RI Analytical Results (Surface Soil and Sediment)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
<i>Surface Soil</i>									
Cyanide	mg/kg	8/ 12	•		0.11			Yes	No Background Data Available
1,3,5-Trinitrobenzene	µg/kg	10/ 47	•		550	110000		Yes	No Background Data Available
2,4,6-Trinitrotoluene	µg/kg	28/ 47	•		260	5800000		Yes	Detected > 5% of Samples
2,4-Dinitrotoluene	µg/kg	5/ 47	•		100	1500		Yes	Detected > 5% of Samples
HMX	µg/kg	2/ 47	•		2600	9100		Yes	No Background Data Available
RDX	µg/kg	2/ 47	•		1800	49000		Yes	No Background Data Available
Aluminum	mg/kg	47/ 47	15600	4/ 47	1860	47600	20000 – 100000	Yes	> 5% Detect Above Background
Antimony	mg/kg	8/ 12	•		0.45	8.8		Yes	No Background Data Available
Arsenic	mg/kg	47/ 47	19.6	3/ 37	4.5	77	5.2 – 27.0	Yes	> 5% Detect Above Background
Barium	mg/kg	47/ 47	75	21/ 47	22.2	1380	300 – 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	12/ 12	•		0.2	2.5	1.5 – 2.0	Yes	No Background Data Available
Cadmium	mg/kg	42/ 47	0.29	35/ 47	0.15	23.5	1 – 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	12/ 12	•		452	56700	1100 – 31000	No	Essential Nutrient
Chromium	mg/kg	47/ 47	18.7	17/ 47	4.8	394	15.0 – 100.0	Yes	> 5% Detect Above Background
Cobalt	mg/kg	12/ 12	•		3.9	33.7	7 – 20	Yes	No Background Data Available
Copper	mg/kg	12 / 12	•		11.3	110	7.0 – 70.0	Yes	No Background Data Available
Iron	mg/kg	12/ 12	•		13500	75600	15000 – 50000	No	Essential Nutrient

Table 1-1 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Lead	mg/kg	47/ 47	17.9	41/ 47	10.8	3610	15 – 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	12/ 12	•		750	9100	3000 – 15000	No	Essential Element
Manganese	mg/kg	47/ 47	728	10/ 47	113	2140	150 – 1000	Yes	> 5% Detect Above Background
Mercury	mg/kg	41/ 47	0.08	14/ 47	0.03	1.4	0.03 – 0.22	Yes	> 5% Detect Above Background
Nickel	mg/kg	12/ 12	•		9.4	45.8	15 – 50	Yes	No Background Data Available
Potassium	mg/kg	12/ 12	•		358	2690	11800 – 25100	No	Essential Element
Selenium	mg/kg	44/ 47	2.6	4/ 47	0.32	4.3	< 0.1 – 1.2	Yes	> 5% Detect Above Background
Silver	mg/kg	1/ 47	0.24	0/ 47	0.24	0.24	0.7	No	Below Background
Sodium	mg/kg	12/ 12	•		148	535	5000 – 7000	No	Essential Element
Thallium	mg/kg	12/ 12	•		0.84	7.9		Yes	No Background Data Available
Vanadium	mg/kg	12/ 12	•		5.5	92.9	20 – 150	Yes	No Background Data Available
Zinc	mg/kg	47/ 47	72.1	34/ 47	34.1	1560	25 – 110	Yes	> 5% Detect Above Background
4,4'-DDD	µg/kg	2/ 12	•		42	250		Yes	No Background Data Available
4,4'-DDE	µg/kg	4/ 12	•		3.3	840		Yes	No Background Data Available
4,4'-DDT	µg/kg	3/ 12	•		63	450		Yes	No Background Data Available
Aldrin	µg/kg	1/ 12	•		2.5	2.5		Yes	No Background Data Available
Alpha chlordane	µg/kg	3/ 12	•		19	140		Yes	No Background Data Available
Aroclor-1254	µg/kg	5/ 12	•		95	36000		Yes	No Background Data Available
Aroclor-1260	µg/kg	1/ 12	•		680	680		Yes	No Background Data Available

Table 1-1 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Dieldrin	µg/kg	1/ 12	•		170	170		Yes	No Background Data Available
Endosulfan I	µg/kg	1/ 12	•		40	40		Yes	No Background Data Available
Endosulfan II	µg/kg	1/ 12	•		8.7	8.7		Yes	No Background Data Available
Endrin	µg/kg	1/ 12	•		37	37		Yes	No Background Data Available
Endrin aldehyde	µg/kg	2/ 12	•		9.6	53		Yes	No Background Data Available
Gamma chlordane	µg/kg	4/ 12	•		1.9	250		Yes	No Background Data Available
Heptachlor epoxide	µg/kg	1/ 12	•		2.3	2.3		Yes	No Background Data Available
Anthracene	µg/kg	1/ 12	•		60	60		Yes	No Background Data Available
Benzo(a)anthracene	µg/kg	5/ 12	•		77	330		Yes	No Background Data Available
Benzo(a)pyrene	µg/kg	5/ 12	•		86	420		Yes	No Background Data Available
Benzo(b)fluoranthene	µg/kg	4/ 12	•		100	400		Yes	No Background Data Available
Bis(2-ethylhexyl)phthalate	µg/kg	4/ 12	•		74	530		Yes	No Background Data Available
Carbazole	µg/kg	5/ 12	•		94	500		Yes	No Background Data Available
Chrysene	µg/kg	5/ 12	•		42	1400		Yes	Detected > 5% of Samples
Di-n-butyl phthalate	µg/kg	1/ 12	•		36	36		Yes	No Background Data Available
Dibenzo(a,h)anthracene	µg/kg	6/ 12	•		90	600		Yes	No Background Data Available
Dimethyl phthalate	µg/kg	4/ 12	•		410	14000		Yes	No Background Data Available

Table 1-1 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Fluoranthene	µg/kg	3/ 12	•		40	160		Yes	No Background Data Available
Indeno(1,2,3-cd)pyrene	µg/kg	1/ 12	•		1900	1900		Yes	No Background Data Available
N-nitrosodiphenylamine	µg/kg	2/ 12	•		110	270		Yes	No Background Data Available
Pentachlorophenol	µg/kg	1/ 12	•		3900	3900		Yes	No Background Data Available
Phenanthrene	µg/kg	4/ 12	•		67	500		Yes	No Background Data Available
Pyrene	µg/kg	5/ 12	•		110	890		Yes	No Background Data Available
Acetone	µg/kg	1/ 9	•		270	270		Yes	No Background Data Available
Chloroform	µg/kg	3/ 12	•		2	2		Yes	Detected > 5% of Samples
Toluene	µg/kg	5/ 12	•		6	31		Yes	Detected > 5% of Samples
<i>Sediment</i>									
Cyanide	mg/kg	2/ 3	•		0.35	1.1		Yes	No Background Data Available
1,3,5-Trinitrobenzene	µg/kg	2/ 22	•		380	6800		Yes	No Background Data Available
2,4,6-Trinitrotoluene	µg/kg	3/ 22	•		430	770000			Detected > 5% of Samples
HMX	µg/kg	2/ 22	•		2800	12000		Yes	No Background Data Available
RDX	µg/kg	2/22	•		430	16000		Yes	No Background Data Available
Aluminum	mg/kg	22/ 22	15600	2/ 22	3400	19900	20000 – 100000		> 5% Detect Above Background
Antimony	mg/kg	2/ 3	•		15.3	2460		Yes	No Background Data Available

Table 1-1 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Arsenic	mg/kg	22/ 22	19.6	7/ 22	6.9	67.1	5.2 – 27.0	Yes	> 5% Detect Above Background
Barium	mg/kg	22/ 22	75	16/ 22	38.5	269	300 – 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	3/ 3	•		0.38	1.7	1.5 – 2.0	Yes	No Background Data Available
Cadmium	mg/kg	20/ 22	0.29	18/ 22	0.21	26.9	1 – 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	3/ 3	•		3040	36200	1100 – 31000	No	Essential Nutrient
Chromium	mg/kg	22/ 22	18.7	7/ 22	9.5	345	15.0 – 100.0	Yes	> 5% Detect Above Background
Cobalt	mg/kg	3/ 3	•		4.7	43.2	7 – 20	Yes	No Background Data Available
Copper	mg/kg	3/ 3	•		9	558	7.0 – 70.0	Yes	No Background Data Available
Iron	mg/kg	3/ 3	•		9340	199000	15000 – 50000	No	Essential Nutrient
Lead	mg/kg	22/ 22	17.9	14/ 22	12.9	2220	15 – 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	3/ 3	•		2110	9370	3000 – 15000	No	Essential Nutrient
Manganese	mg/kg	22/ 22	728	9/ 22	80.1	2340	150 – 1000	Yes	> 5% Detect Above Background
Mercury	mg/kg	15/ 22	0.08	7/ 22	0.05	1.4	0.03 – 0.22	Yes	> 5% Detect Above Background
Nickel	mg/kg	3/ 3	•		9.8	108	15 – 50	Yes	No Background Data Available
Potassium	mg/kg	3/ 3	•		185	673	11800 – 25100	No	Essential Nutrient
Selenium	mg/kg	20/ 22	2.6	4/ 22	0.43	10.3	< 0.1 – 1.2	Yes	> 5% Detect Above Background
Silver	mg/kg	2/ 22	0.24	2/ 22	1.5	3.9	0.7	Yes	> 5% Detect Above Background
Sodium	mg/kg	3/ 3	•		195	484	5000 – 7000	No	Essential Nutrient
Thallium	mg/kg	3/ 3	•		0.8	8.1		Yes	No Background Data Available

Table 1-1 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Vanadium	mg/kg	3/ 3	•		11.9	14.5	20 – 150	Yes	No Background Data Available
Zinc	mg/kg	22/ 22	72.1	17/ 22	48.2	2530	25 – 110	Yes	> 5% Detect Above Background
4,4'-DDD	µg/kg	1/ 3	•		12	12		Yes	No Background Data Available
4,4'-DDE	µg/kg	1/ 3	•		740	740		Yes	No Background Data Available
4,4'-DDT	µg/kg	1/ 3	•		440	440		Yes	No Background Data Available
Alpha chlordane	µg/kg	1/ 3	•		9.9	9.9		Yes	No Background Data Available
Aroclor-1254	µg/kg	2/ 3	•		290	44000		Yes	No Background Data Available
Endrin	µg/kg	1/ 3	•		160	160		Yes	No Background Data Available
Endrin aldehyde	µg/kg	1/ 3	•		320	320		Yes	No Background Data Available
Gamma chlordane	µg/kg	2/ 3	•		11	130		Yes	No Background Data Available
Heptachlor	µg/kg	1/ 3	•		3.4	3.4		Yes	No Background Data Available
Anthracene	µg/kg	1/ 3	•		260	260		Yes	No Background Data Available
Benzo(a)anthracene	µg/kg	2/ 3	•		260	860		Yes	No Background Data Available
Benzo(a)pyrene	µg/kg	3/ 3	•		350	1300		Yes	No Background Data Available
Benzo(b)fluoranthene	µg/kg	2/ 3	•		600	3000		Yes	No Background Data Available
Benzo(g,h,i)perylene	µg/kg	2/ 3	•		460	1400		Yes	No Background Data Available
Benzo(k)fluoranthene	µg/kg	2/ 3	•		500	1500		Yes	No Background Data Available

Table 1-1 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Bis(2-ethylhexyl)phthalate	µg/kg	2/ 3	•		120	490		Yes	Detected > 5% of Samples
Carbazole	µg/kg	1/ 3	•		240	240		Yes	No Background Data Available
Chrysene	µg/kg	3/ 3	•		130	1800		Yes	No Background Data Available
Di-n-butyl phthalate	µg/kg	1/ 3	•		870	870		Yes	No Background Data Available
Dibenzo(a,h)anthracene	µg/kg	2/ 3	•		180	560		Yes	No Background Data Available
Fluoranthene	µg/kg	2/ 3	•		510	2100		Yes	No Background Data Available
Indeno(1,2,3-cd)pyrene	µg/kg	2/ 3	•		440	1100		Yes	No Background Data Available
Phenanthrene	µg/kg	2/ 3	•		190	380		Yes	No Background Data Available
Pyrene	µg/kg	3/ 3	•		140	1400		Yes	No Background Data Available
Acetone	µg/kg	1/ 2	•		110	110		Yes	No Background Data Available
Chloroform	µg/kg	1/ 3	•		4	4		Yes	Detected > 5% of Samples

HMX = octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
 RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine
 RI = remedial investigation
 USGS = U.S. Geological Survey

Table 1-2. Load Line 1 Phase I RI Analytical Results (Groundwater)

Analyte	Frequency of Detects	Minimum Detect (µg/L)	Maximum Detect (µg/L)
<i>Groundwater</i>			
Cyanide	1/ 7	2.9	2.9
Aluminum	7/ 7	27.8	235
Arsenic	3/ 7	8.4	64.1
Barium	7/ 7	20.3	105
Beryllium	2/ 6	0.33	0.43
Calcium	6/ 6	4050	196000
Cobalt	5/ 6	1.4	27.5
Copper	4/ 6	0.93	7.4
Iron	4/ 6	37.3	822
Magnesium	6/ 6	2590	80700
Manganese	7/ 7	130	3120
Mercury	3/ 7	0.1	0.13
Nickel	6/ 6	1.6	73.2
Potassium	6/ 6	1010	5090
Sodium	6/ 6	4360	18100
Zinc	4/ 7	9.1	82.5
Heptachlor	1/ 6	0.05	0.05
2,4-Dimethylphenol	1/ 5	1	1
Diethyl phthalate	1/ 6	1	1
Acetone	1/ 4	18	18
Methylene chloride	1/ 7	11	11

RI = remedial investigation

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2.0 HAZARD/RISK ANALYSIS

The purpose of the task hazard/risk analysis is to identify and assess potential hazards that may be encountered by personnel and to prescribe required controls. Table 2-1, a general checklist of hazards that may be posed by this project, indicates whether a particular major type of hazard is present. If additional tasks or significant hazards are identified during the work, this document will be modified by addendum or field change order to include the additional information.

Table 2-1. Hazards Inventory

Yes	No	Hazard
	X	Confined space entry
	X	Excavation entry (deeper than 1.2 m)
X		Heavy equipment (drill rigs and power augers)
X		Fire and explosion (fuels)
X		Electrical shock (utilities)
X		Exposure to chemicals (contaminants and chemical tools)
X		Temperature extremes
X		Biological hazards (ticks, poisonous plants)
	X	Radiation or radioactive contamination
X		Noise (drill rigs, power augers, and power tools for brush clearing)
	X	Drowning
X		OE (residual explosives and propellants only)

OE = ordnance and explosives

Specific tasks are as follows:

- OE surveys and sample location clearance,
- vegetation clearing with machete and chainsaw,
- surface soil sampling with hand augers or scoops,
- subsurface soil boring and sampling with power augers and hollow-stem auger rig,
- surface water and sediment sampling using hand tools,
- bedrock coring and air rotary drilling,
- equipment decontamination at the central equipment decontamination facility,
- field analysis of explosives and metals, and
- characterization and handling of investigation-derived wastes.

2.1 TASK-SPECIFIC HAZARD ANALYSIS

Table 2-2 presents task-specific hazards, task-specific hazard analyses (Risk Assessment Code), relevant hazard controls, and required monitoring, if appropriate, for all of the planned site tasks. The Risk Assessment Codes in Table 2-2 are derived through a qualitative risk assessment process using probability codes and severity codes. The severity codes are:

- I = injuries/illnesses involving permanent total disability or death;
- II = injuries/illnesses with permanent partial disability or temporary total disability;
- III = injuries/illnesses resulting in temporary, reversible conditions with period of disability of less than 3 months; and
- IV = injuries/illnesses with reversible adverse effects requiring only minor treatment.

The probability codes are

- A = likely to occur immediately;
- B = probably will occur in time;
- C = possible to occur in time; and
- D = unlikely to occur.

2.2 POTENTIAL EXPOSURES

Environmental contamination is known to exist at this location, and controls will be used to minimize exposure. Information on the significant contaminants and chemical tools that will be used for the project is contained in Table 2-3. This table includes contaminants that pose a potential to cause adverse effects in site workers during, or after, the execution of this project. It excludes potential contaminants that are unlikely to pose a threat to site workers.

Table 2-2. Hazards Analysis

Safety and Health Hazards	Risk Assess. Codes	Controls	Monitoring
<i>Vegetation Clearing with Machetes and Chainsaws</i>			
General safety hazards (rotating machinery, moving equipment, slips, and falls)	B, II	<p>Level D PPE (see Section 5.0) plus hardhat, heavy-duty work gloves, and chainsaw chaps.</p> <p>Uninvolved personnel will be kept at a distance of at least 50 feet.</p> <p>An audible warning will be used to alert personnel when a tree is falling.</p> <p>No elevated (climbing trees, standing on ladders, etc.) chainsaw use.</p> <p>Only personnel experienced with chainsaw use will operate saws.</p> <p>Team members will be at least 10 feet apart but within visual contact during cutting.</p> <p>Chainsaw equipped with anti-kickback protection.</p> <p>Chainsaw adjusted so that chain does not move at idle speed.</p> <p>Chainsaw will not be used to cut above shoulder height.</p> <p>Machetes equipped with lanyard and lanyard looped around wrist during use to prevent accidental release of machete.</p>	Daily safety inspections.
Contact with OE	C, II	<p>Pre-entry screening survey and continuous escort by OE specialist support.</p> <p>On-site training in ordnance recognition for all field personnel.</p> <p>Withdrawal of all SAIC and subcontractor personnel from immediate area and field marking of suspect area if ordnance or suspected ordnance is discovered. Notification of USACE Project Manager and facility EOD personnel if ordnance is discovered.</p>	Visual and instrument surveys for ordnance conducted by OE expert personnel.
Exposure to chemicals (see Table 2-3)	D, IV	No contact with potentially contaminated material is expected during this task. As a precaution, hands will be washed prior to taking anything by mouth. Medical clearance will be required.	Daily safety inspections.
Gunfire (deer hunting with shotguns loaded with slugs is allowed in some areas on Fridays and Saturdays during season, October and November)	D, I	No field work during hunting season.	None.
Noise	B, II	Hearing protection while operating or within 25 feet of operating chainsaw.	Daily safety inspections.

Table 2-2. (continued)

Safety and Health Hazards	Risk Assess. Codes	Controls	Monitoring
Fire (fuels)	D, III	Chainsaw turned off and allowed to cool for 5 minutes prior to fueling. Fuel in safety cans with flame arresters. No ignition sources in fuel storage or refueling areas. Fire extinguisher (see Section 9.0).	Daily safety inspections.
Biological hazards (bees, ticks, wasps, snakes, and poison ivy)	C, III	PPE (boots, work clothes). Pants tucked into boots or wrapped with duct tape. Insect repellant, as necessary.	Visual survey.
Electric shock	D, II	None expected. SSHO will verify.	Visual survey of all work areas.
Temperature extremes	C, II	Administrative controls (see Section 8.0).	Ambient temperature, heart rates as appropriate.
<i>Soil and Shallow Sediment Sampling with Hand Augers or Scoops</i>			
General safety hazards (manual lifting, slips, falls, traffic, and nearby D&D activities)	D, IV	Level D PPE (see Section 5). Hard hat if overhead hazards are present; HAZWOPER training. Buddy system. Coordination with D&D program personnel, high-visibility vests and other control measures if traffic poses a hazard.	Daily site safety inspections.
Contact with OE	D, II	OE clearance of sample locations in advance. Ordnance is not known or expected; thus, full-time OE support is not required during sampling. On-site training in ordnance recognition for all field personnel. Visual surveillance for OE. Withdrawal of all SAIC and subcontractor personnel and field marking of the area if ordnance or suspected ordnance is discovered. Notification of USACE Project Manager and facility EOD personnel if ordnance is discovered.	Visual and instrument surveys for ordnance conducted by OE specialist personnel. Visual surveillance for OE by all site workers.
Drowning (highly unlikely, ditches and creek expected to be less than 2 feet deep)	D, IV	Coast guard-approved personal flotation devices if working on or near water deeper than 4 feet.	Daily safety inspections.
Exposure to chemicals (see Table 2-3)	D, III	Natural rubber or similar gloves for contact with potentially contaminated material. Gloves will be disposed after single use. Washing face and hands and any other exposed areas prior to taking anything by mouth. Minimal contact. Fifteen-minute eyewash within 100 feet if corrosive sample preservatives are being poured. Hazardous Waste operations medical clearance.	Photoionization detector, visual surveillance for significant contamination.

Table 2-2 (continued)

Safety and Health Hazards	Risk Assess. Codes	Controls	Monitoring
Gunfire (deer hunting with shotguns loaded with slugs allowed in some areas on Fridays and Saturdays during season)	D, I	No field work at dawn or dusk in areas open to hunting (during open hunting season). High-visibility vests in these areas. When possible, schedule work in these areas for Sunday through Thursday.	None.
Biological hazards (poison ivy, bees, ticks, and wasps)	C, III	PPE (boots, work clothes). Pants tucked into boots or wrapped with duct tape. Insect repellent, as necessary.	Visual survey.
Temperature extremes	C, II	Administrative controls (see Section 9.0). Chilled fluids available if >70 degrees Fahrenheit. Frequent breaks in shaded area.	Ambient temperature, heart rates as appropriate.
<i>Soil Boring and Soil Sampling Using a Hand-Operated Power Auger</i>			
General safety hazards (rotating machinery, moving equipment, slips, falls, traffic, and nearby D&D activities)	C, II	Level D PPE (see Section 5.0). Hard hat if overhead hazards are present. Operate auger per manufacturers' directions. Positive action control (Deadman switch) or easily accessible kill switch on power auger. HAZWOPER training. Buddy system. Coordination with D&D program personnel, high-visibility vests and other control measures if traffic poses a hazard.	Daily site safety inspections.
Contact with OE	D, II	OE clearance of sample locations in advance. Ordnance is not known or expected; thus, full-time OE support is not required during sampling. On-site training in ordnance recognition for all field personnel. Withdrawal of all SAIC and subcontractor personnel from immediate area and field marking of suspect area if ordnance or suspected ordnance is discovered. Notification of USACE Project Manager and facility EOD personnel if ordnance is discovered.	Visual and instrument surveys for ordnance conducted by OE expert personnel. Visual surveillance for OE by all site personnel.
Exposure to chemicals (see Table 2-3)	D, IV	Natural rubber or similar gloves for contact with potentially contaminated material. Gloves will be disposed after single use. Fifteen-minute eyewash within 100 feet if corrosive sample preservatives are being poured. Washing face and hands and any other exposed areas prior to taking anything by mouth. Minimal contact. Medical clearance.	PID monitoring, visual surveillance for dust generation, and visual surveillance for significant contamination.

Table 2-2 (continued)

Safety and Health Hazards	Risk Assess. Codes	Controls	Monitoring
Gunfire (deer hunting with shotguns loaded with slugs is allowed in some areas on Fridays and Saturdays during season)	D, I	No field work at dawn or dusk in areas open to hunting during hunting season. High-visibility vests in these areas. When possible, schedule work in these areas for Sunday through Thursday.	None.
Noise	B, II	Hearing protection within 7.6 m (25 feet) of equipment when operating.	Daily safety inspections.
Fire (fuels)	D, III	Fuel in safety cans with flame arresters. No ignition sources in fuel storage or refueling areas. Fire extinguisher rated at least 10-ABC immediately available (see Section 9.0). Allow power auger to cool for at least 10 minutes before refueling.	Daily safety inspection.
Biological hazards (poison ivy, bees, ticks, and wasps)	C, III	PPE (boots, work clothes). Pants tucked into boots or wrapped with duct tape. Insect repellant, as necessary.	Visual survey.
Electric shock	D, II	Identification and clearance of underground utilities. Contact local utilities clearance organization and appropriate site personnel.	Visual of all work areas.
Temperature extremes	C, II	Administrative controls (see Section 9.0). Chilled fluids if > 70 degrees Fahrenheit.	Ambient temperature, heart rates as appropriate.
<i>Installation of Monitoring Wells Using NX Coring and Subsequent Overdrilling with 4-inch Air Rotary Bit</i>			
General safety hazards (power machinery, moving equipment, slips, falls, traffic, and nearby D&D activities)	D, III	Level D PPE (see Section 5.0) plus hard hat. Personnel not involved with equipment will stand clear during operation. HAZWOPER training. Buddy system. Medical clearance. Drilling locations will be mowed and cleared prior to mobilization of the field team to the site. Coordination with D&D program personnel, high-visibility vests and other control measures if traffic poses a hazard.	Daily site safety inspections.
Contact with OE	D, II	Drilling sites will be cleared by OE specialist personnel. Ordnance is not known or expected; thus, full-time OE support is not required during sampling. On-site training in ordnance recognition for all field personnel. Visual surveillance for OE. Withdrawal of all SAIC and subcontractor personnel and field marking of the area if ordnance or suspected ordnance is discovered. Notification of USACE Project Manager and facility EOD personnel if ordnance is discovered.	Visual and instrument surveys for ordnance conducted by OE specialist personnel. Visual surveillance for OE by all site personnel.

Table 2-2 (continued)

Safety and Health Hazards	Risk Assess. Codes	Controls	Monitoring
Exposure to chemicals (see Table 2-3)	D, III	Natural rubber or similar gloves for contact with potentially contaminated material. Gloves will be disposed after single use. Washing face and hands and any other exposed areas prior to taking anything by mouth. Minimal contact. Air rotary drill rigs will be equipped with dust suppression systems. Fifteen-minute eyewash in the immediate area.	Photoionization detector, visual surveillance for dust generation, and visual surveillance for significant contamination.
Gunfire (deer hunting with shotguns loaded with slugs is allowed in some areas on Fridays and Saturdays during season)	D, I	No field work at dawn or dusk in areas open to hunting (during hunting season). High-visibility vests in these areas. When possible, schedule work in these areas for Sunday through Thursday.	None.
Noise	B, III	Hearing protection within 7.6 m (25 feet) of equipment during operation.	Daily safety inspections.
Fire (fuels)	D, III	Fuel in safety cans with flame arresters. Ignition sources excluded from fuel storage and fuel pouring areas. Fire extinguisher rated at least 10-ABC immediately available (see Section 9.0).	Daily safety inspection.
Biological hazards (poison ivy, bees, ticks, and wasps)	C, III	PPE (boots, work clothes). Pants tucked into boots or wrapped with duct tape. Insect repellant, as necessary.	Visual survey.
Electric shock	D, II	Identification and clearance of aboveground and underground utilities. Contact local utilities locating organization and appropriate site personnel to locate buried utilities. Observe minimum distances from aboveground utilities specified in Section 9.0.	Visual of all work areas.
Temperature extremes	C, II	Administrative controls (see Section 9.0). Chilled fluids immediately available if temperature > 70 degrees Fahrenheit.	Ambient temperature, heart rates as appropriate.
<i>Well Development, Slug Testing, Groundwater Sampling Using Low-Flow Purging Techniques</i>			
Safety hazards associated with equipment, traffic, and nearby D&D activities	D, IV	Level D PPE. Hard hat if overhead hazards are present (see Section 5.0). HAZWOPER training. Buddy system. Coordination with D&D program personnel, high-visibility vests and other control measures if traffic poses a hazard.	Daily safety inspections of SAIC operations.

Table 2-2 (continued)

Safety and Health Hazards	Risk Assess. Codes	Controls	Monitoring
Contact with unexploded ordnance (OE)	D, II	Pre-clearance of well areas by OE specialist personnel. Training in ordnance recognition for all field personnel. Visual surveillance for the presence of OE. Withdrawal of all SAIC and subcontractor personnel and field marking of the area if ordnance or suspected ordnance is discovered. Notification of USACE and facility EOD personnel if ordnance is discovered.	Visual surveys for ordnance.
Exposure to chemicals (see Table 2-3)	D, IV	Natural rubber or similar gloves for contact with potentially contaminated material. Gloves will be disposed after single use. Washing face and hands and any other exposed areas prior to taking anything by mouth. Minimal contact. Fifteen-minute eyewash within 100 feet if corrosive sample preservatives are being poured.	PID if previous monitoring indicated a potential overexposure.
Gunfire (deer hunting with shotguns loaded with slugs is allowed in some areas on Fridays and Saturdays during season)	D, I	No field work at dawn or dusk in areas open to hunting during season. High-visibility vests in these areas. When possible, schedule work in these areas for Sunday through Thursday.	None.
Biological hazards (poison ivy, bees, ticks, and wasps)	C, III	PPE (boots, work clothes). Pants tucked into boots or wrapped with duct tape. Insect repellant, as necessary.	Visual survey.
Temperature extremes	C, II	Administrative controls (see Section 9.0).	Ambient temperature, heart rates as appropriate.
<i>Field Laboratory Analysis</i>			
General safety hazards	D, IV	HAZWOPER training.	Daily site safety inspections.

Table 2-2 (continued)

Safety and Health Hazards	Risk Assess. Codes	Controls	Monitoring
Exposure to chemicals (see Table 2-3)	B, II	Natural rubber or similar gloves for contact with potentially contaminated material or chemicals. Safety glasses. Lab coat or long-sleeved shirt. Washing face and hands and any other exposed areas prior to taking anything by mouth. Minimal contact. Perform screening in well-ventilated outdoors area or in area with forced exhaust to draw vapors out of the room. If screening is done indoors, it must be done inside an exhaust hood or immediately in front of an exhaust fan. Fifteen-minute eyewash within 100 feet. The operator must thoroughly review (and document review) all applicable MSDSs.	PID monitoring at least twice per day after 1 hour of screening.
Fire (chemical reagents)	D, III	Flammable reagents closed when not in use. If flammable solvents are used, the exhaust fan must be turned on before beginning screening and kept on during screening. Flammables cabinet if more than 25 gallons of flammable material stored inside. Fire extinguisher rated at least 10-ABC nearby (see Section 9.0).	Daily safety inspection.
<i>Disposal of Investigation-Derived Wastes (Soil Cuttings and Decontamination Rinsates)</i>			
General safety hazards (power machinery, moving equipment, slips, and falls)	D, III	Level D PPE (see Section 5.0) plus heavy-duty work gloves. Hardhat if overhead hazards are present. Personnel not involved with equipment (trailer-mounted liquid tank, manual drum truck, drum grapppler, Tommy lift, etc.) will stand clear during operation. HAZWOPER training. Buddy system. No personnel under lifted loads. Only adequately trained, experienced personnel will be allowed to operate equipment. Equipment used to lift or move drums will be used within its rated weight capacity. Coordination with D&D program management and protective measures, potentially including high-visibility vests, if traffic or other hazards are present.	Daily site safety inspections.

Table 2-2 (continued)

Safety and Health Hazards	Risk Assess. Codes	Controls	Monitoring
Contact with OE	D, II	On-site training in ordnance recognition for all field personnel. Visual surveillance for OE. Withdrawal of all SAIC and subcontractor personnel and field marking of the area if ordnance or suspected ordnance is discovered. Notification of USACE Project Manager and facility EOD personnel if ordnance is discovered.	Visual surveys for ordnance.
Exposure to chemicals (see Table 2-3)	D, III	Natural rubber or similar gloves for contact with potentially contaminated material. Washing face and hands and any other exposed areas prior to taking anything by mouth. Minimal contact Medical clearance.	Daily site safety inspections.
Gunfire (deer hunting with shotguns loaded with slugs allowed in some areas on Fridays and Saturdays during season)	D, I	No field work at dawn or dusk in areas open to hunting (during season). High-visibility vests in these areas. When possible, schedule work in these areas for Sunday through Thursday.	None.
Biological hazards (poison ivy, bees, ticks, and wasps)	C, III	PPE (boots, work clothes). Pants tucked into boots or wrapped with duct tape. Insect repellant, as necessary.	Visual survey.
Temperature extremes	C, II	Administrative controls (see Section 9.0). Chilled fluids immediately available if temperature > 70 degrees Fahrenheit.	Ambient temperature, heart rates as appropriate.
<i>Equipment Decontamination (Hot Water Washing, Soap and Water Washing, Solvent Rinse)</i>			
General equipment decontamination hazards (hot water, slips, falls, and equipment handling)	C, III	Level D+ PPE (see Section 5.0) plus: Nitrile or PVC gloves, face shield, and Saranax or rain suit (when operating steam washer). HAZWOPER training.	Daily safety inspections.
Noise (spray washer)	B, II	Hearing protection when within 7.6 m (25 feet) of operating washer.	Daily safety inspections.
Fire (flammable decontamination solvents and gasoline)	D, III	Exclusion of ignition sources during solvent use. Control of flammable materials (quantities in decontamination area limited to single-day use, proper storage). Fire extinguisher (see Section 9.0).	Daily safety inspections.

Table 2-2 (continued)

Safety and Health Hazards	Risk Assess. Codes	Controls	Monitoring
Exposure to chemicals (see Table 2-3)	D, III	Natural rubber or similar gloves for handling potentially contaminated materials. Adequate ventilation during solvent use. Washing face and hands and any other exposed areas prior to taking anything by mouth. Minimal contact. Medical clearance.	Daily safety inspection
Temperature extremes	C, II	Administrative controls (see Section 9.0).	Temperature measurements as appropriate, heart rate monitoring as appropriate.

- D&D = Decontamination and Decommissioning
- EOD = Explosives ordnance disposal
- HAZWOPER = Hazardous Waste Operations and Emergency Response
- MSDS = Material Safety Data Sheet
- OE = Ordnance and explosives
- PID = Photoionization detector
- PPE = Personal protective equipment
- PVC = Polyvinyl chloride
- SAIC = Science Applications International Corporation
- USACE = U.S. Army Corps of Engineers.

Table 2-3. Potential Exposures for the Phase II RI at Load Line 1

Chemical^a	TLV/PEL/STEL/IDLH^b	Health Effects/ Potential Hazards^c	Chemical and Physical Properties^c	Exposure Route(s)^c
DNT (dinitrotoluene)	TLV/TWA: 0.2 mg/m ³ , A2 IDLH: Ca [50 mg/m ³]	Suspected human carcinogen, anorexia, cyanosis, and reproductive effects	Orange-yellow solid, VP: 1 mm; FP: 404°F	Inhalation Absorption Ingestion Contact
Gasoline (used for fuel)	TLV/TWA: 300 ppm IDLH: Ca	Potential carcinogen per NIOSH, dizziness, eye irritation, and dermatitis	Liquid with aromatic odor; FP: -45°F; VP: 38 to 300 mm	Inhalation Ingestion Absorption Contact
Hydrochloric acid (potentially used to preserve water samples or for equipment decontamination)	TLV: 5 ppm ceiling IDLH: 50 ppm	Irritation of eyes, skin, and respiratory system	Liquid; VP: fuming; IP: 12.74 eV; FP: none	Inhalation Ingestion Contact
Isopropyl alcohol (potentially used for equipment decontamination)	TLV/TWA: 400 ppm STEL: 500 ppm IDLH: 2000 ppm	Irritation of eyes, skin, respiratory system; drowsiness, headache	Colorless liquid with alcohol odor; VP: 33 mm; IP: 10.10 eV; FP: 53°F	Inhalation Ingestion Contact
Lead	TLV/TWA: 0.05 mg/m ³ , A3 PEL/TWA: 0.05 mg/m ³ IDLH: 100 mg/m ³	Weakness, anorexia, abdominal pain, anemia	Solid metal; VP: 0 mm; FP: NA; IP: NA	Inhalation Ingestion Contact
Liquinox (used for decontamination)	TLV/TWA: None	Inhalation may cause local irritation to mucus membranes	Yellow odorless liquid (biodegradable cleaner); FP: NA	Inhalation Ingestion
Methanol (potentially used for equipment decontamination)	TLV/TWA: 200 ppm Skin notation IDLH: 6000 ppm	Irritation of eyes, skin, respiratory system; headache; optic nerve damage	Liquid; VP: 96 mm; IP: 10.84 eV; FP: 52°F	Inhalation Absorption Ingestion Contact

Table 2-3 (continued)

Chemical ^a	TLV/PEL/STEL/IDLH ^b	Health Effects/ Potential Hazards ^c	Chemical and Physical Properties ^c	Exposure Route(s) ^c
HMX (octogen)	TLV/TWA: None established, toxicity assumed to be similar to RDX as compounds are very similar	Explosive; assumed irritation of eyes and skin, dizziness, weakness	Assumed similar to RDX- FP: explodes; VP: 0.0004 mm at 230°F	Assumed: Inhalation Absorption Ingestion Contact
RDX (cyclonite)	TLV/TWA: 0.5 mg/m ³ , A4 Skin notation IDLH: none established	Explosive; irritation of eyes and skin, dizziness, weakness	White powder; FP: explodes; VP: 0.0004 mm at 230°F	Inhalation Absorption Ingestion Contact
TNT (trinitrotoluene)	TLV/TWA: 0.5 mg/m ³ Skin notation IDLH: 500 mg/m ³	Cluster headache; irritation of skin and mucus membranes, liver damage, and kidney damage	Pale solid; FP: explodes; VP: 0.0002 mm	Inhalation Absorption Ingestion Contact

^aThe potential chemicals were obtained from the *Phase I Remedial Investigation Report for the Phase I Remedial Investigation of High Priority Areas of Concern at the Ravenna Army Ammunition Plan, Ravenna, Ohio* (USACE 1998).

^bFrom 1999 Threshold Limit Values, *NIOSH Pocket Guide to Chemical Hazards*, 1997.

^cFrom 1997 *NIOSH Pocket Guide to Chemical Hazards, the Condensed Chemical Dictionary*, Tenth Edition.

IP = ionization potential

TWA = time-weighted average

FP = flash point

PEL = permissible exposure limit

VP = vapor pressure

IDLH = immediately dangerous to life and health

STEL = short-term exposure limit

NA = not available

TLV = threshold limit value

NIOSH = National Institute for Occupational Safety and Health

RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine

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3.0 STAFF ORGANIZATION, QUALIFICATIONS, AND RESPONSIBILITIES

This section presents the personnel (and their associated telephone numbers) responsible for site safety and health and emergency response. [Table 3-1](#) identifies the SAIC and subcontractor individuals who will fill key roles. See the Facility-wide Safety and Health Plan (FSHP) for information on the roles and responsibilities of key positions.

Table 3-1. Staff Organization

Position	Name	Phone
Program Manager (DACA62-94-D-0029)	Ike Diggs	423-481-8710
Health and Safety Manager	Steve Davis CIH, CSP	423-481-4755
Project Manager	Steve Selecman	423-481-8761
Technical Manager	Kevin Jago	423-481-4614
Field Operations Manager	Kathy Dominic	937-431-2220
Site Safety and Health Officer (well installation)	Heather Smith	423-481-4602
Site Safety and Health Officer (soil, sediment, and surface water sampling)	Martha Clough	937-431-2220

CIH = Certified Industrial Hygienist

CSP = Certified Safety Personnel

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4.0 TRAINING

Training requirements are outlined in the FSHP. In addition to the FSHP's requirements, at least two first aid/cardiopulmonary resuscitation (CPR)-trained personnel must be onsite during field activities.

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5.0 PERSONAL PROTECTIVE EQUIPMENT

General guidelines for the selection and use of PPE are presented in the FSHP. Specific PPE requirements for the Phase I RI at Erie Burning Grounds are presented in the hazard/risk analysis section (Chapter 2.0).

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6.0 MEDICAL SURVEILLANCE

Medical surveillance requirements are outlined in the FSHP.

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7.0 EXPOSURE MONITORING/AIR SAMPLING PROGRAM

Assessment of airborne chemical concentrations will be performed, as appropriate, to ensure that exposures do not exceed acceptable levels. Action levels, with appropriate actions, have been established for this monitoring. In addition to the specified monitoring, the Site Safety and Health Officer (SSHO) may perform, or require, additional monitoring such as organic vapor monitoring in the equipment decontamination area, personnel exposure sampling for specific chemicals, etc. The deployment of monitoring equipment will depend on the activities being conducted and the potential exposures. All personal exposure monitoring records will be maintained in accordance with 29 *Code of Federal Regulations* 1910.20. The minimum monitoring requirements and action levels are presented in [Table 7-1](#).

Most of Phase II RI field work is not expected to pose airborne exposure hazards for the following reasons:

- the work will be performed in open areas with natural ventilation;
- the site has been inactive since 1971, and no activities have occurred at the site since the early 1990s; thus, any volatile contaminants should have evaporated;
- prior site sampling indicated that contaminants are unlikely to pose an airborne hazard; and
- the most probable contaminants (heavy metals and explosive residues) are materials with relatively low vapor pressures.

For these reasons, air monitoring using a photoionization detector (PID) or equivalent is planned only for subsurface soil boring and sampling and monitoring well drilling and installation. The SSHO will, of course, examine site conditions and will contact the Health and Safety Manager and initiate additional monitoring if there is any indication of potential airborne exposure.

Table 7-1. Monitoring Requirements and Action Limits

Hazard or Measured Parameter	Area	Interval	Limit	Action	Tasks
Airborne organics with PID or equivalent	Breathing zone [0.9 m (3 feet) from source or 0.36 m (14 inches)] in front of employee's shoulder	At least once every 30 minutes in areas of intrusive work, at least twice a day in the mobile lab (when lab in use)	<5 ppm >5 ppm	Level D Withdraw and evaluate <ul style="list-style-type: none"> • identify contaminants • notify Project Manager and H&S Manager 	Drilling, soil sampling, well development, and groundwater sampling; if previous sampling indicates a potential for overexposure, on-site laboratory analysis.
Detector tubes	Breathing zone	If organic vapor >5 ppm	PEL/TLV	Withdraw and evaluate; controls may include engineering, administrative, or personal protective measures	
Flammability and oxygen content with combustible gas indicator	Near borehole and any area where flammable gases are suspected	Only if PID readings exceed 100 ppm or other indicators of flammability observed	<10% LEL >10% LEL	Continue and evaluate source Withdraw and allow area to ventilate; notify Project Manager and H&S Manager	Intrusive tasks
Noise	None; SAIC has performed monitoring of drill rigs and generators on previous projects	Only if there is some doubt about noise levels	85 dBA and any area perceived as noisy	Require the use of hearing protection	None; hearing protection will be worn within the exclusion zone around drill rigs, excavation equipment, power augers, and generators
Visible contamination	All	Continuously	Visible contamination of skin or personal clothing	Upgrade PPE to preclude contact; may include disposable coveralls, boot covers, etc.	All

Table 7-1 (continued)

Hazard or Measured Parameter	Area	Interval	Limit	Action	Tasks
Visible airborne dust	All	Continuously	Visible dust generation	Stop work; use dust suppression techniques such as wetting surface	All

H&S = Health and Safety
LEL = Lower explosive limit
PEL = Permissible exposure limit
PID = Photoionization detector
PPE = Personal protective equipment
ppm = parts per million
SAIC = Science Applications International Corporation
TLV = Threshold limit value

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8.0 HEAT/COLD STRESS MONITORING

General requirements for heat/cold stress monitoring are contained in the FSHP.

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9.0 STANDARD OPERATING SAFETY PROCEDURES

Standard operating safety procedures are described in the FSHP.

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10.0 SITE CONTROL MEASURES

Site control measures are described in the FSHP. Because Load Line 1 is currently undergoing demolition, multiple personnel are routinely working in some of the proposed sampling areas. For these reasons, site control will be implemented at subsurface soil boring and monitoring well drilling locations requiring the use of drilling rigs. Surface soil, surface water, and sediment sampling locations will not require site control measures under normal circumstances. If site conditions require site control, it will be implemented as described in the FSHP.

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11.0 PERSONNEL HYGIENE AND DECONTAMINATION

Personal hygiene and decontamination requirements are described in the FSHP and in Chapter 2.0 of this addendum.

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12.0 EQUIPMENT DECONTAMINATION

Equipment decontamination procedures are described in the FSHP.

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13.0 EMERGENCY PROCEDURES AND EQUIPMENT

Emergency contacts, telephone numbers, directions to the nearest medical facility, and general procedures can be found in the FSHP. The SAIC Field Operations Manager will remain in charge of all SAIC and subcontractor personnel during emergency activities. The SAIC field office will serve as the assembly point if it becomes necessary to evacuate one or more sampling locations. The SSHO will verify that the emergency information in the FSHP is correct during mobilization for the Phase II RI.

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14.0 LOGS, REPORTS, AND RECORD KEEPING

Logs, reports, and record keeping requirements are described in the FSHP.

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15.0 REFERENCES

NIOSH (National Institute for Occupational Safety and Health). 1997. NIOSH Pocket Guide to Chemical Hazards, the Condensed Chemical Dictionary, 10th edition.

USACE (U.S. Army Corps of Engineers). 1998. Phase I Remedial Investigation Report for the Phase I Remedial Investigation of High Priority Areas of Concern at the Ravenna Army Ammunition Plant, Ravenna, Ohio, DACA62-94-D-0029, D.O. 0010 and 0022, February.

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